NASA Technical Memorandum 104784

Analysis of Impactor Residues in Tray Clamps from the Long Duration Exposure Facility

Part 2: Clamps from Bay "B" of the Satellite

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Part 2: Clamps from Bay "B" of the Satellite

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National Aeronautics and
Space Administration

**Solar System Exploration
Division
1994**

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Acronyms

EDXA	energy dispersive X-ray analysis
FOILS	Facility for Optical Inspection of Large Surfaces
JSC	NASA/Lyndon B. Johnson Space Center
LDEF	Long Duration Exposure Facility
LEO	low Earth orbit
M&D SIG	Meteoroid & Debris Special Investigation Group
SEM	scanning electron microscopy

Introduction

The Long Duration Exposure Facility (LDEF) was placed in low-Earth orbit (LEO) in 1984 and was recovered 5.7 years later. The LDEF hosted several individual experiments that were specifically designed to characterize critical aspects of meteoroid and debris environment in LEO. It was realized from the beginning, however, that the most efficient use of the satellite would be to examine the entire surface for impact features. In this regard, particular interest has centered on common exposed materials that faced in all LDEF pointing directions. Among the most important of these materials has been the tray clamps. Therefore, in an effort to understand the nature of particulates in LEO and their effects on spacecraft hardware better, we are analyzing residues found in impact features on LDEF tray clamp surfaces. This catalog presents all data from clamps from Bay B of the LDEF. NASA Technical Memorandum 104759 (published March 1993) has cataloged impacts that occurred on Bay A. Subsequent catalogs will include clamps from succeeding bays of the satellite.

All LDEF experiment trays were held in place by a series of aluminum clamps (fig. 1). Each clamp had an exposed area of approximately 58 cm^2. One-half of the LDEF tray clamps have been archived at the NASA/Johnson Space Center (JSC) by the Meteoroid & Debris Special Investigation Group (M&D SIG). These archives are available for study by qualified investigators. For more information regarding these materials, contact the JSC Curatorial Facility. The remaining half of the clamps are being studied by the LDEF Materials Space Investigation Group.

Optical scanning of clamps—beginning with Bay A Row 01 and working through the entire satellite—is being documented in the Facility for Optical Inspection of Large Surfaces (FOILS) at JSC to locate and document impact features that are as small as 30 microns. These impacts are then examined by scanning electron microscopy/energy dispersive X-ray analysis (SEM/EDXA) to characterize further those features that contain appreciable impactor residue. Based upon the bulk composition of those residues and using criteria developed at JSC[2], we have made a preliminary discrimination between micrometeoroid- and space debris-containing impact features. These data are in a catalog format that includes (1) an optical photograph of each clamp, (2) a secondary electron image of the impact, (3) associated parameters such as impact feature size, (4) an EDXA plot of the residue, (5) impactor origin (if applicable), and (6) a curatorial number that will facilitate requests for specific impact features by interested investigators. All results are being input into the M&D SIG computerized database, which documents all LDEF meteoroid and debris results and is accessible to investigators via SPAN, Internet, or modem.[2]

LDEF Tray Clamps

LDEF experiment trays were held in place by a series of chromic-anodized aluminum (6061-T6) clamps (fig. 2). Eight clamps were used to attach the experiment trays on each of the 12 sides of the LDEF, while experiment trays on the Earth and space ends were held in place by 12 clamps. Each clamp was fastened to the spacecraft frame using three stainless-steel hex bolts. Clamps exposed an area of approximately 58 cm^2 each (4.8 cm $\times$ 12.7 cm $\times$ 0.45 cm, minus the bolt coverage). All 774 LDEF clamps were surveyed for impact features greater than 0.5 mm in diameter during experiment tray deintegration at the NASA/Kennedy Space Center. Some 337 out of 774 LDEF tray clamps have been archived by the M&D SIG in the Curatorial Facility at JSC and are available for scientific examination by qualified individuals.

A clamp numbering scheme was devised that would provide hardware location information with respect to its position within a particular bay (fig. 2). From the labeling scheme, it can be seen that a clamp occupying position 1 of Bay A02 would be identified by the label A02-C01, with A02 indicating the experiment location of Bay "A" and Row "02", and with C01 interpreted as "C" for the clamp and "01" being the clamp number. Each clamp uses a Cartesian coordinate system to reference impact locations on exposed surfaces. The X and Y coordinates were measured in millimeters using a standard origin assigned by the M&D SIG at the lower left corner of each clamp (fig. 3).

Results

Each of the clamps was optically scanned. All impact features greater than 40 microns (and some as small as 30 microns) were labeled and their position was documented. After scanning, an optical photograph was taken of the clamp illustrating each of the impact features located optically. Clamps that contained no detectable impact features are not included in this catalog. These clamps are B02-C05, B03-C01, B03-C06, B03-C08, and A04-C01, which are still available to individuals for further analysis. SEM/EDXA was then conducted on each feature that has been identified optically. Not all features identified are high-velocity impacts. In some cases, because of resolution limits during optical inspection, clamp manufacturing flaws, handling flaws, and contamination spots were mistakenly identified as impact features. During SEM/EDXA analysis, these features were properly identified and labeled as such (figs. 4 through 7). These features include craters and pits caused during the manufacturing and handling of the clamps. When clamp edges were ground smooth,

abrasive grit could become trapped between the clamps when they were stacked one on top of the other. Movement caused these grains to roll and leave tracks and pits.[1] The secondary electron images were obtained at 30 deg from normal. Because the initial intent of this survey was to identify only those impacts that contained large amounts of micrometeoritic residue, a minimal amount of time was spent analyzing for small or unobvious projectile remnants. The EDX spectra obtained were qualitative but served to provide a basic classification of either "natural" or "manmade" for residues, although many of the impacts are classified as having no definite origin. Clamp impacts that have no detectable residues by techniques were used to display a composition typical of the clamp aluminum alloy. Although the exact composition differed slightly from example to example, these spectra were recognizably the same. For this reason, a standard clamp aluminum alloy spectrum is displayed in figure 8. Throughout the catalog, features containing no detectable residue will reference this spectrum. The criteria used to determine impactor origin are described at length in another publication.[2] Figure 9 summarizes the survey residue classification results for our clamp analyses in histogram form. We believe that further, more detailed analyses will undoubtedly uncover evidence of impactor residues in many of the presently unclassified impact craters. The support of such subsequent analyses is our primary objective in publishing this catalog. A factor hindering our analyses is the fact that the clamps have all been anodized, a process that deposits a surface layer of Si, Mg, and S—all of which are important elements for the discrimination of natural from manmade materials. This contamination has been properly considered as background, but in many instances its presence makes characterization of the residues extremely difficult.

References

[1] Redd, Cecil; and Zolensky, Mike E. (1991) *Too exposed* (Scientific correspondence). *Nature 352*, page 289.

[2] Zolensky, M. E.; Zook, H.; Horz, F.; Atkinson, D.; Coombs, C.; Dardano, C.; See, T.; Simon, C.; and Kinard W. (1993) *Interim report of the Meteoroid and Debris Special Investigation Group.* From *Proceedings of the 2nd LDEF Post-Retrieval Conference*, eds., A. Levine and W. Kinard. NASA Conference Publication 3194, pp. 277-302. (Available from the LDEF Project Office at NASA Langley, Mailstop 404).

FIGURE 1. A photograph taken of the trailing/Earth edge of the Long Duration Exposure Facility (A03) during the STS-32 retrieval mission. The arrows placed on the photograph show the location of clamps used to hold experiment trays in place during their exposure in low Earth orbit. The circles or round patches on some of the clamps are test paint coupons. Several possess impact craters but, because of surface contamination impact residues, these were not characterized here.

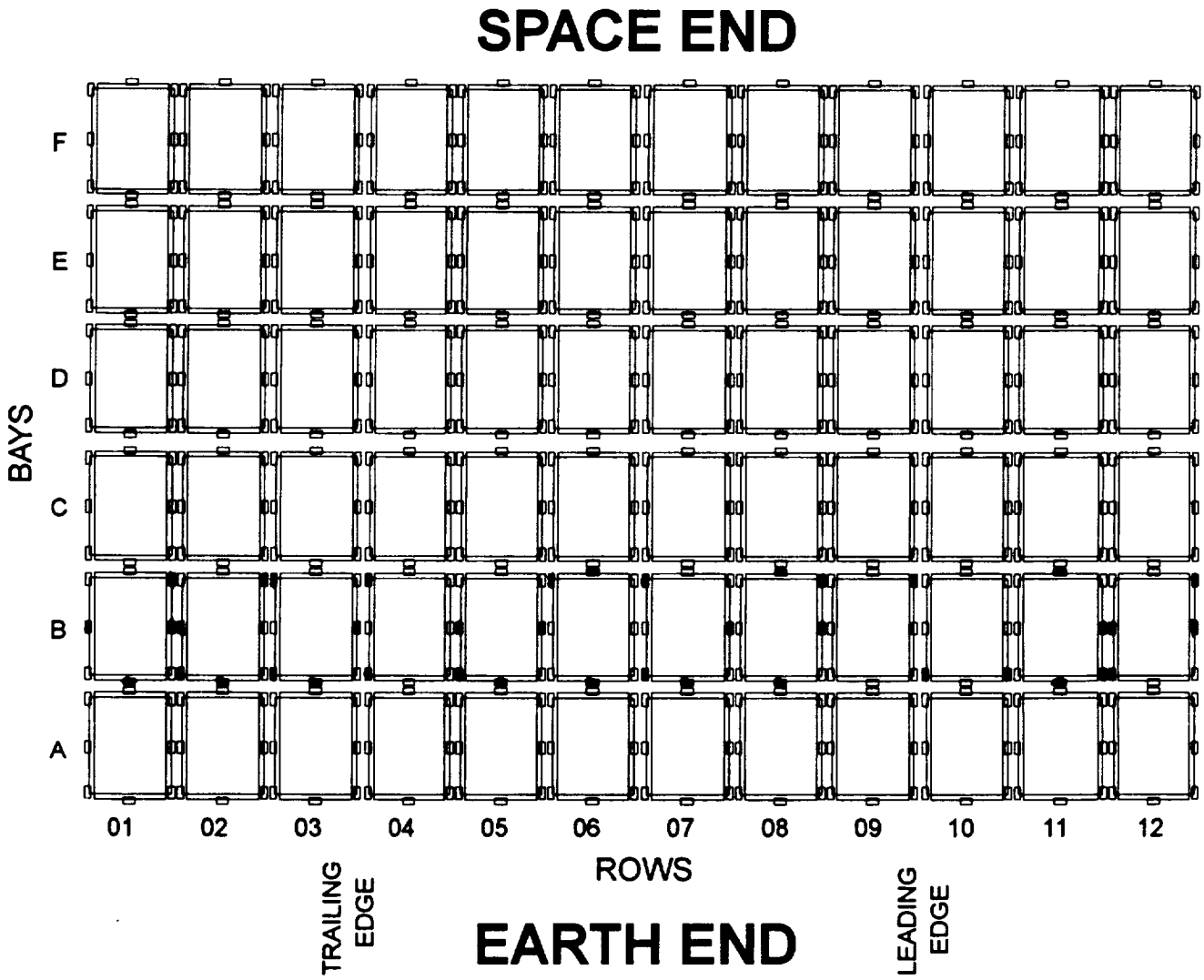


FIGURE 2. This diagram illustrates the numbering scheme used to label LDEF experiments by Bay and Row location. LDEF was a cylinder-shaped satellite with Row 1 being adjacent to Row 12, Bay A being on the Earth end, and Bay F positioned on the space facing end. While in orbit, Row 9 was in the ram direction or the leading edge, with Row 3 being on the trailing edge of motion. Clamps examined for this report are designated by dark fill.

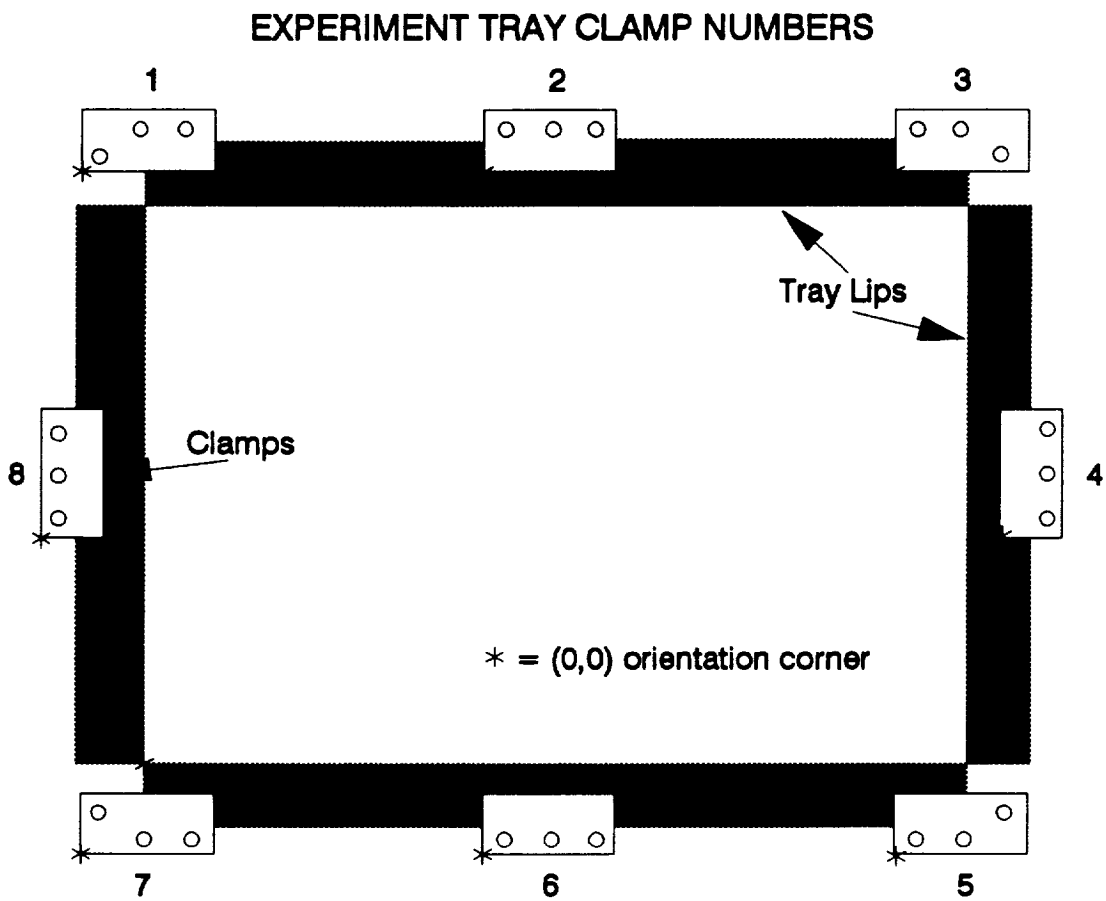


FIGURE 3. This schematic illustrates the numbering plan and positioning layout of tray clamps and bolt holes on the LDEF satellite. The bolt hole locations help to align the clamp to find the lower left orientation corner (0,0).

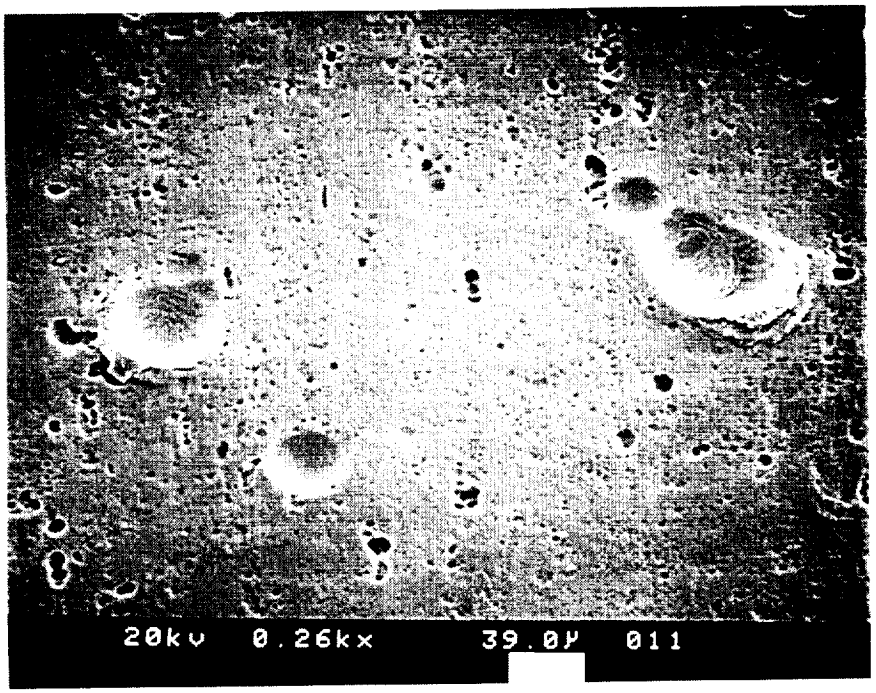


FIGURE 4. Secondary electron image of several impact-like flaws detected on the clamp surface. Features like these are quite abundant and are thought to be flaws acquired during the manufacturing and handling of the clamps.

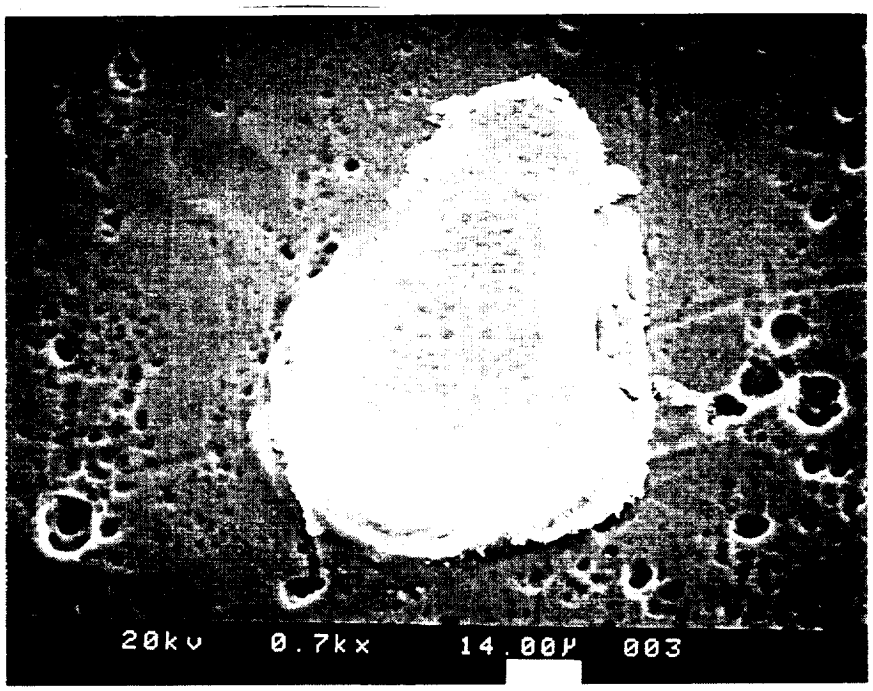


FIGURE 5. This very low velocity feature is similar to that in figure 3. During high magnification optical examination, this specimen appeared to be a typical hypervelocity impact crater. SEM examination determined its probable origin to be a handling flaw.

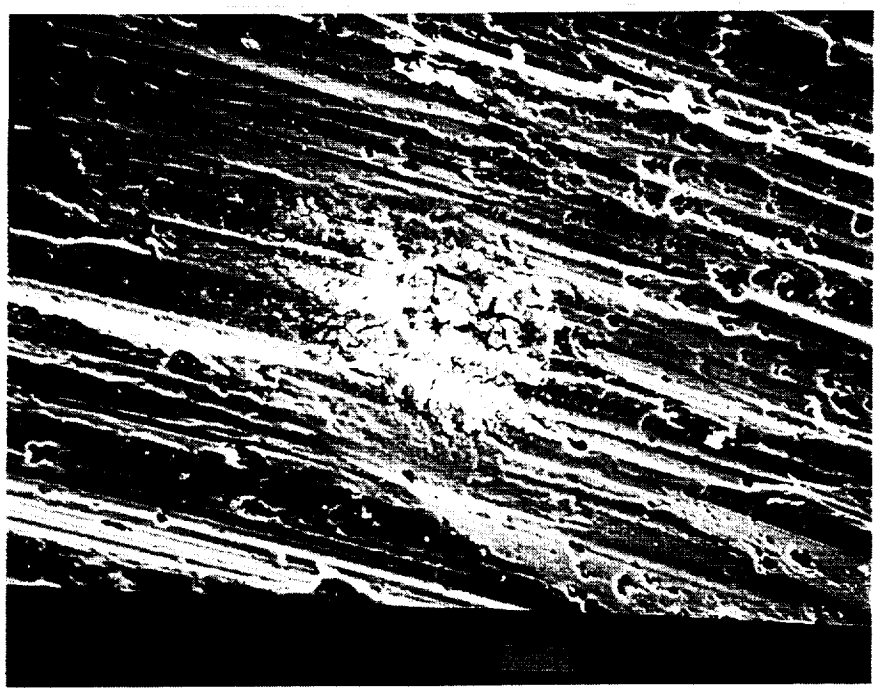


FIGURE 6. Surface flaws from chromic-anodization were also present on many of the clamps. The chemistry of such a flaw shows high levels of Si, Mg, Cl, and S, which are easily recognized by SEM/EDX analysis.

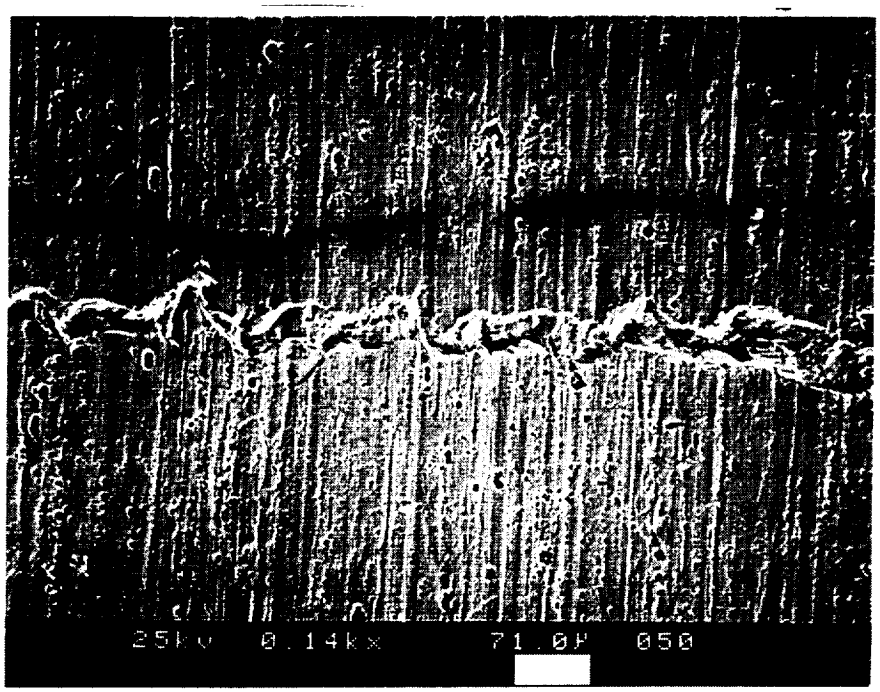


FIGURE 7. An example of a linear, repetitive-type pattern that occurred during the fabrication or preflight handling of clamps and other LDEF hardware.[1]

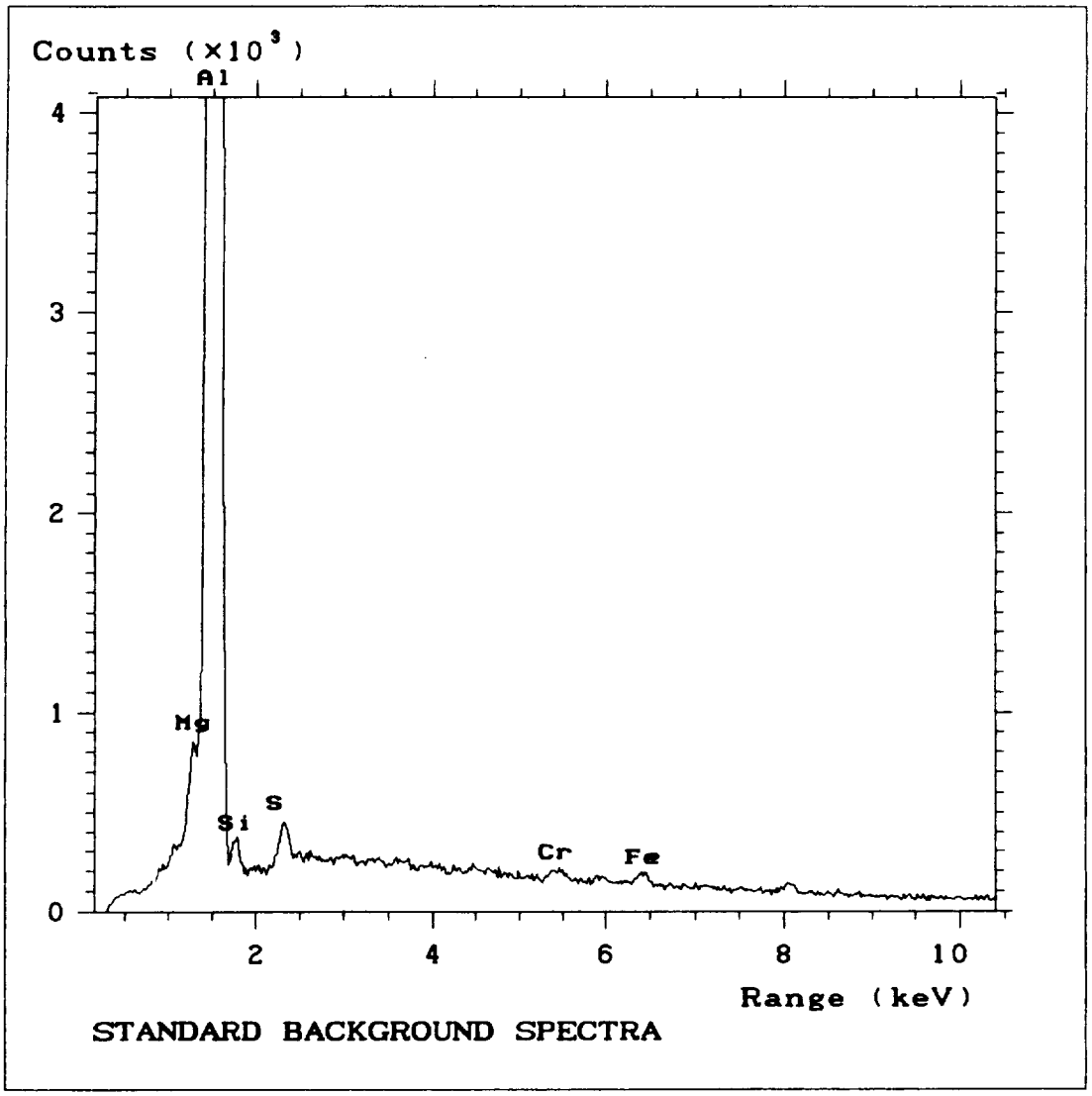


FIGURE 8. Many of the impacts analyzed by SEM/EDXA had no residue detected. These impact features are categorized as being unknown in origin. During analysis, no peaks above background were discernible; only the typical clamp materials were present. This spectra illustrates the typical composition of impacts with no detectable residue found.

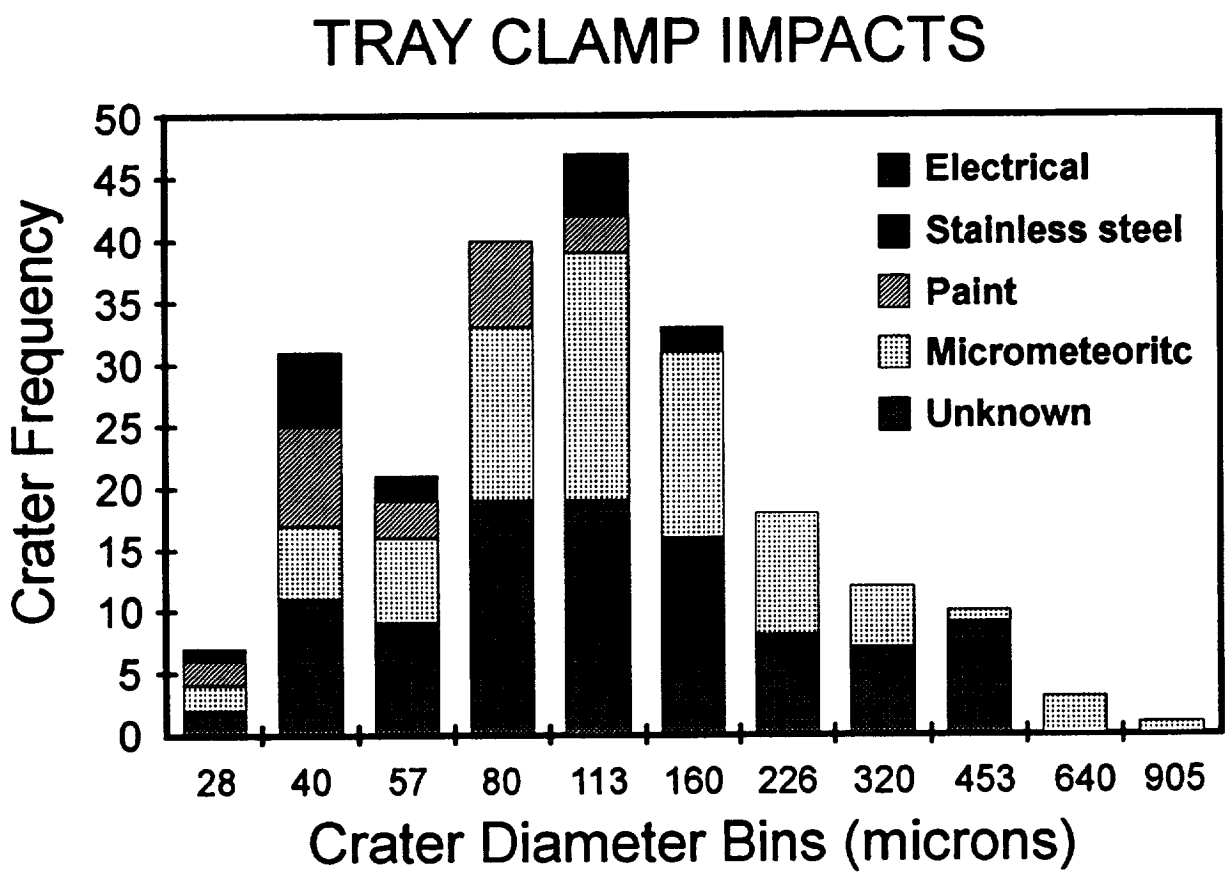
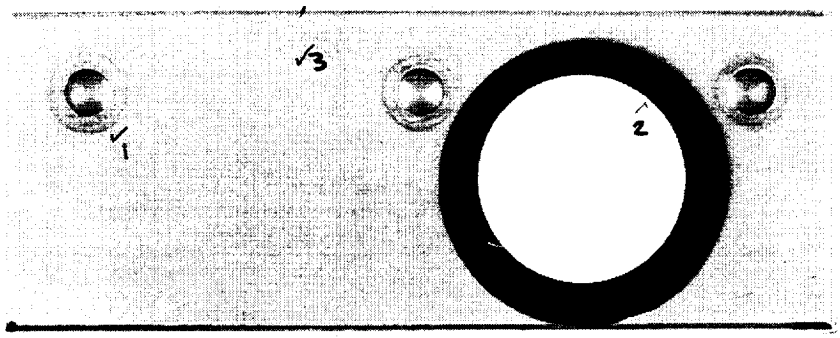


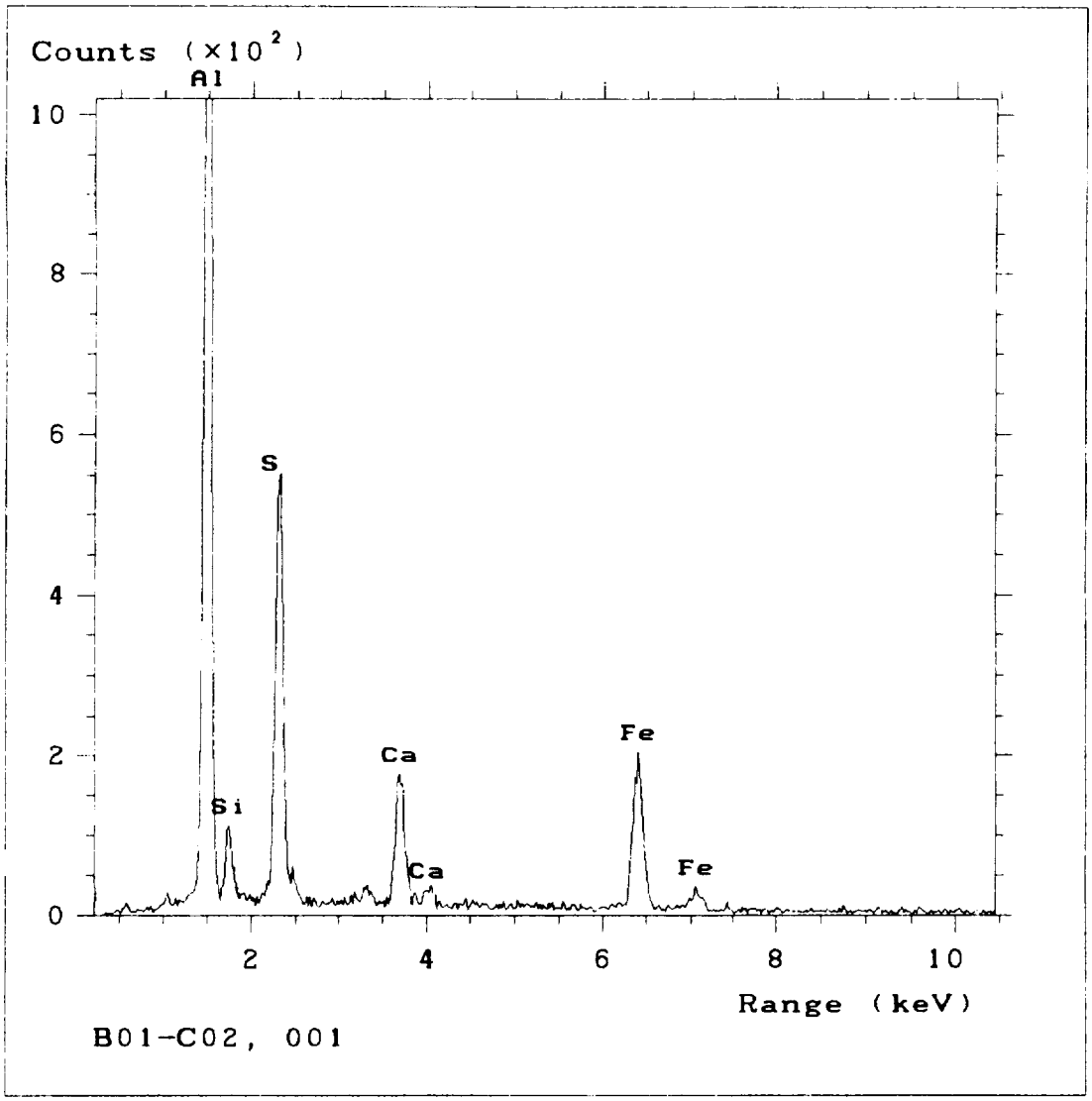
FIGURE 9. Histogram illustrating the determined impactor type versus the impact crater diameter. Samples listed as being contaminated contain significant amounts of foreign material and projectile remnants that are not easily identified.

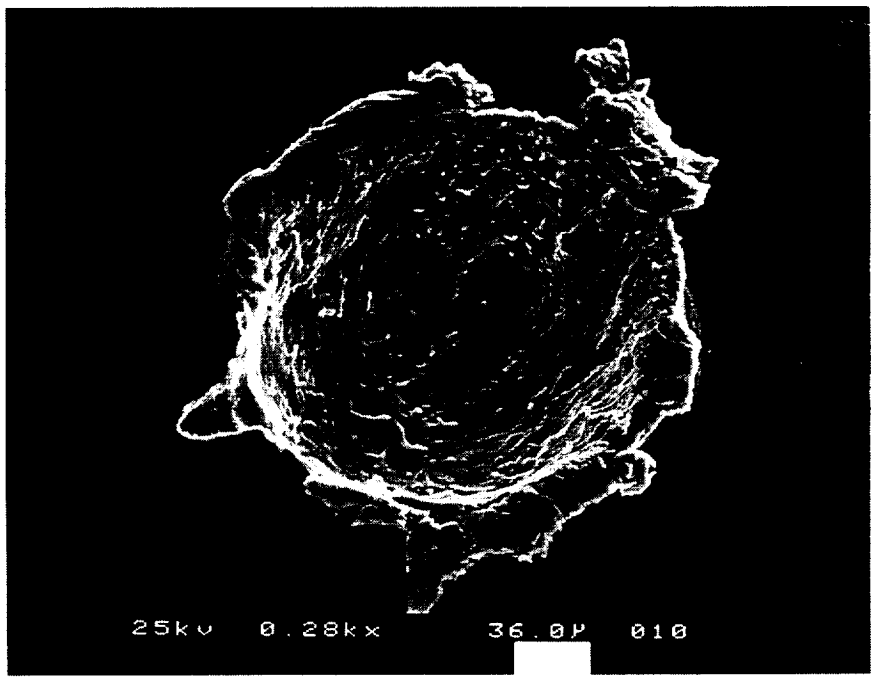
Appendix A

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B01-C02	001	16	26	220	MICROMETEORITIC
	002	98	36	120	PAINT PATCH
	003	43	40	100	MICROMETEORITIC

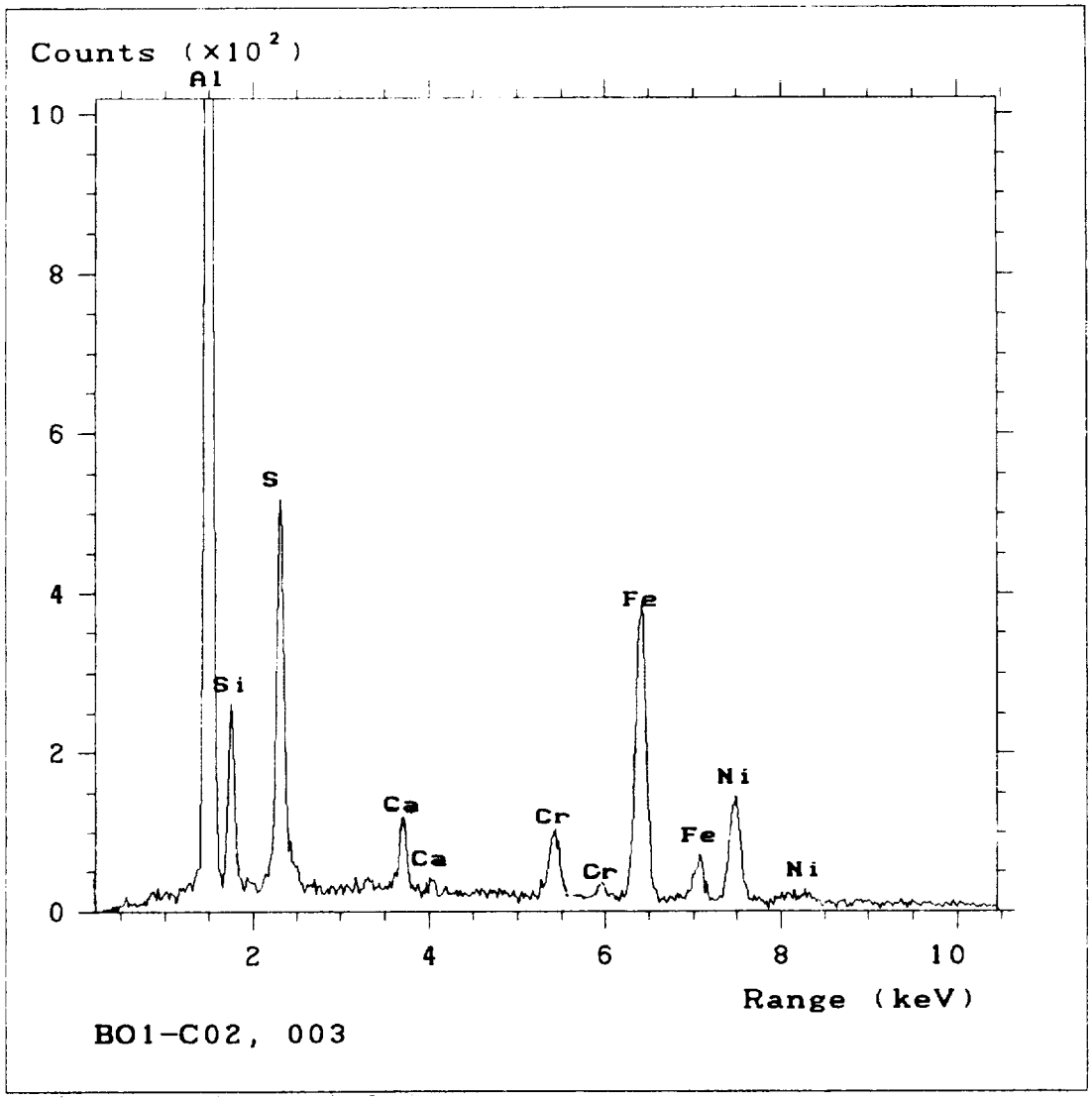


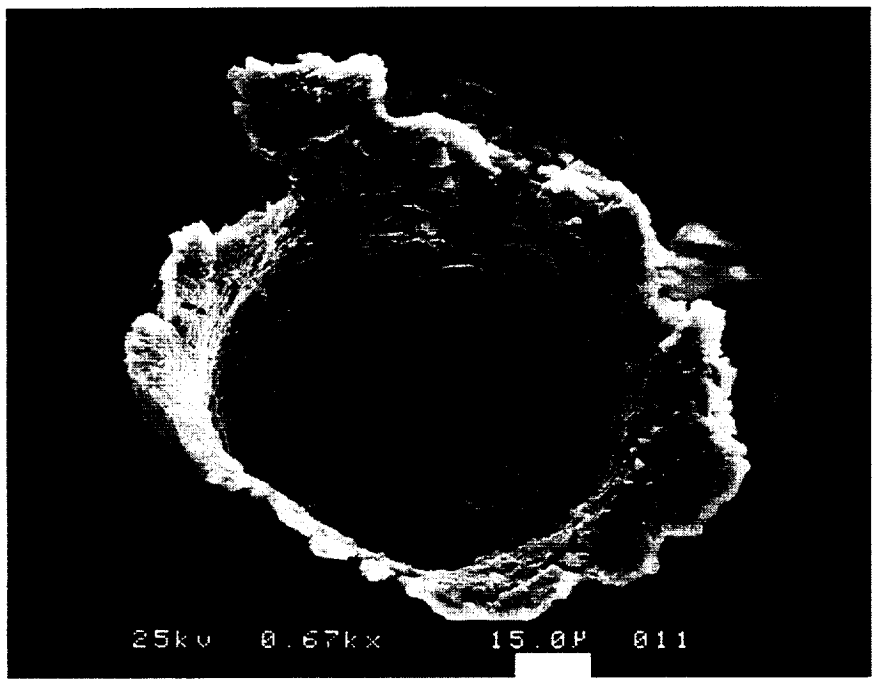
B01-C02


Counts (×10²)
Al
S
Si
Ca
Ca
Fe
Fe
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B01-C02, 001

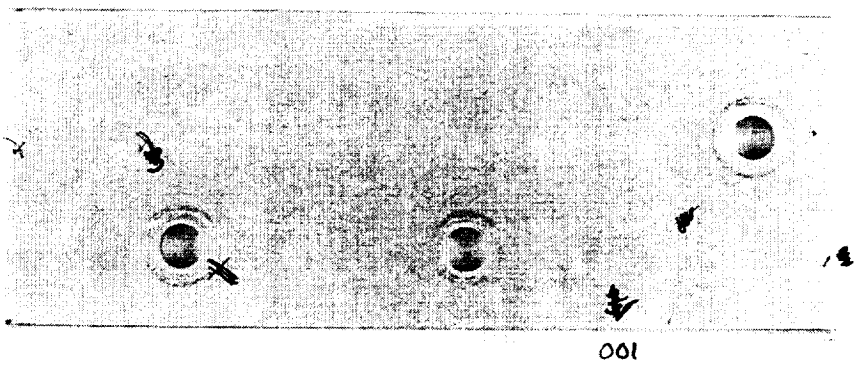

25kv 0.28kx 36.0μ 010

B01-CC2 001

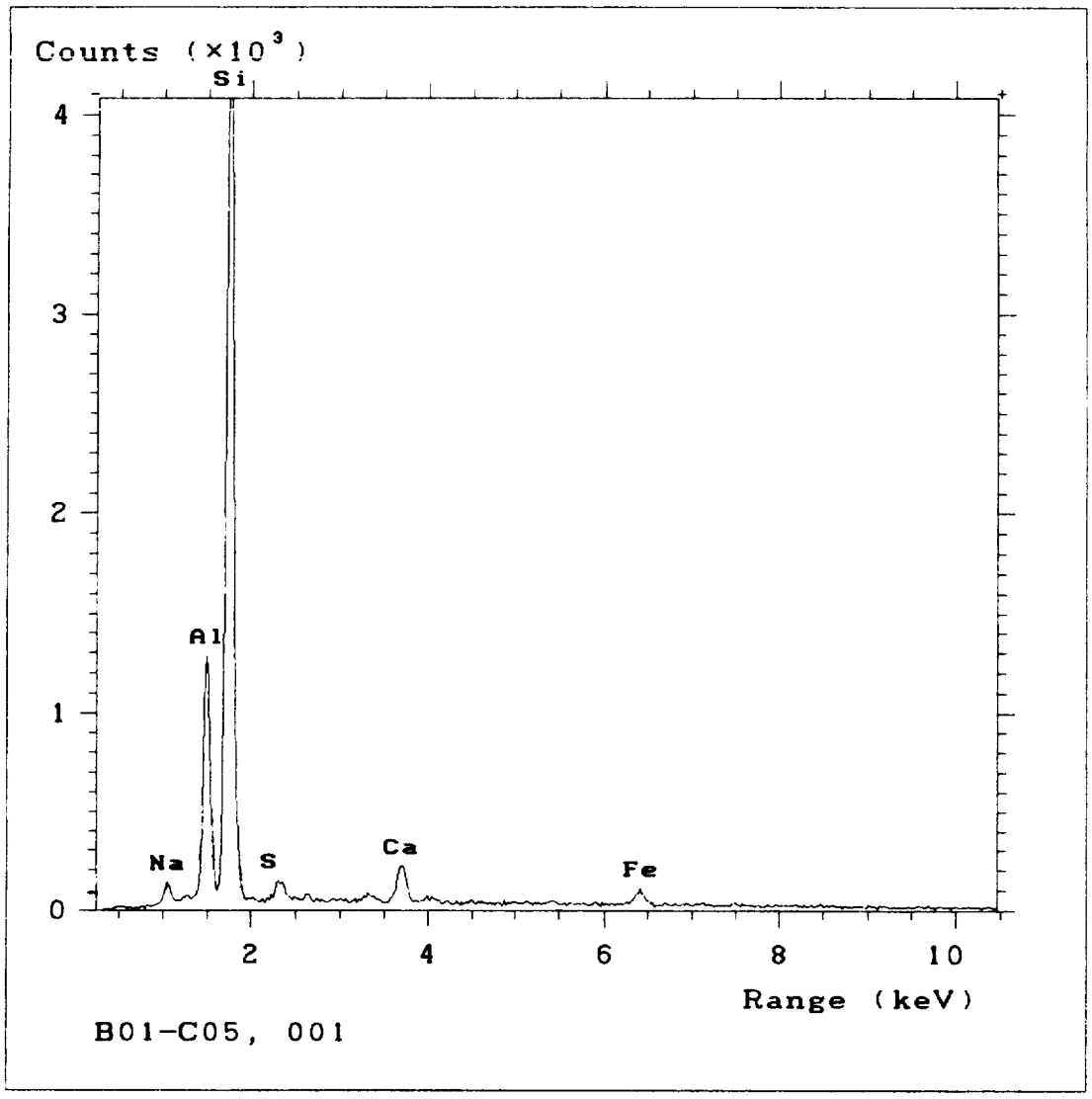

Counts (×10²)
Al
S
Si
Ca
Ca
Cr
Cr
Fe
Fe
Ni
Ni
0
2
4
6
8
10
2
4
6
8
10
Range (keV)
BO1-C02, 003

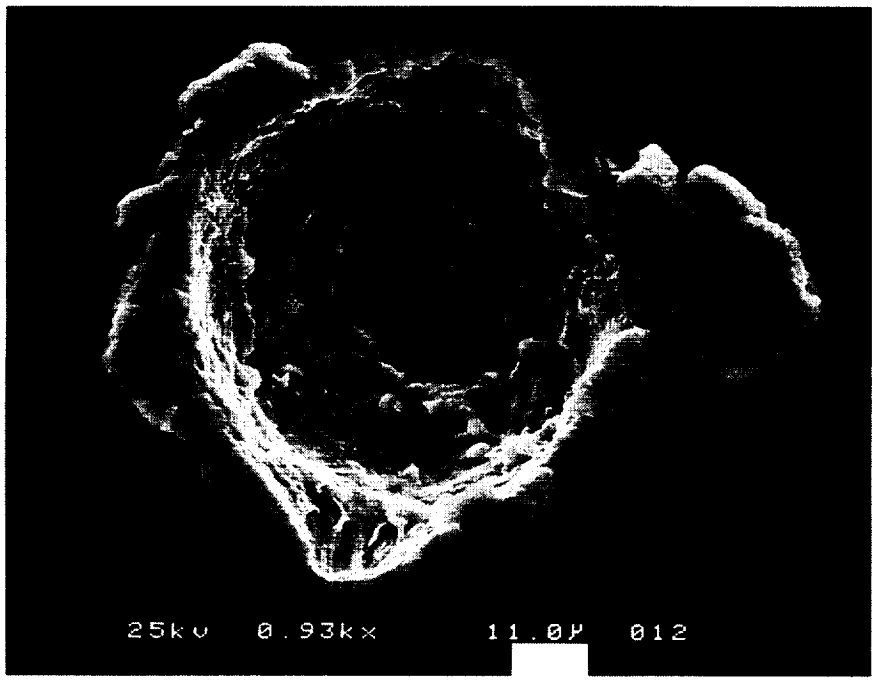

25kv 0.67kx 15.0µ 011

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (μm)	COMMENTS (origin)
B01-C05	001	93	2	100	MICROMETEORITIC



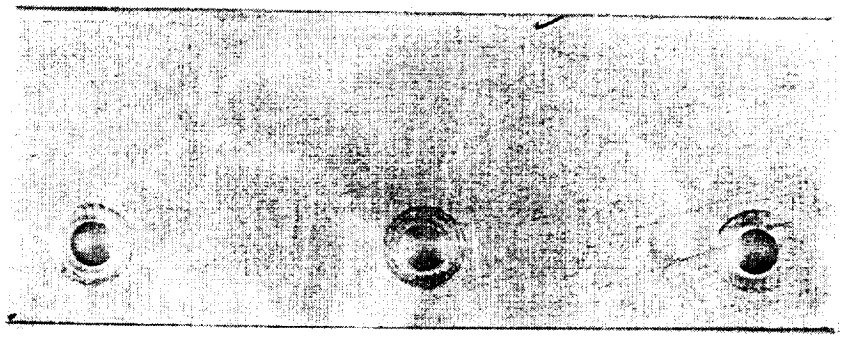
B01-C05


Counts (×10³)
Si
Al
Na
S
Ca
Fe
4
3
2
1
0
2
4
6
8
10
Range (keV)
B01-C05, 001

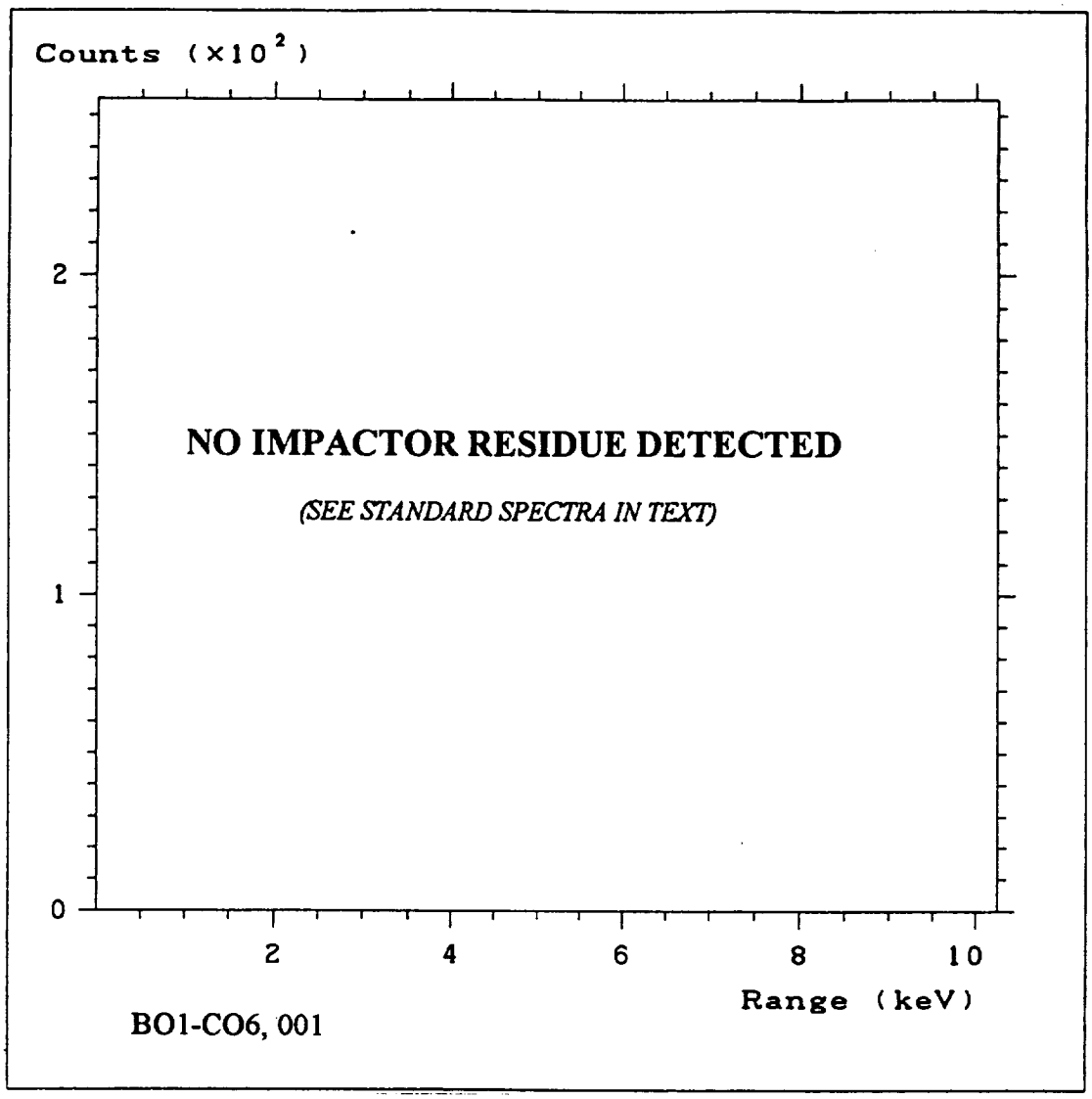

25kv 0.93kx 11.0µ 012

001

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (μm)	COMMENTS (origin)
B01-C06	001	80	45	150	CONTAMINATION



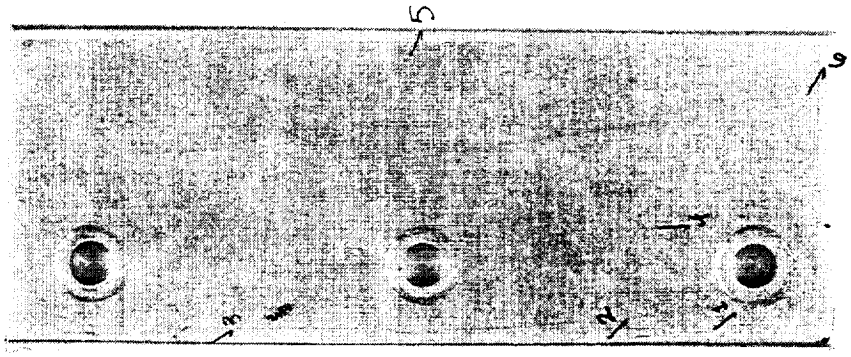
B01-C06


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
BO1-CO6, 001

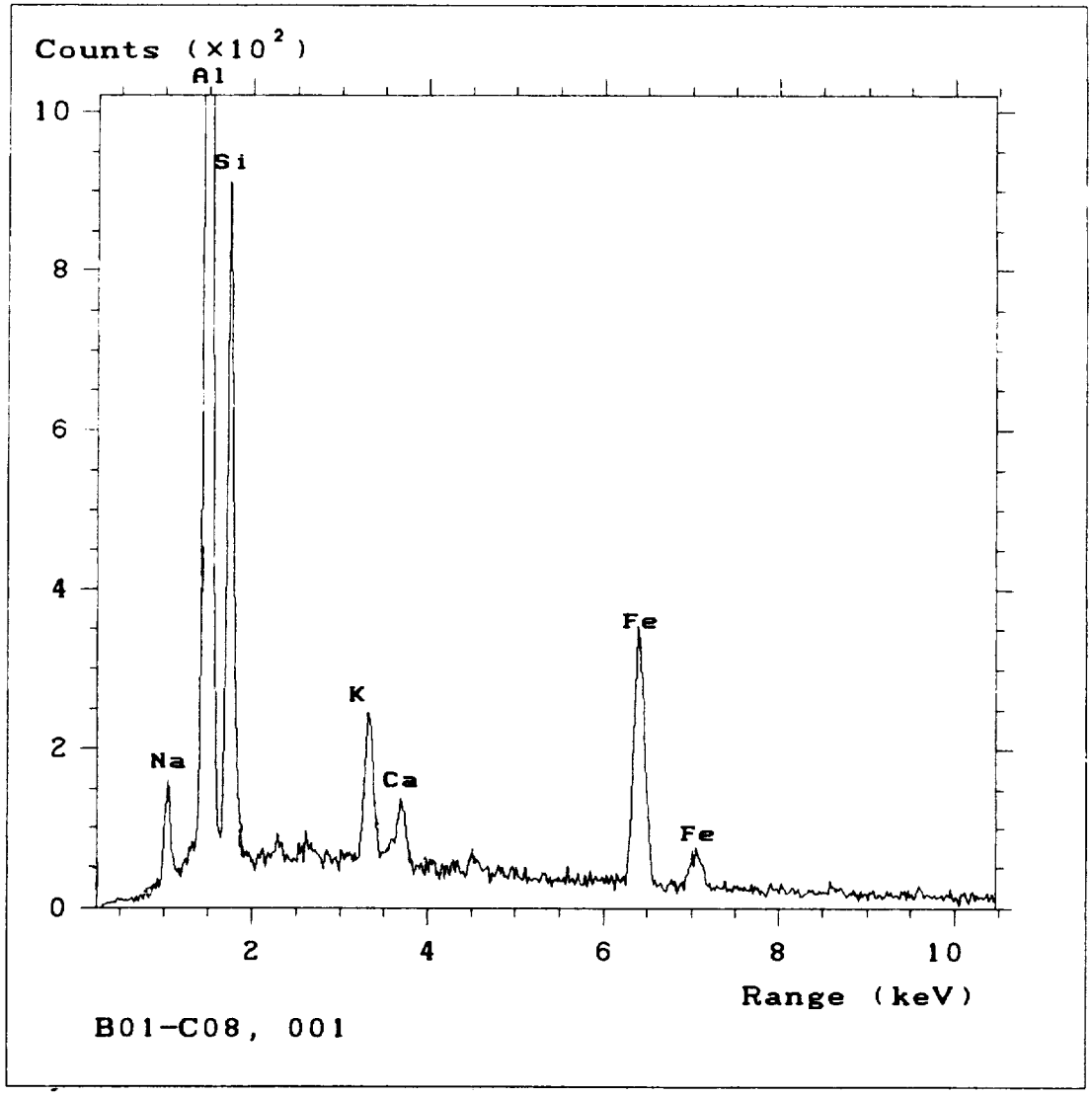
25kv 0.46kx 22.0µ 013

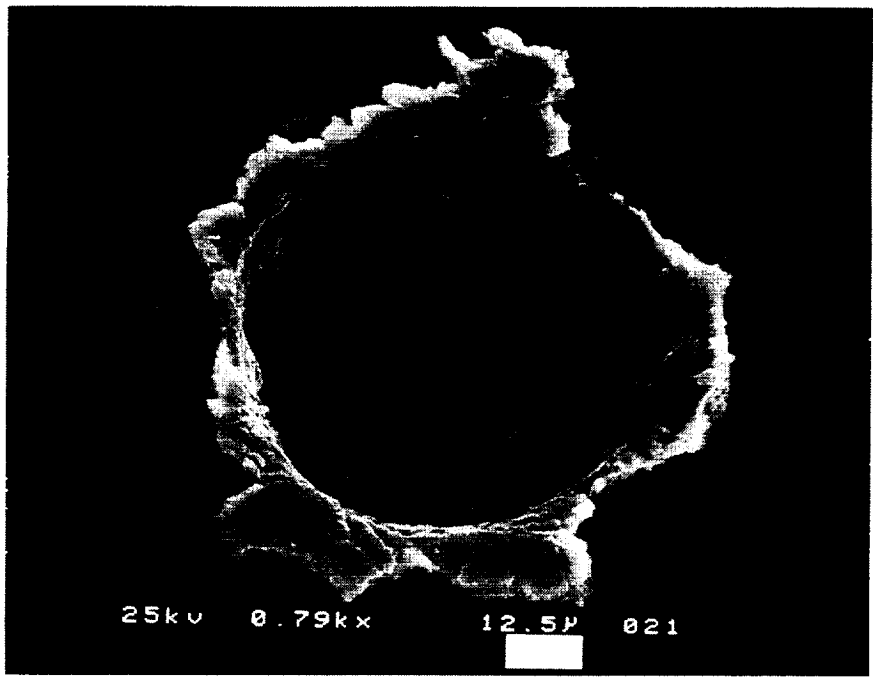
Bo1- C06 ^01

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B01-C08	001	4	12	100	MICROMETEORITIC
	002	3	30	130	STAINLESS STEEL
	003	1	90	40	PAINT
	004	17	20	80	MICROMETEORITIC
	005	48	62	120	MICROMETEORITIC
	006	43	2	140	MICROMETEORITIC

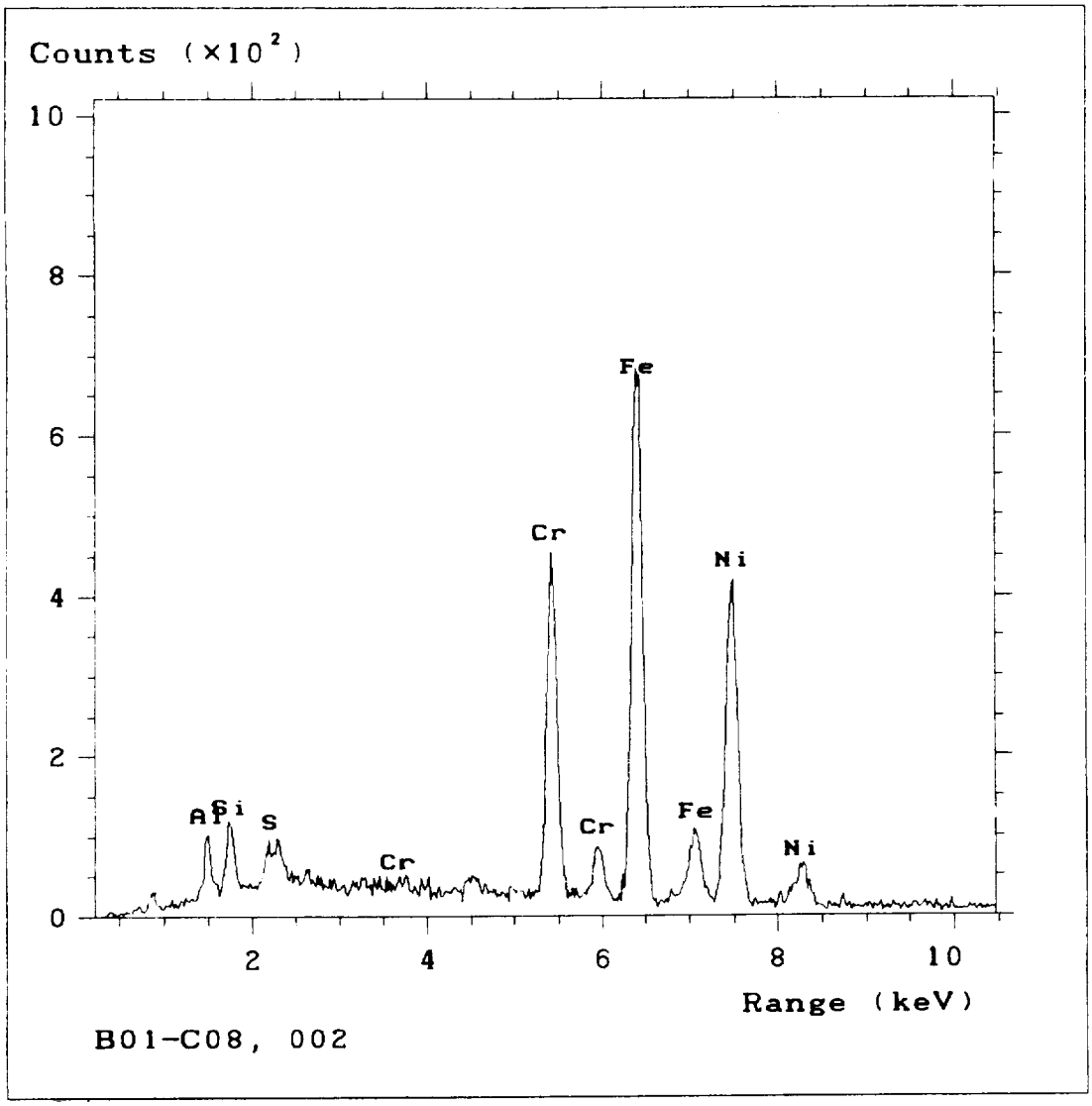


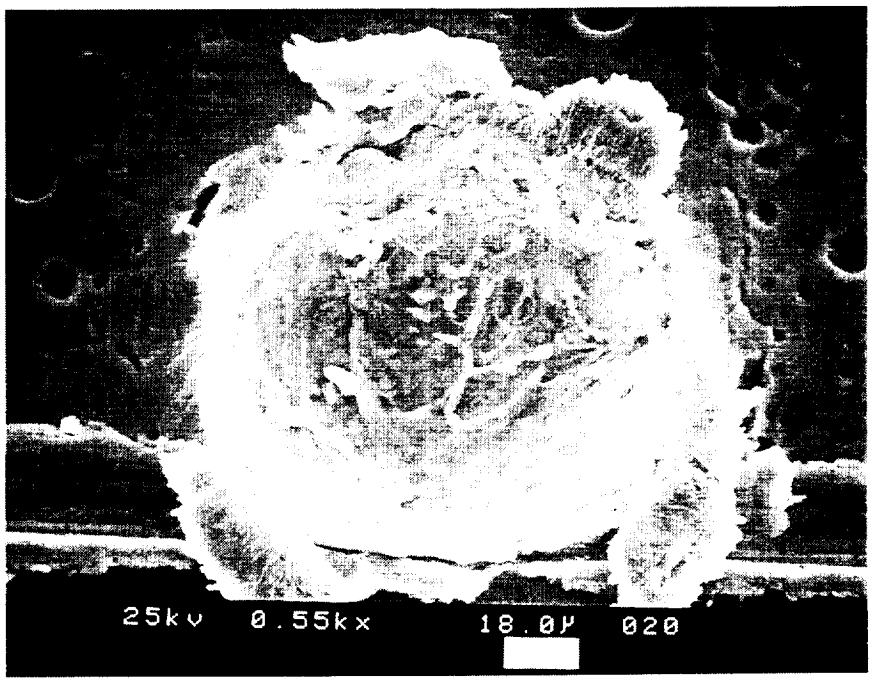
B01-C08





B01-C08 001 mm


Counts (×10²)
10
8
6
4
2
0
Al
Si
S
Cr
Cr
Cr
Fe
Fe
Ni
Ni
2
4
6
8
10
Range (keV)
B01-C08, 002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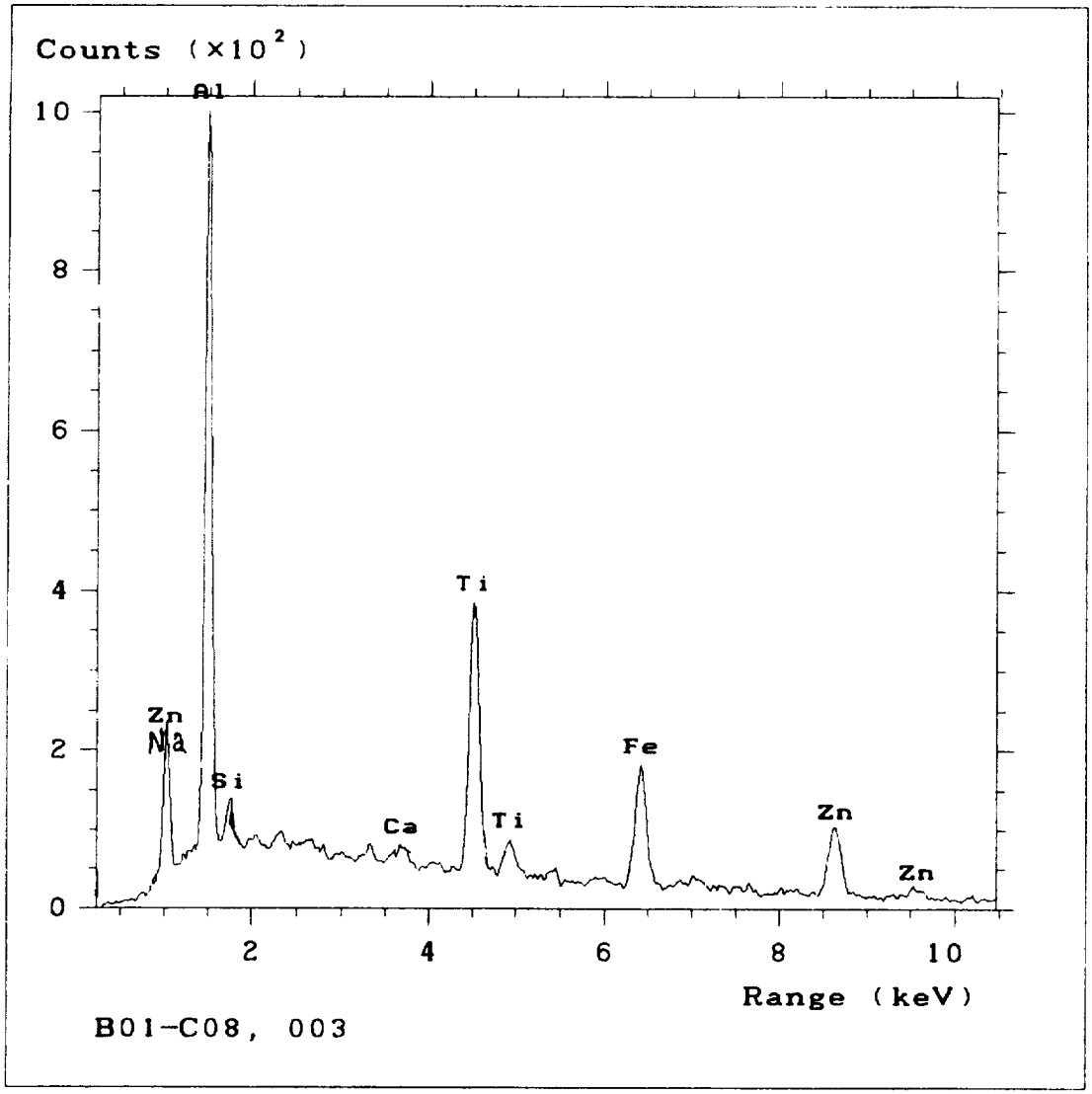
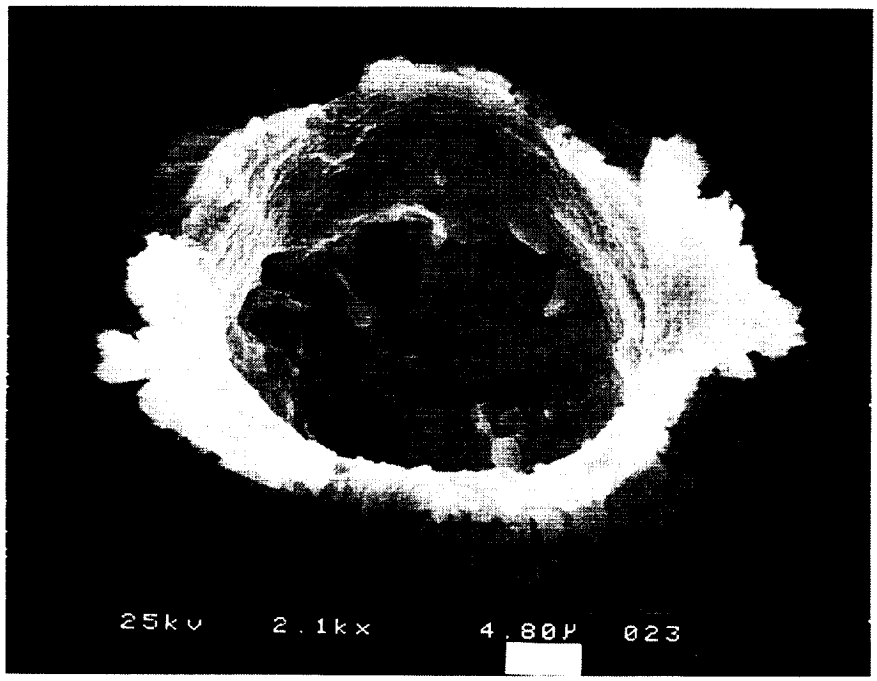
B01 - C08 002


Counts (×10²)
Al
Zn
Na
Si
Ca
Ti
Ti
Fe
Zn
Zn
Range (keV)
B01-C08, 003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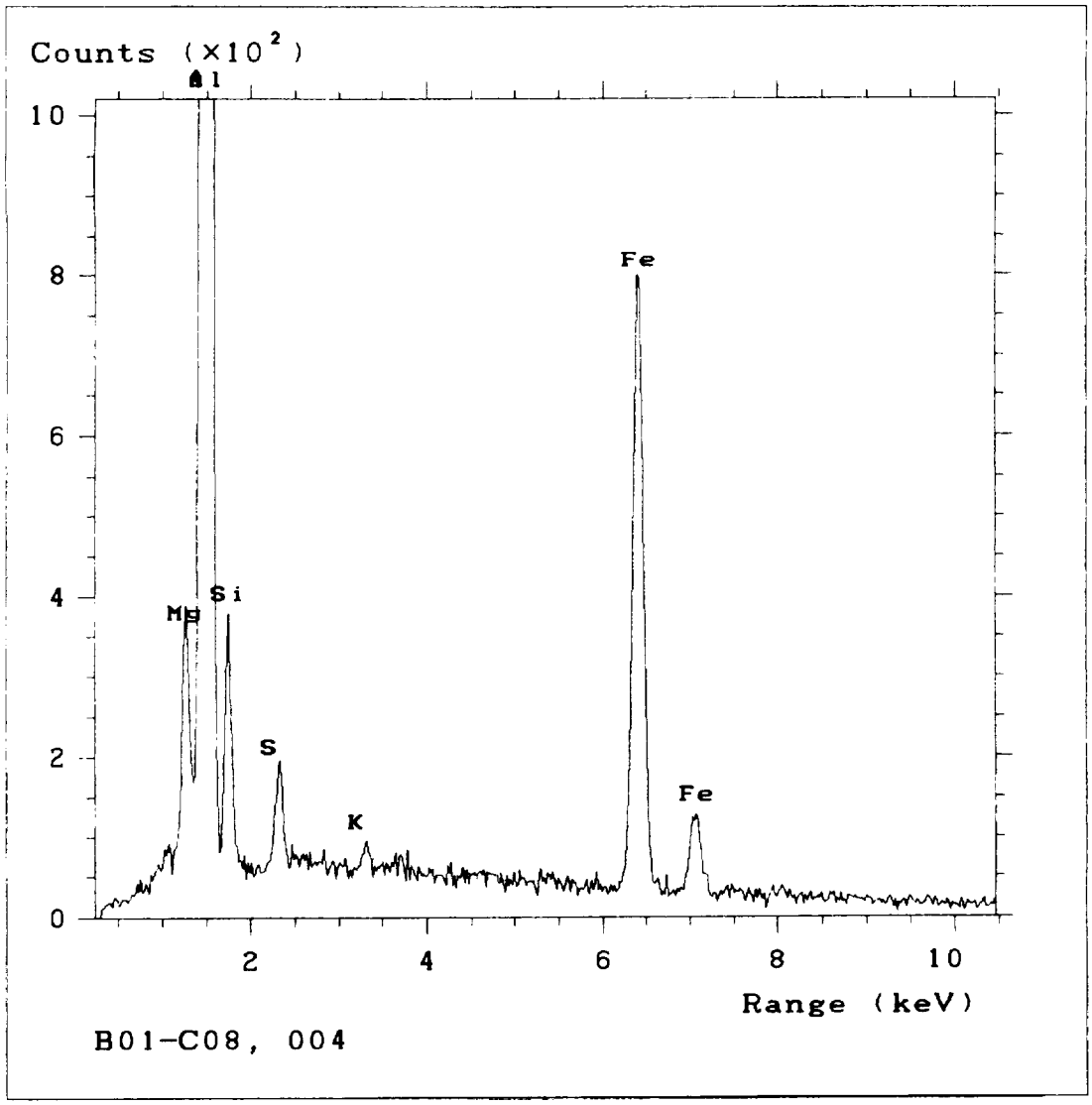
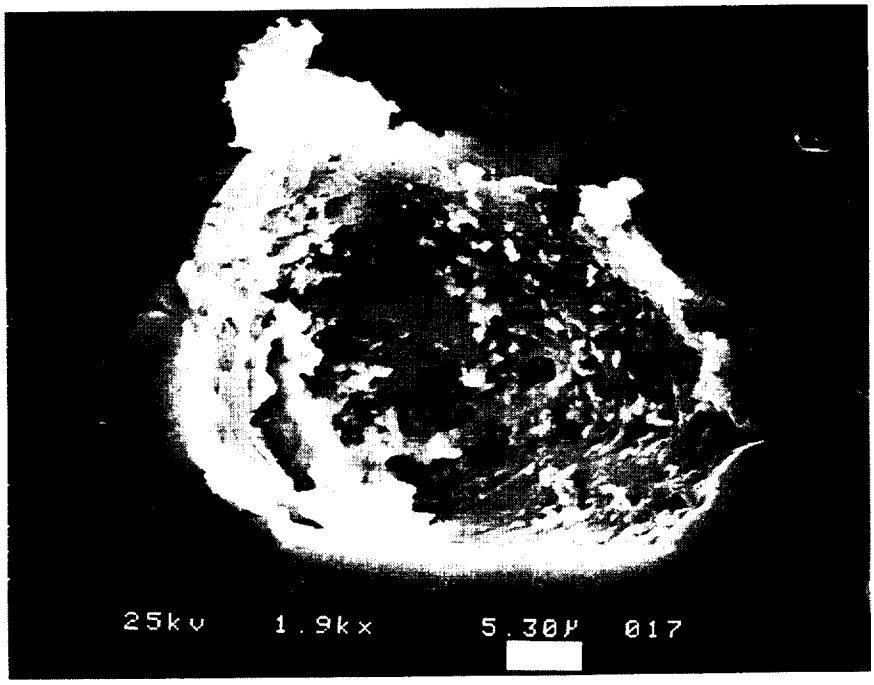
B01 C08 003


Counts (×10²)
Al
Mg
Si
S
K
Fe
Fe
Range (keV)
B01-C08, 004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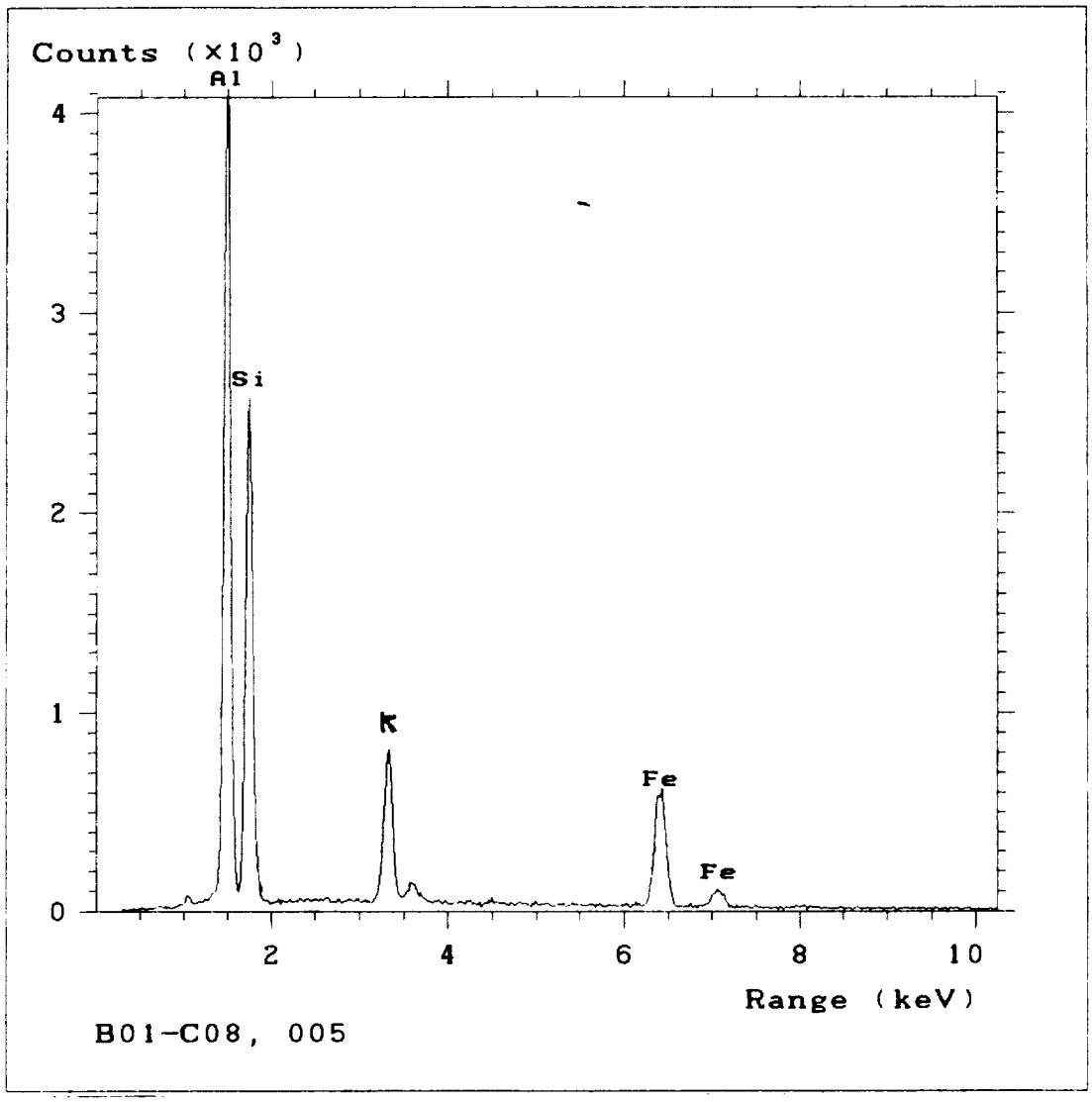
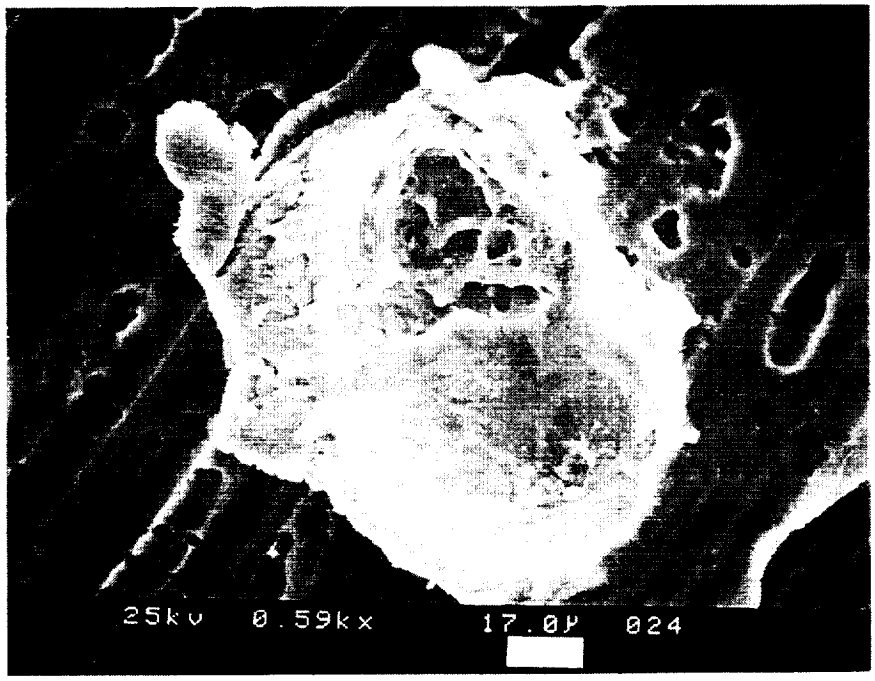
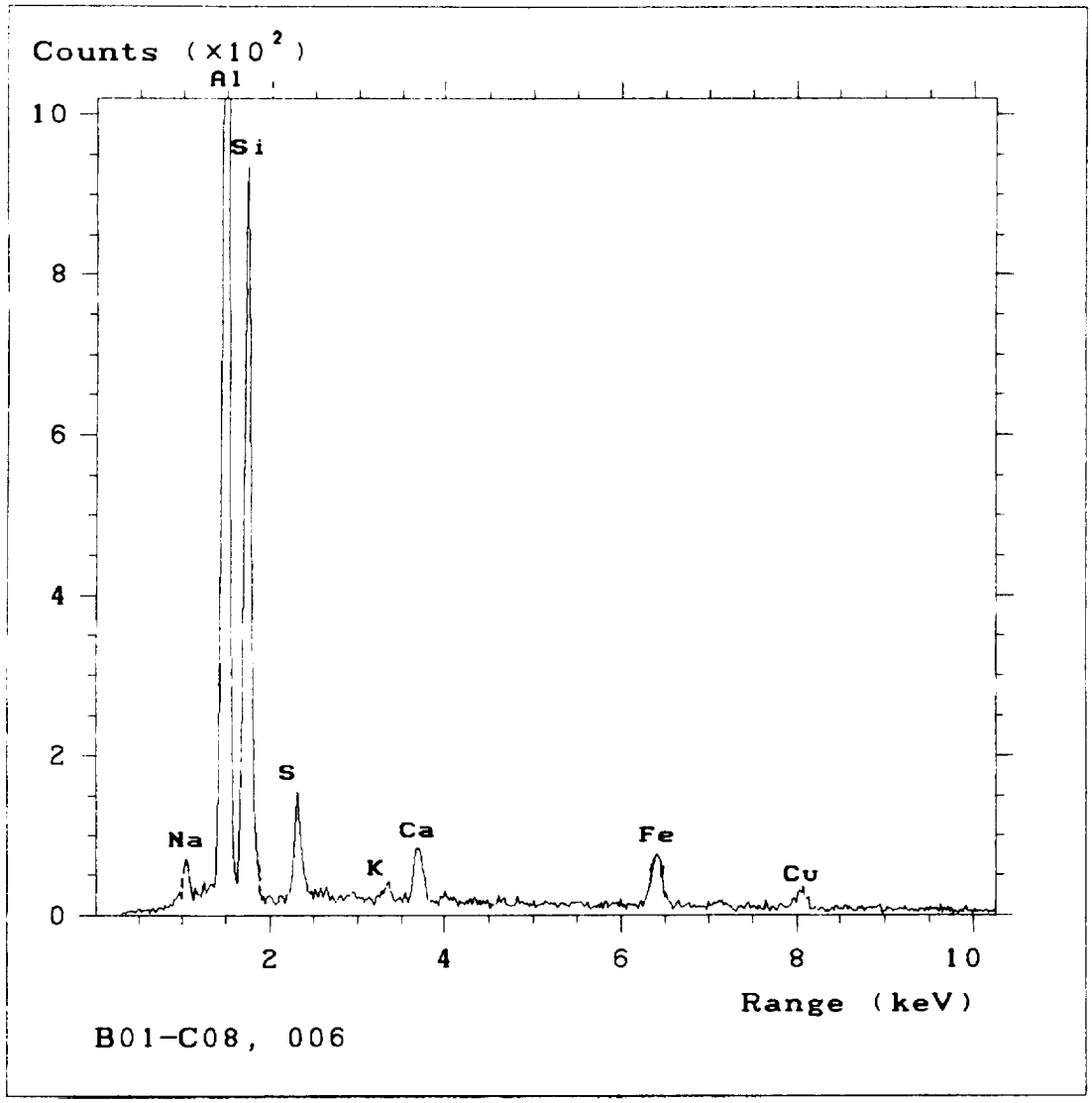
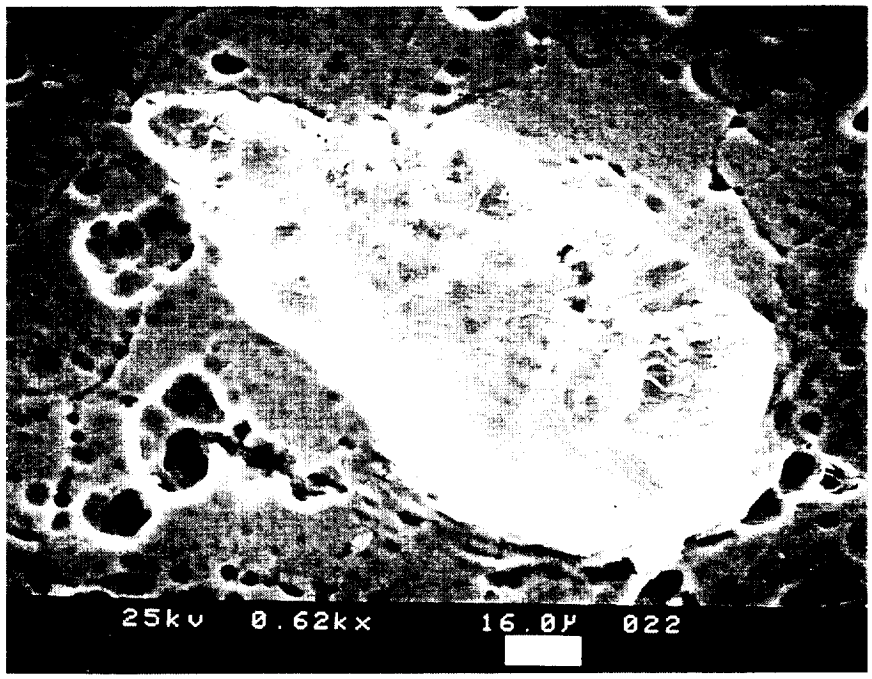
B01-C08 004

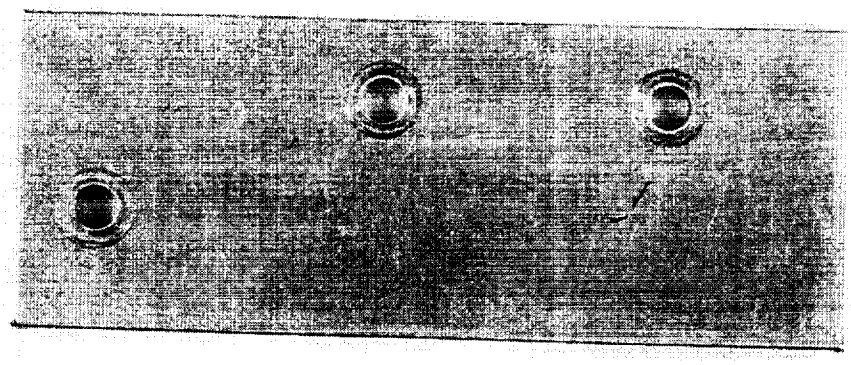

Counts (x10³)
Al
Si
K
Fe
Fe
4
3
2
1
0
2
4
6
8
10
Range (keV)
B01-C08, 005


25kv 0.59kx 17.0µ 024

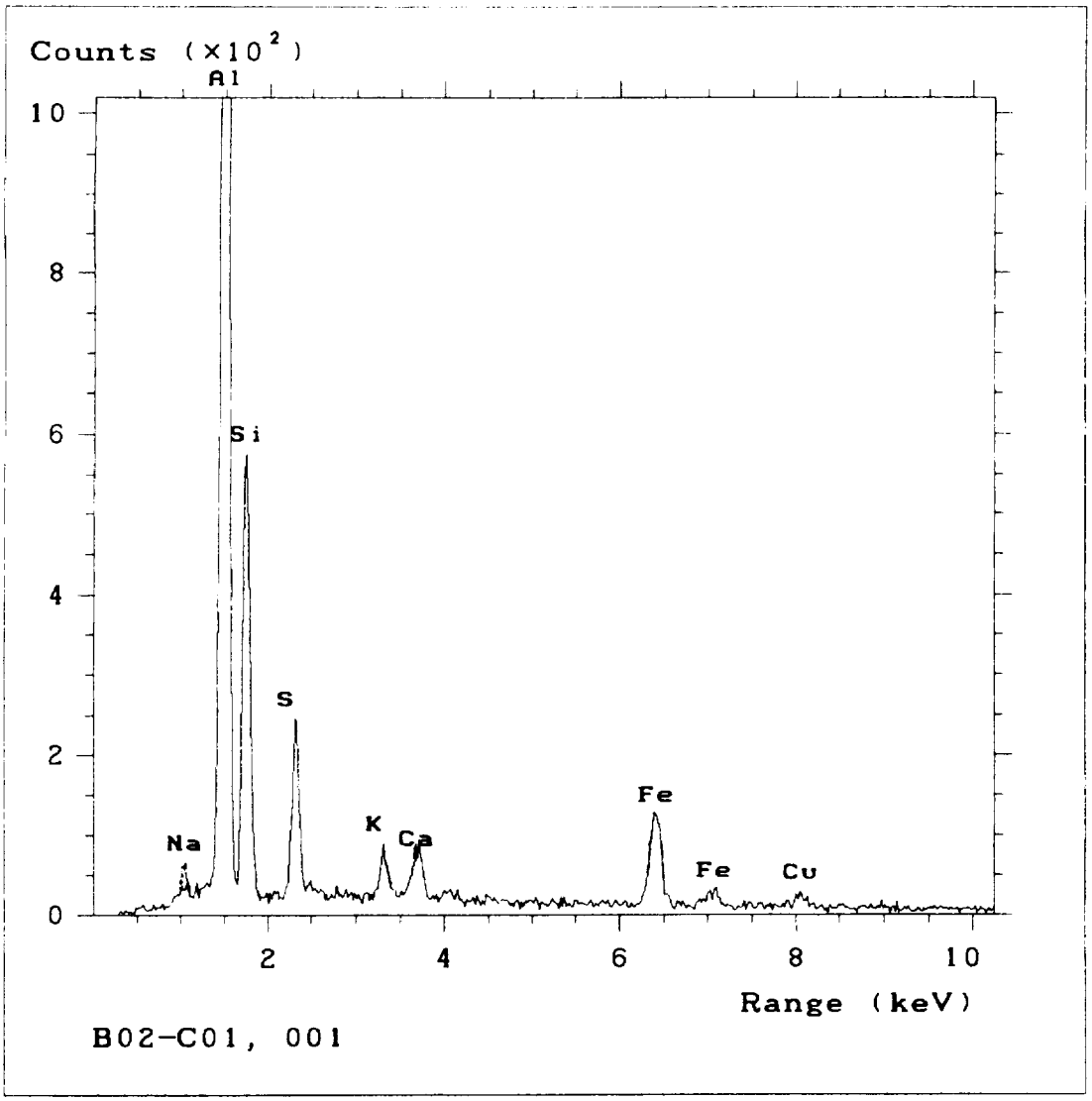

Counts (×10²)
Al
Si
S
Na
K
Ca
Fe
Cu
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B01-C08, 006

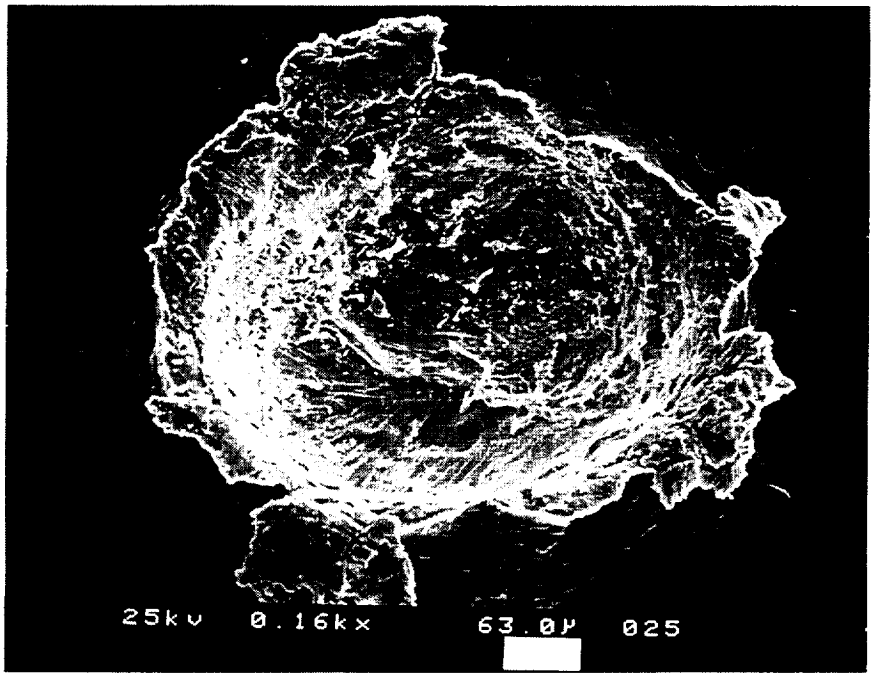

25kv 0.62kx 16.0μ 022

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B02-C01	001	93	21	440	MICROMETEORITIC



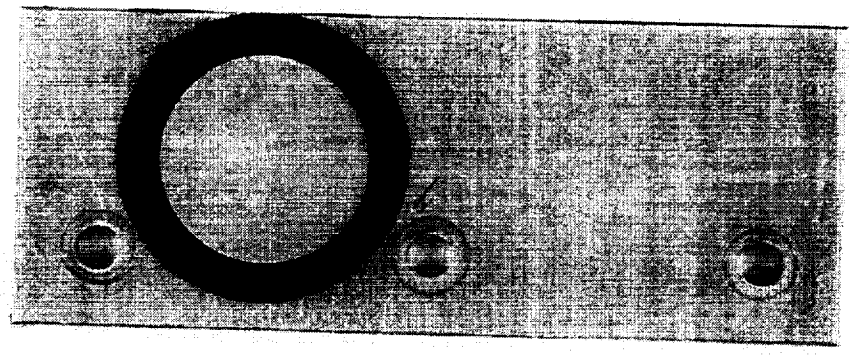
B02-C01


Counts (×10²)
Al
Si
S
Na
K
Ca
Fe
Fe
Cu
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B02-C01, 001

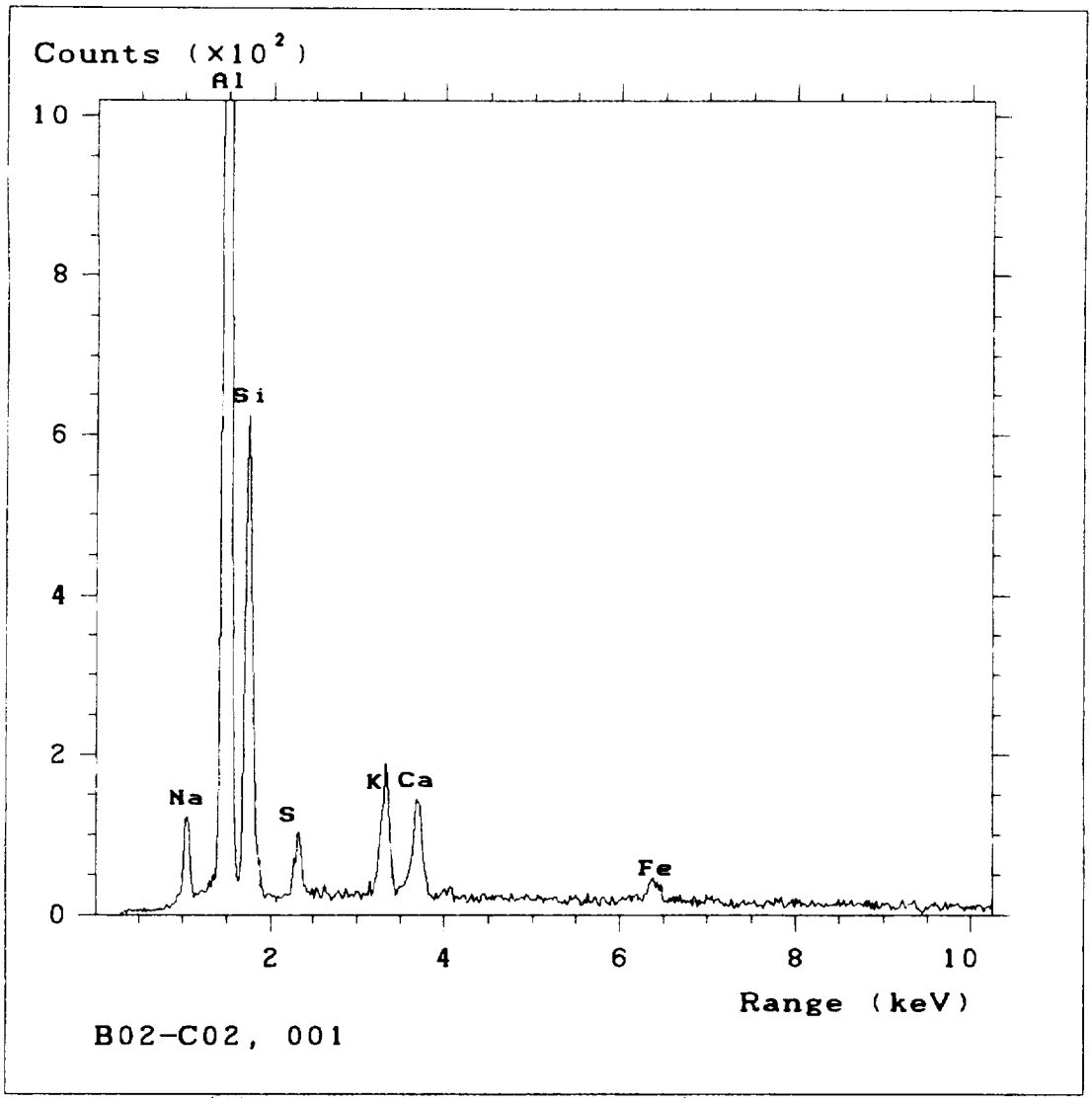

25kv 0.16kx 63.0μ 025

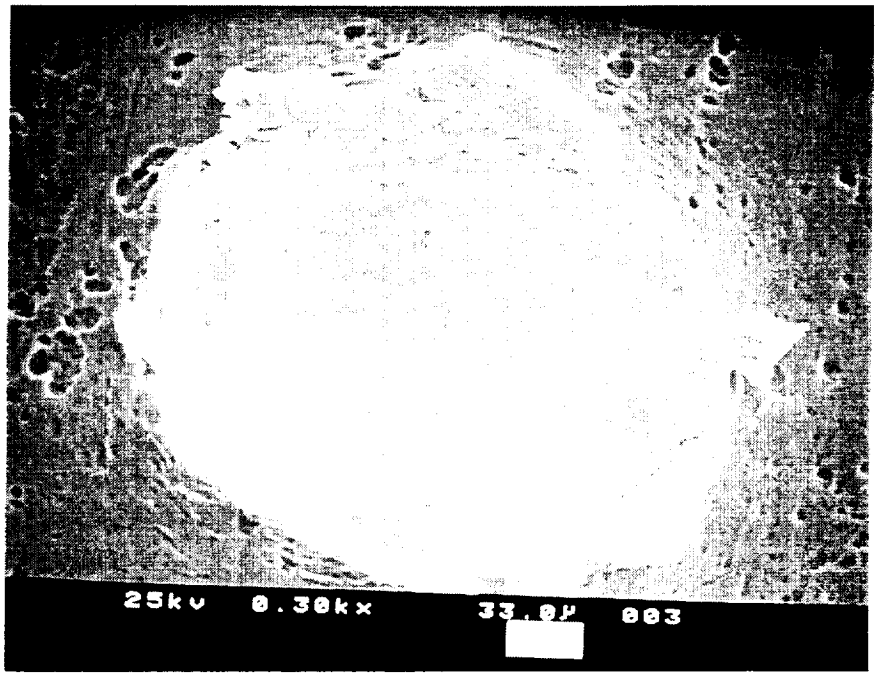
B02 - C01 mm

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B02-C02	001	65	28	270	MICROMETEORITIC



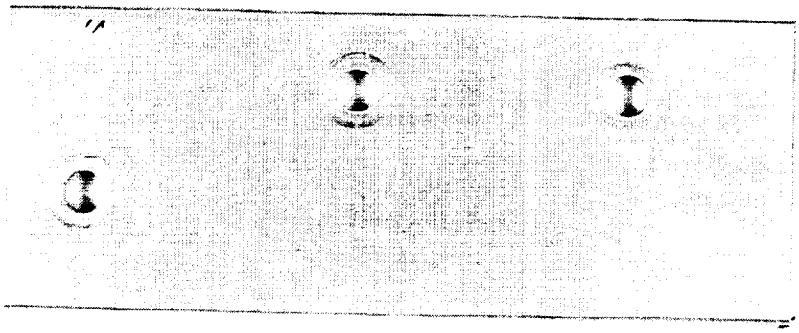
B02-C02





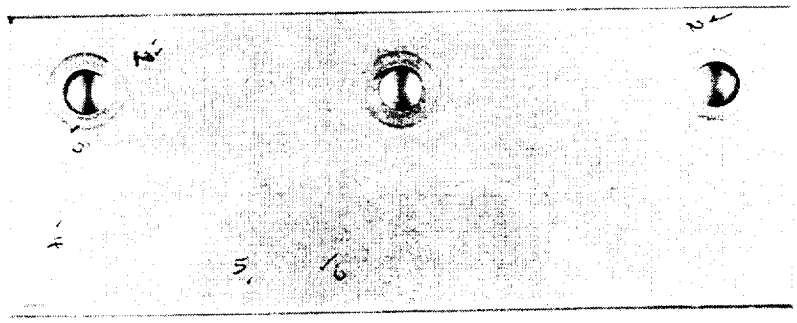
B02-C02 001 mm

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B02-CO5					NO IMPACTS FOUND

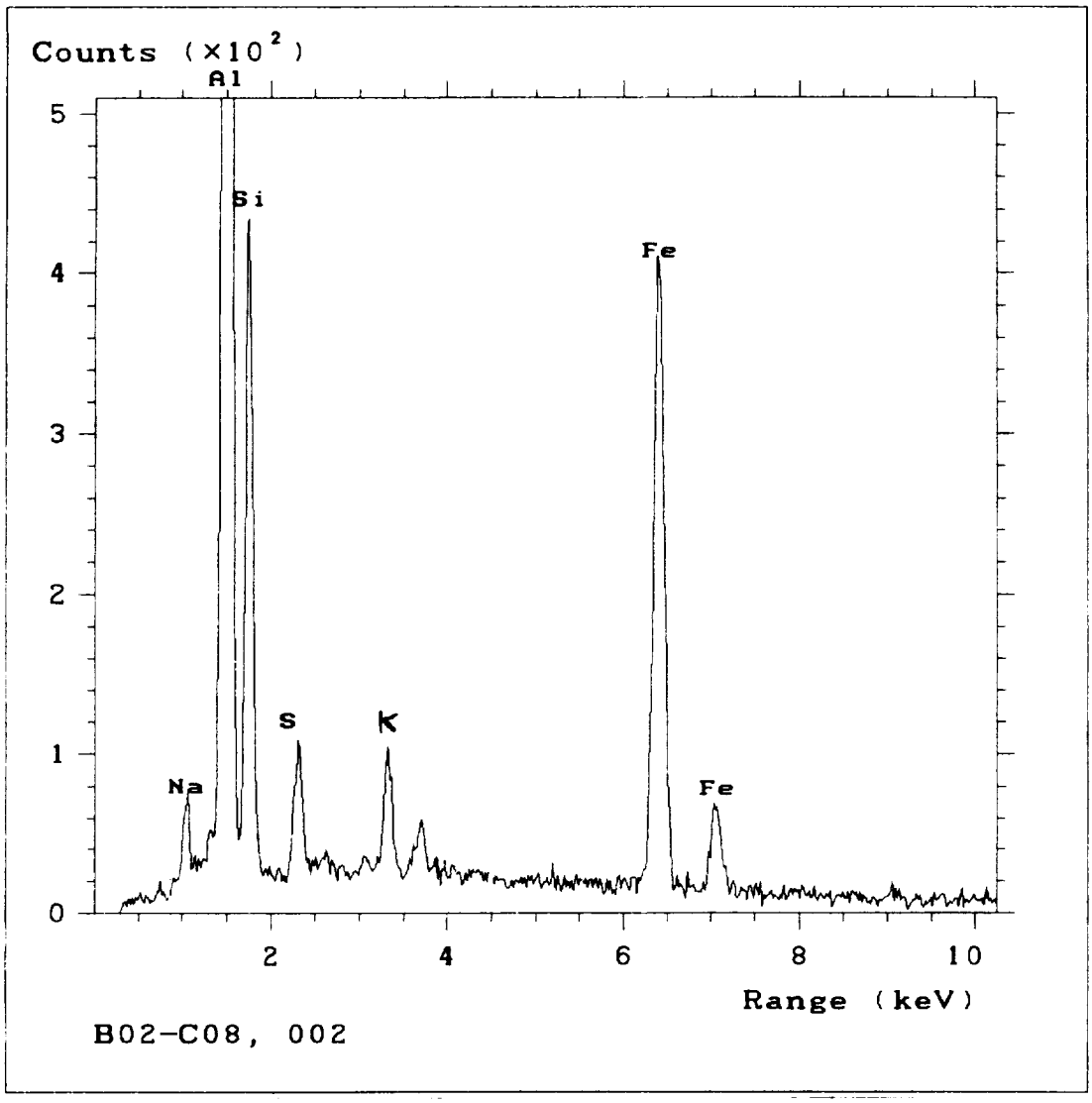


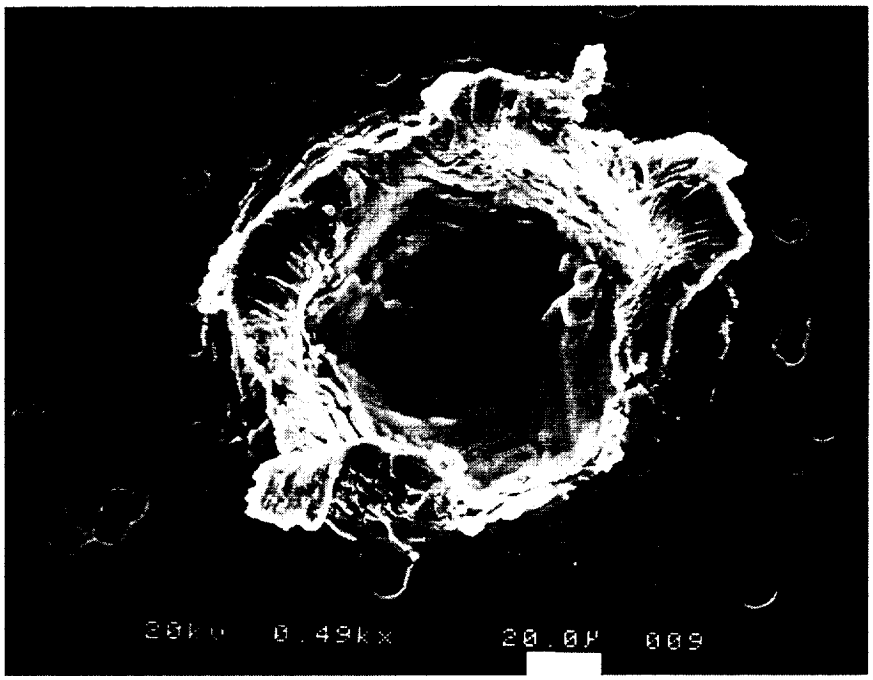
B02-CO5

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B02-CO8	001	5	22	50	NOT AN IMPACT
	002	2	111	150	MICROMETEORITIC
	003	19	8	230	UNKNOWN
	004	35	5	60	NOT AN IMPACT
	005	44	36	40	NOT AN IMPACT
	006	42	49	340	UNKNOWN

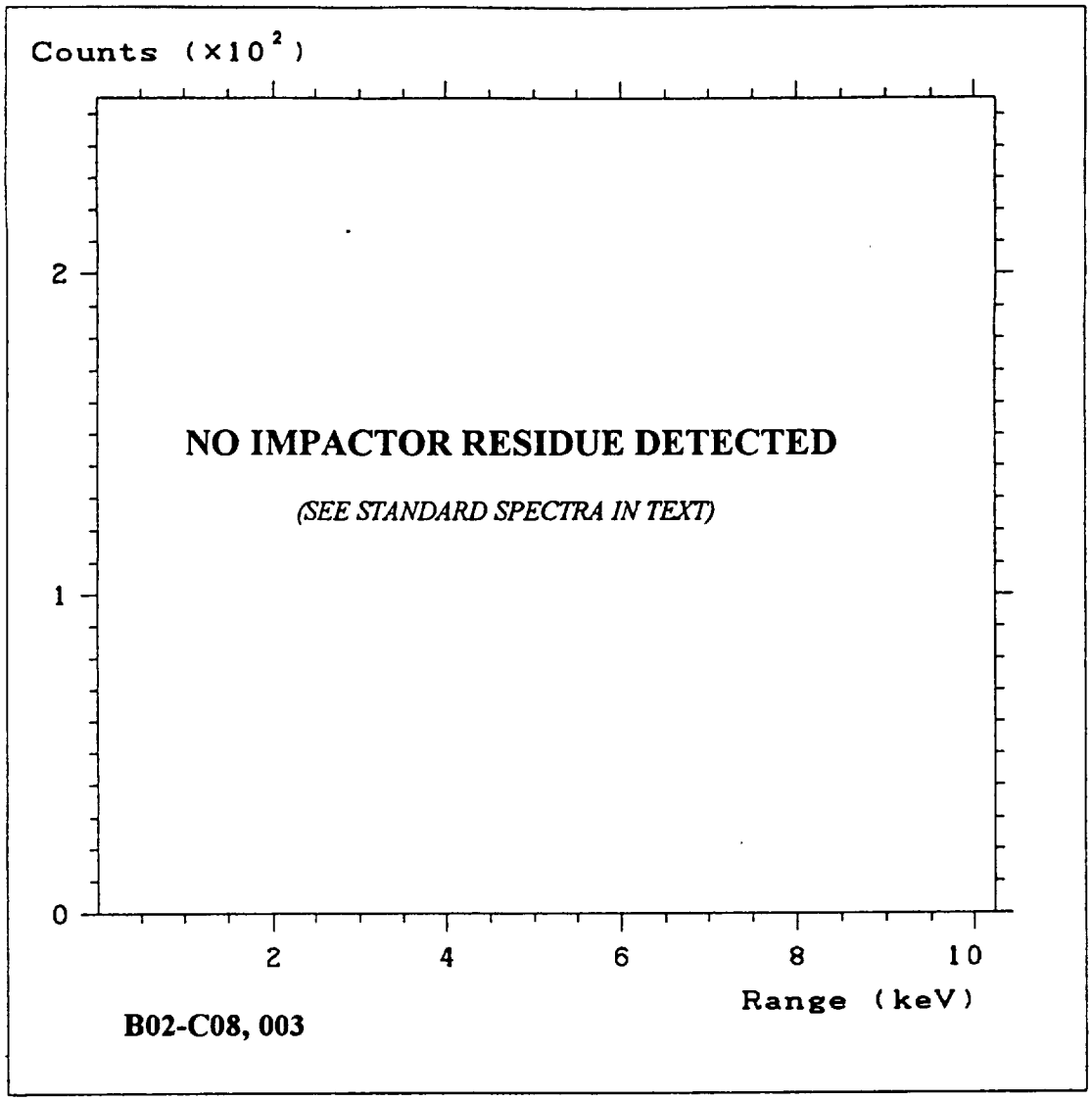


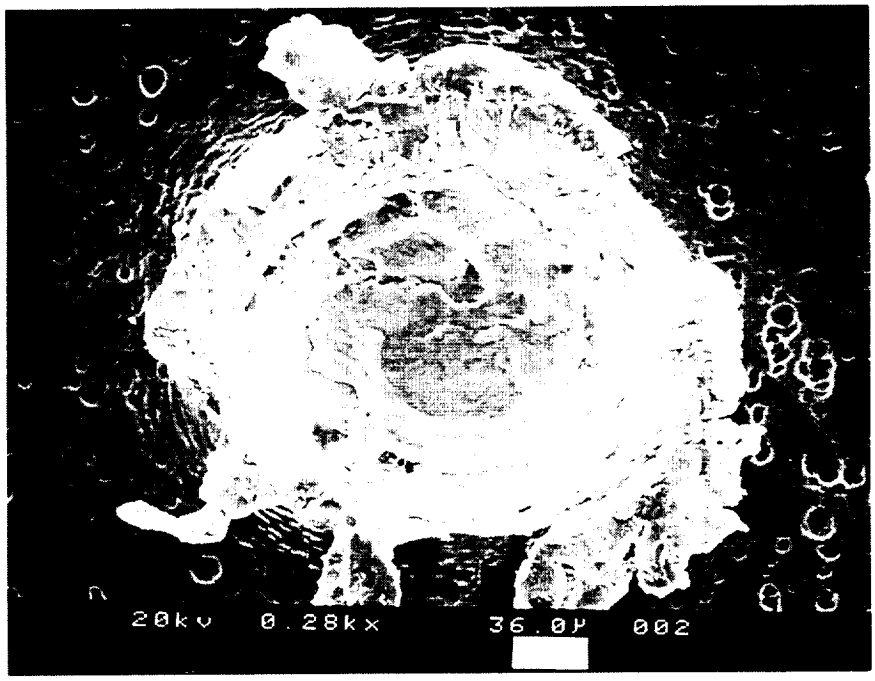
B02 - CO8 ~~003~~


Counts (×10²)
Al
Si
Fe
S
K
Na
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B02-C08, 002

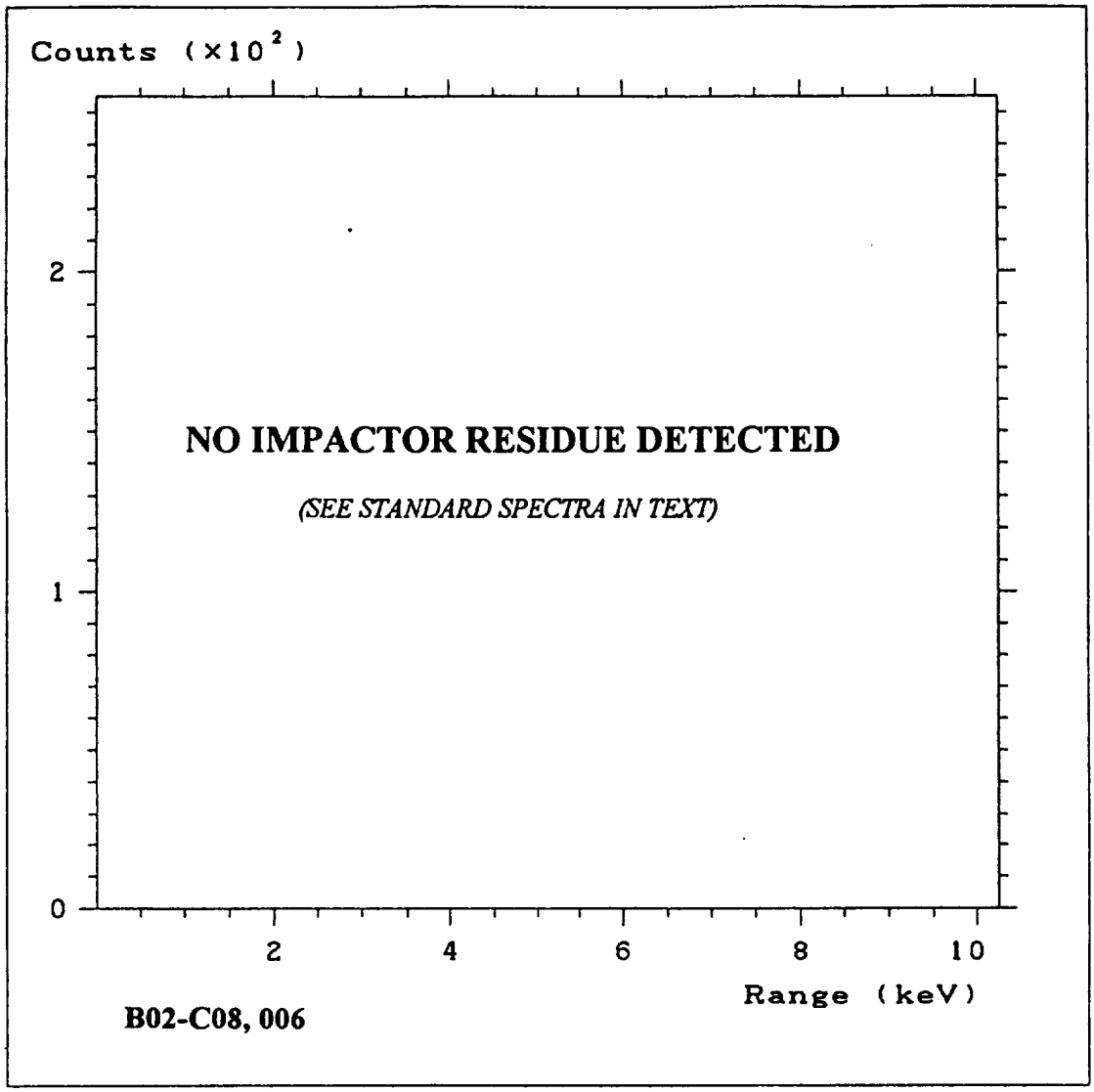

20kV 0.49kx 20.0µ 009

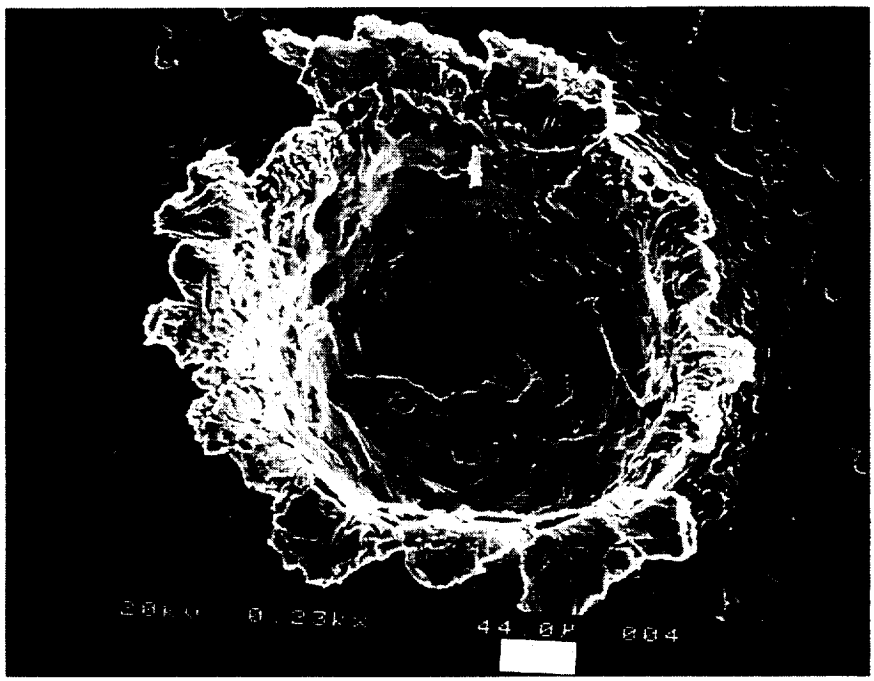
B02-C08 002


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B02-C08, 003


20kv 0.28kx 36.0μ 002

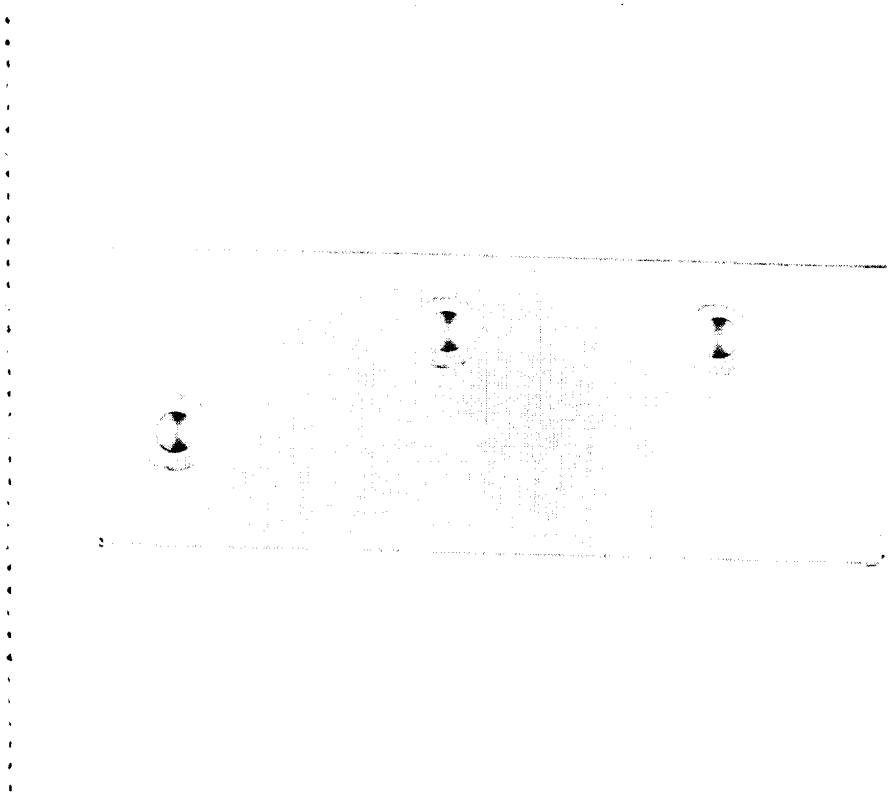
003


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B02-C08, 006

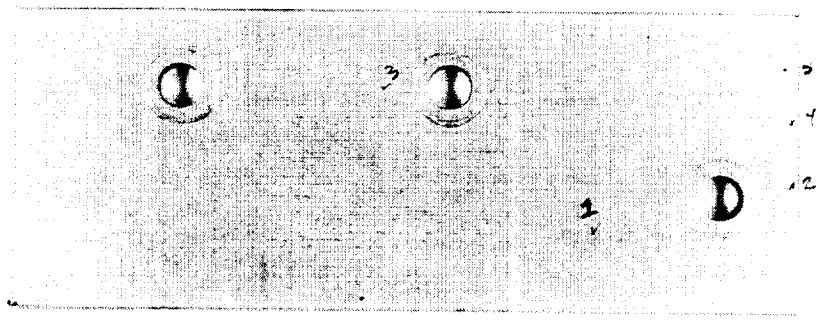

20kV 0.23kX 44.0µ 004

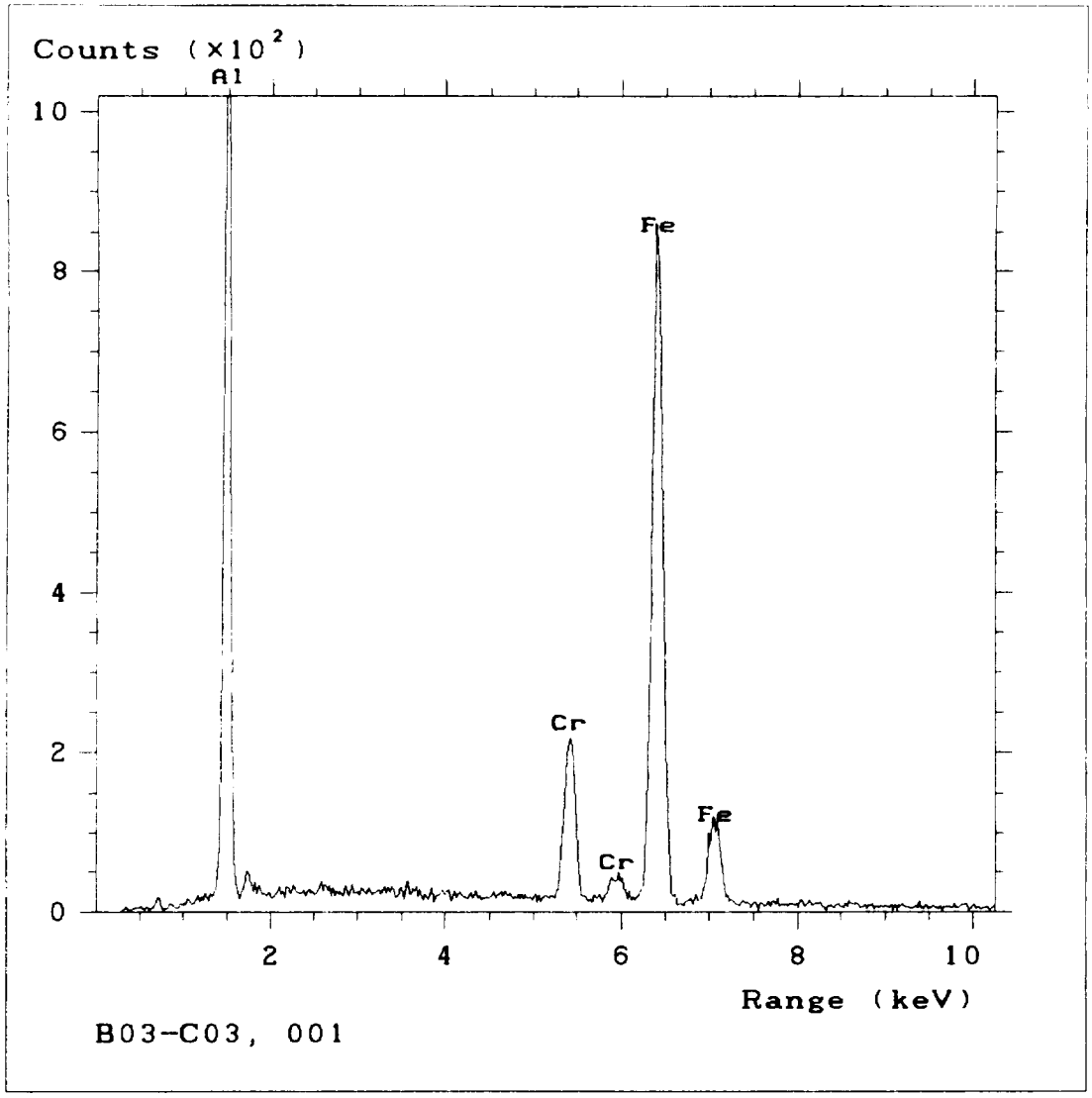
B02-C08 006

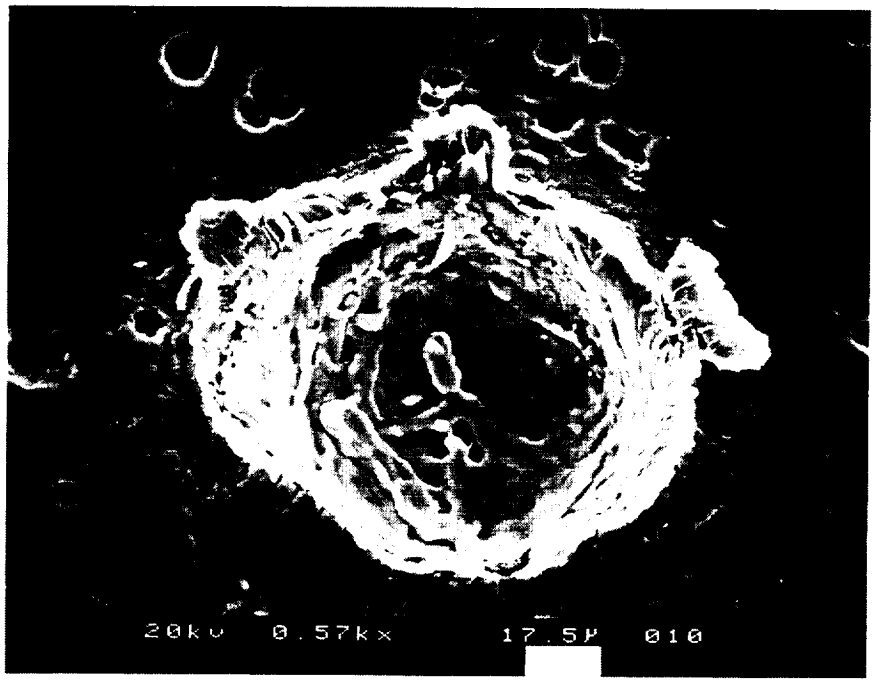
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B03-C01					NO IMPACTS FOUND



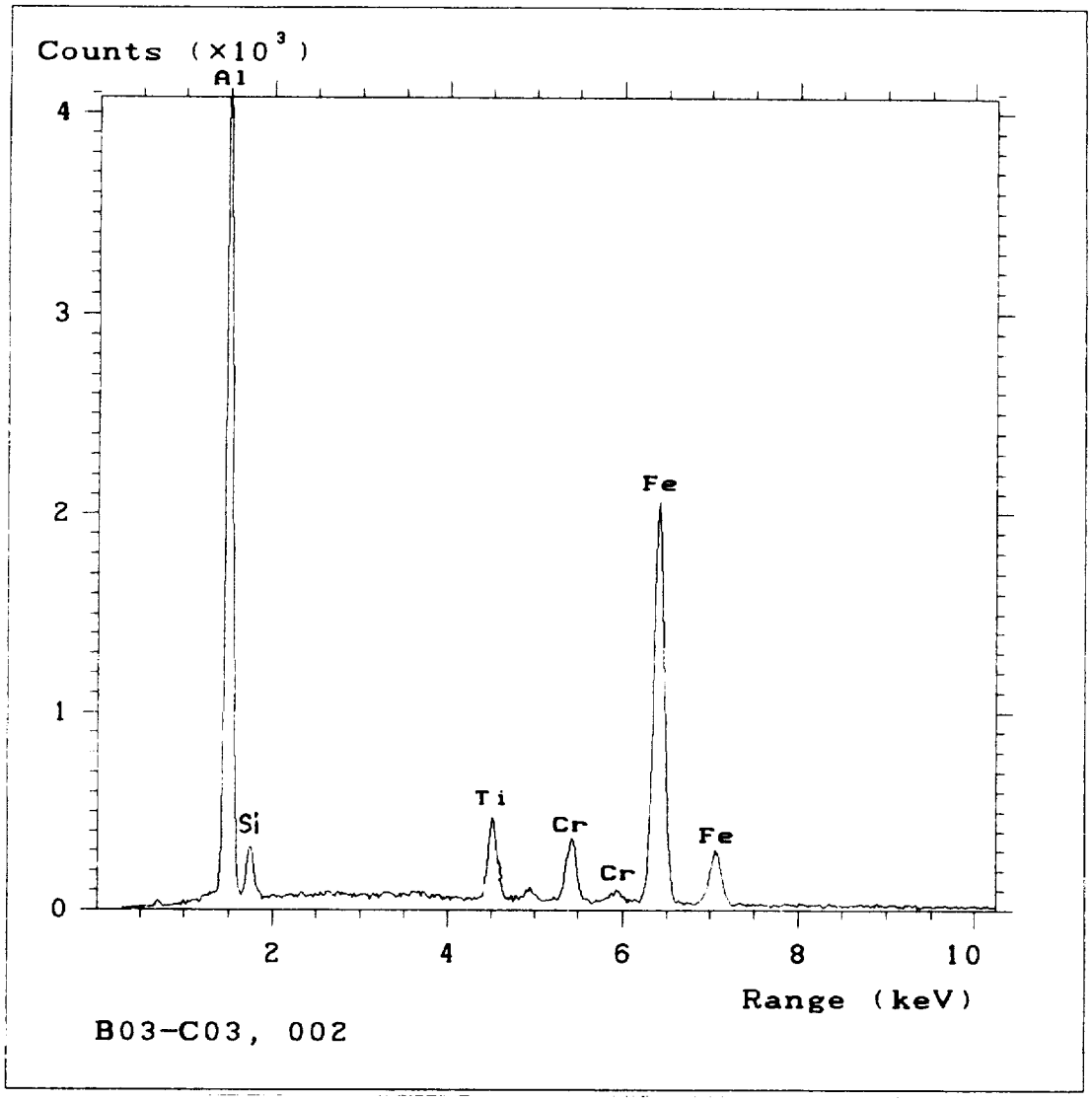
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B03-C03	001	92	11	130	STAINLESS STEEL
	002	126	20	225	STAINLESS STEEL
	003	58	33	40	NOT AN IMPACT
	004	123	37	60	NOT AN IMPACT
	005	125	46	50	NOT AN IMPACT

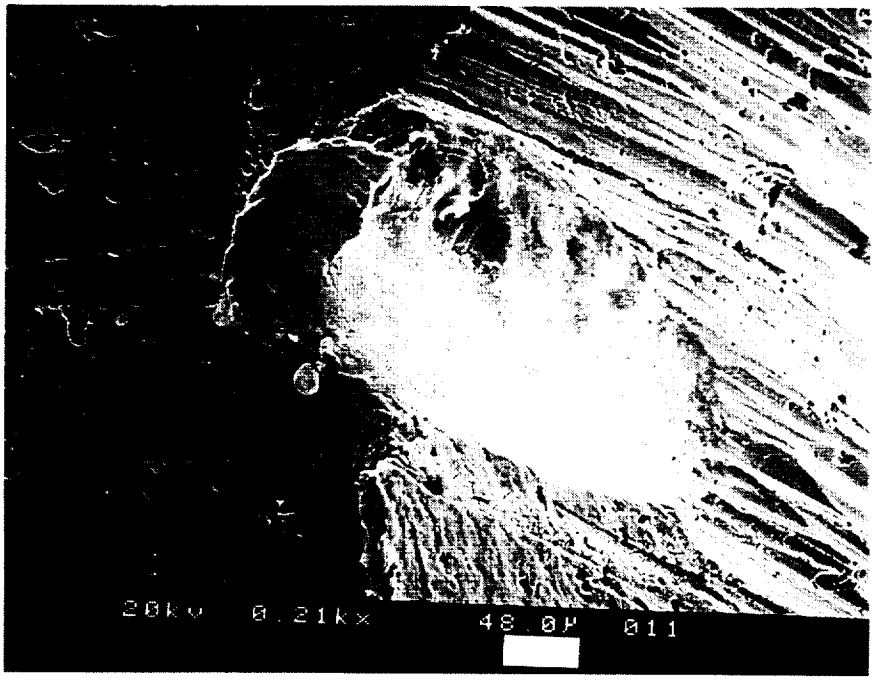






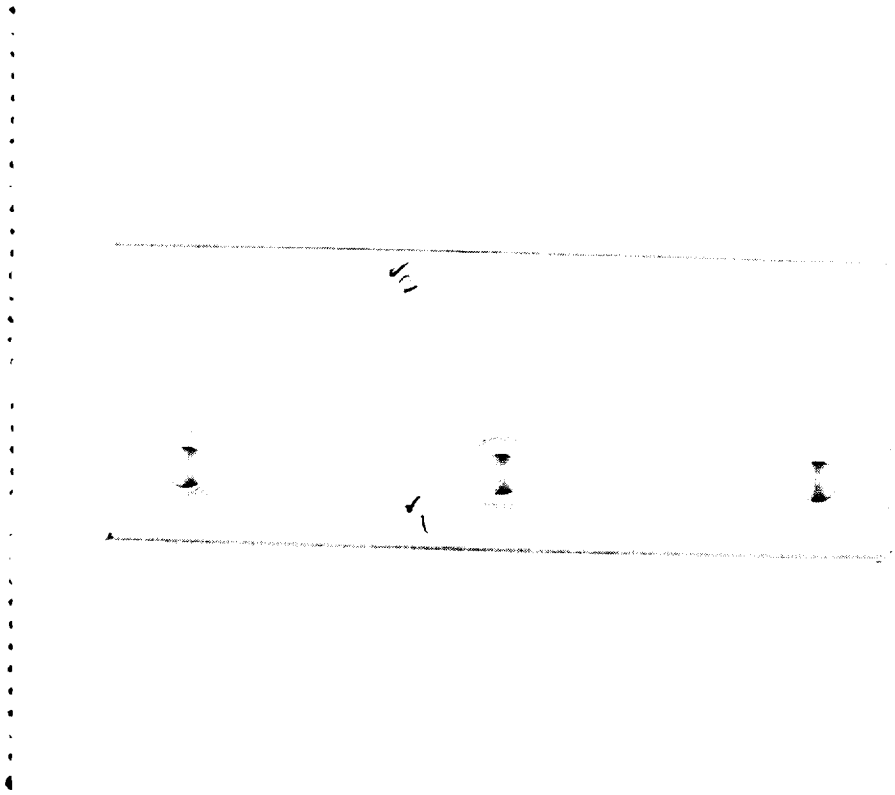
B03-C03 001 55



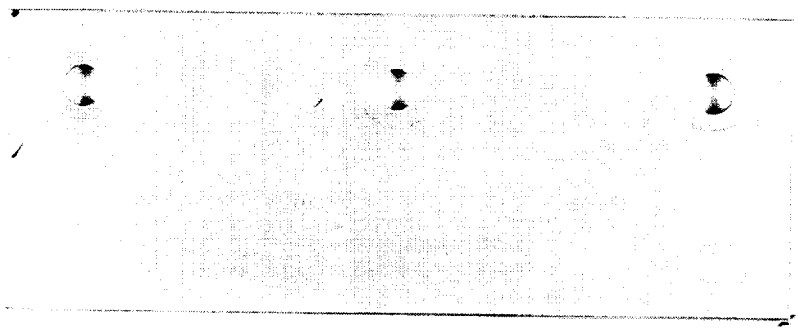


B03.C03 002 Ti, Cr

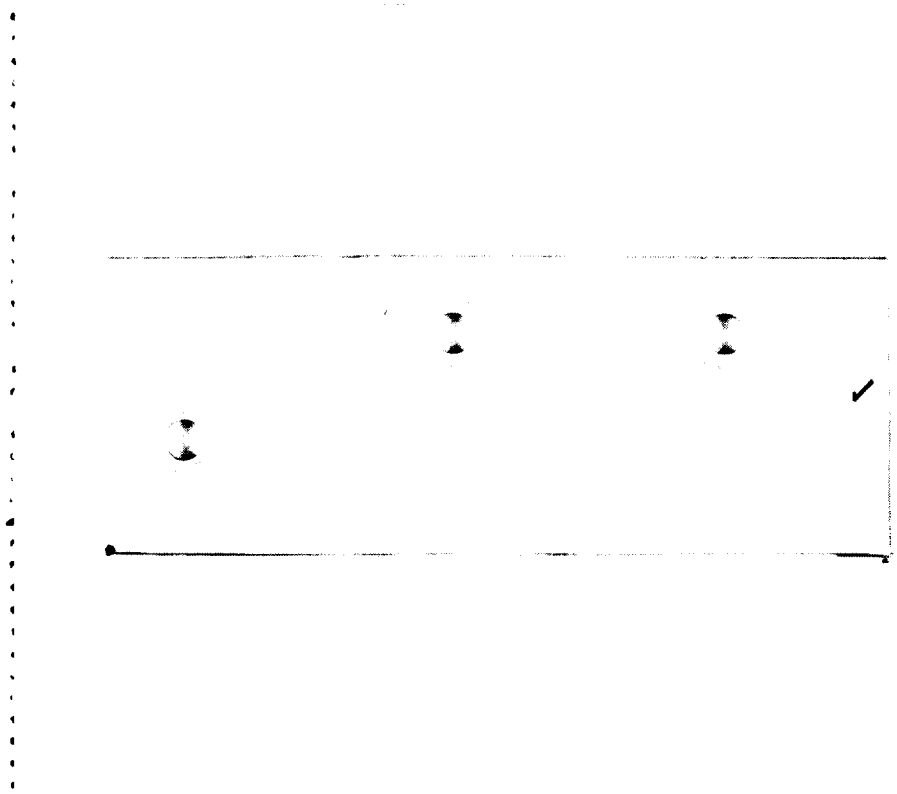
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B03-C06	001	47	4	70	NOT AN IMPACT
	002	44	43	50	NOT AN IMPACT



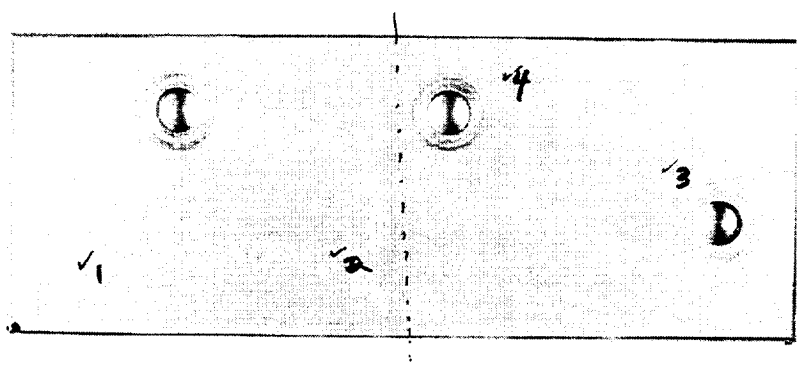
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B03-C08					NO IMPACTS FOUND

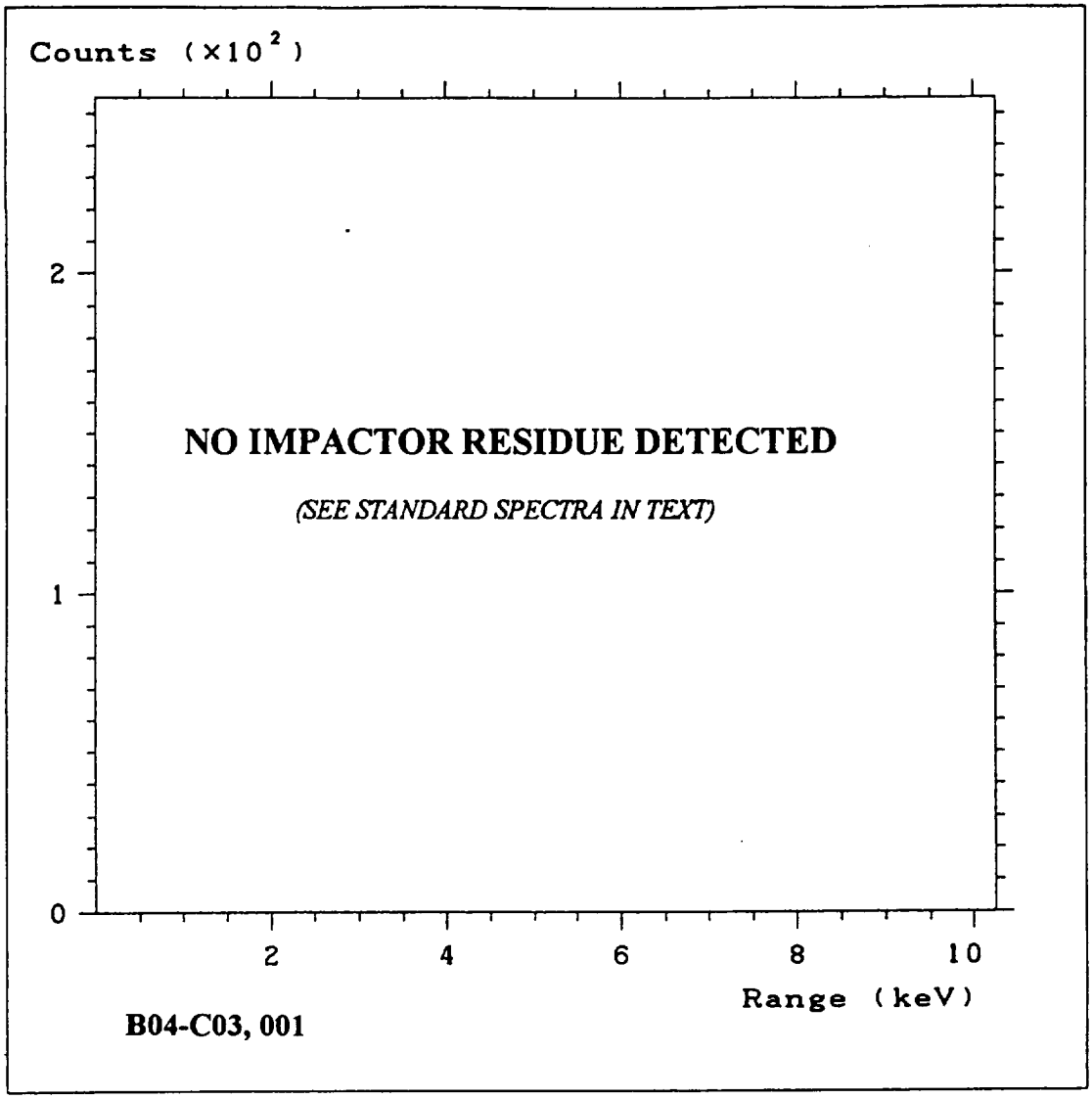


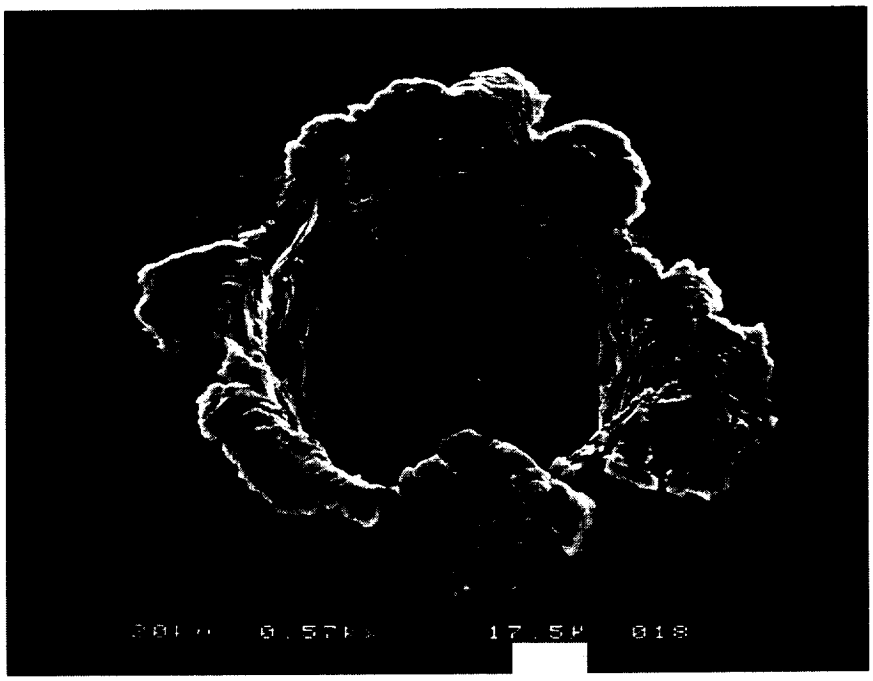
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B04-C01	001	136	21	50	NOT AN IMPACT



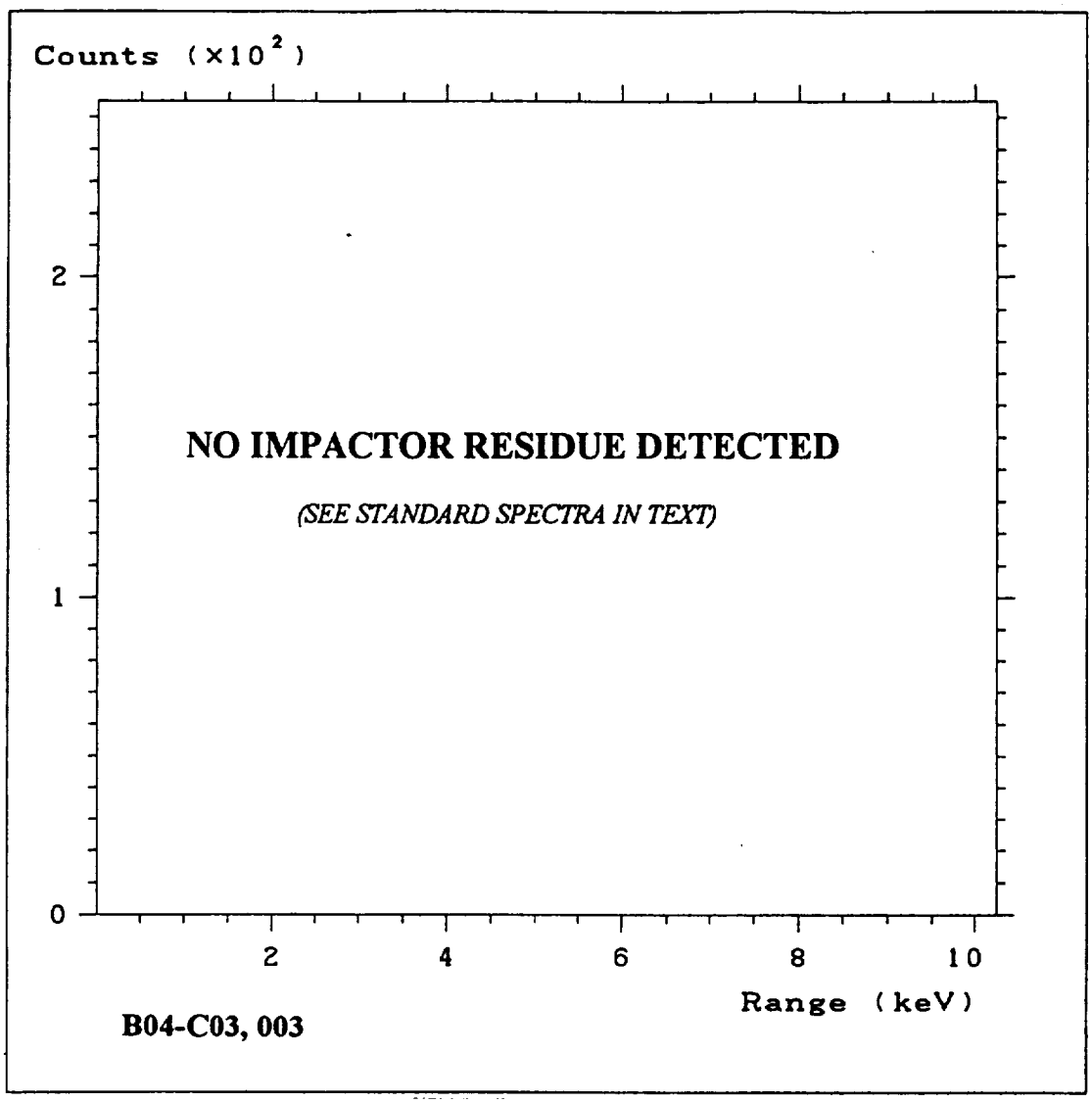
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B04-C03	001	10	9	100	UNKNOWN
	002	50	14	50	NOT AN IMPACT
	003	104	25	120	UNKNOWN
	004	80	40	120	MICROMETEORITIC

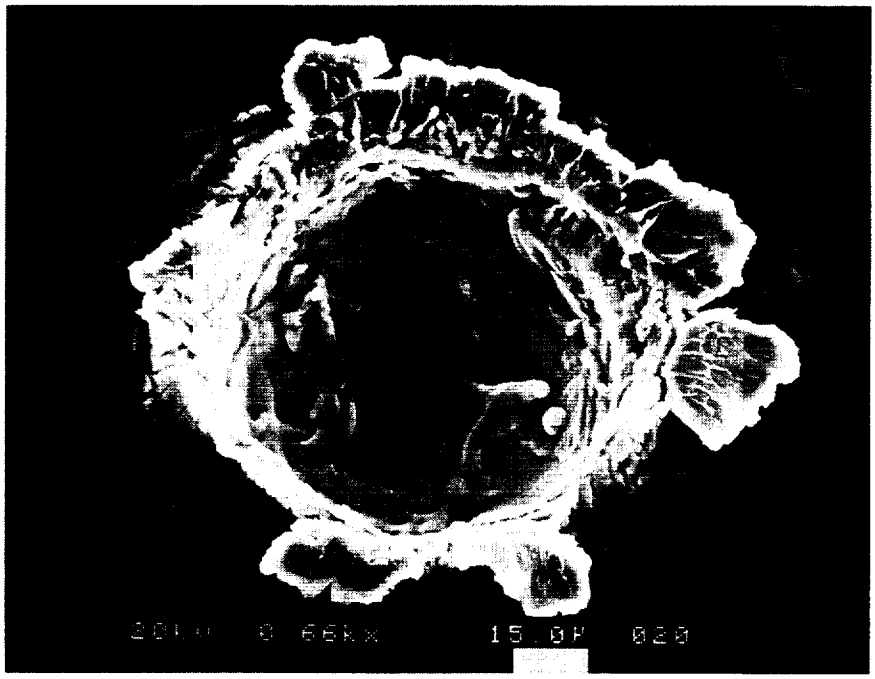



Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B04-C03, 001

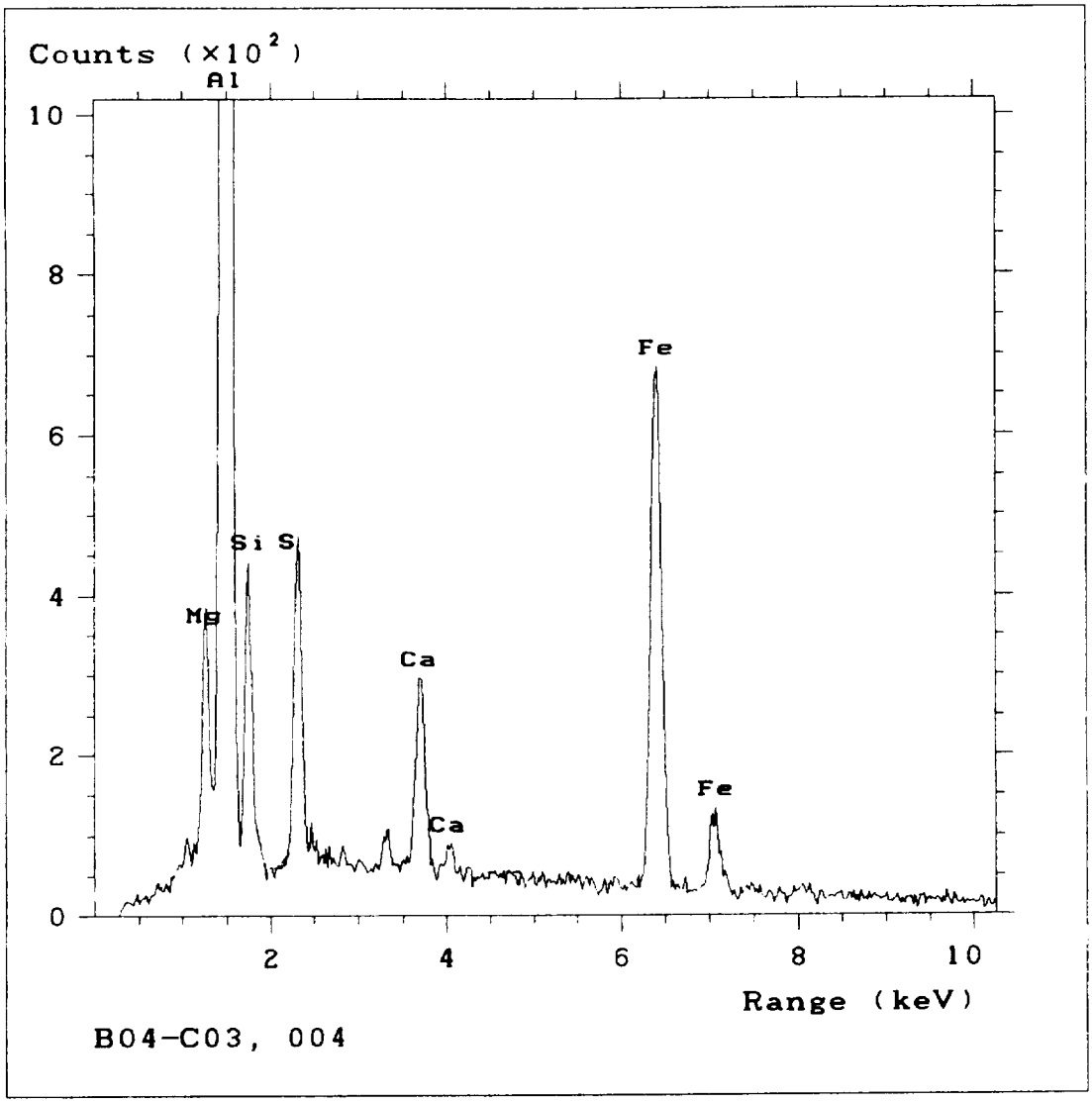


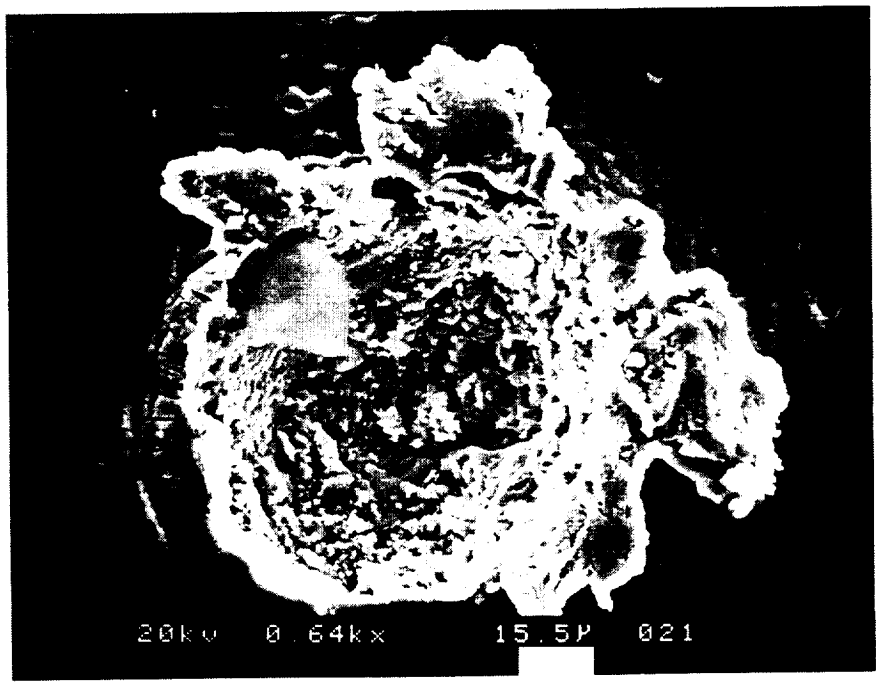
B04-C03 001


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B04-C03, 003


20kV 0.66kX 15.0P 020

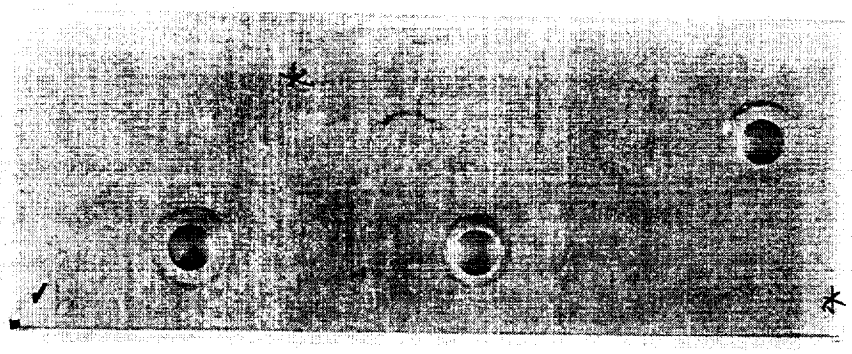
B04-C03 D03


Counts (×10²)
Al
Mg
Si
S
Ca
Ca
Fe
Fe
Range (keV)
B04-C03, 004

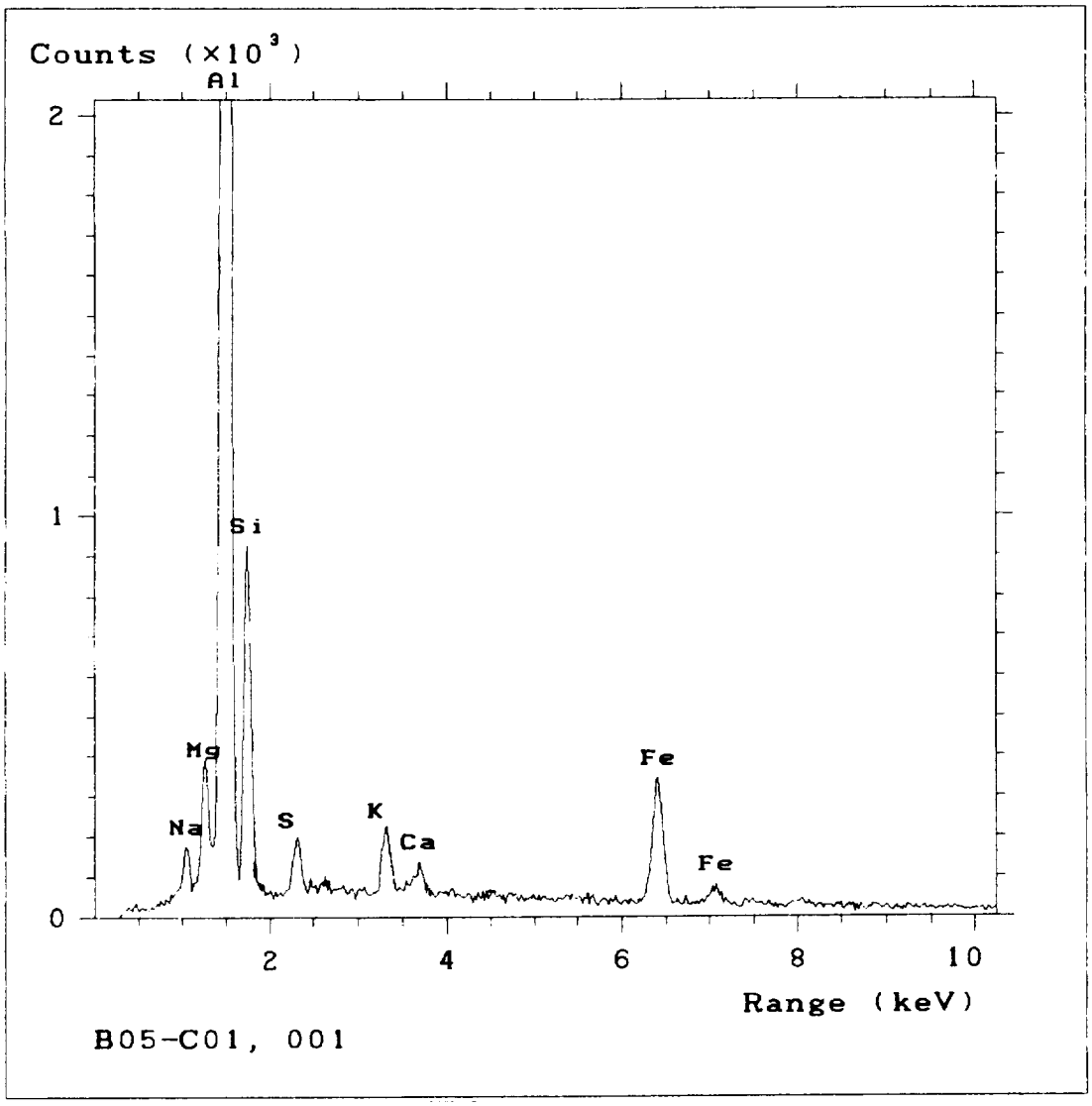

20kv 0.64kx 15.5P 021

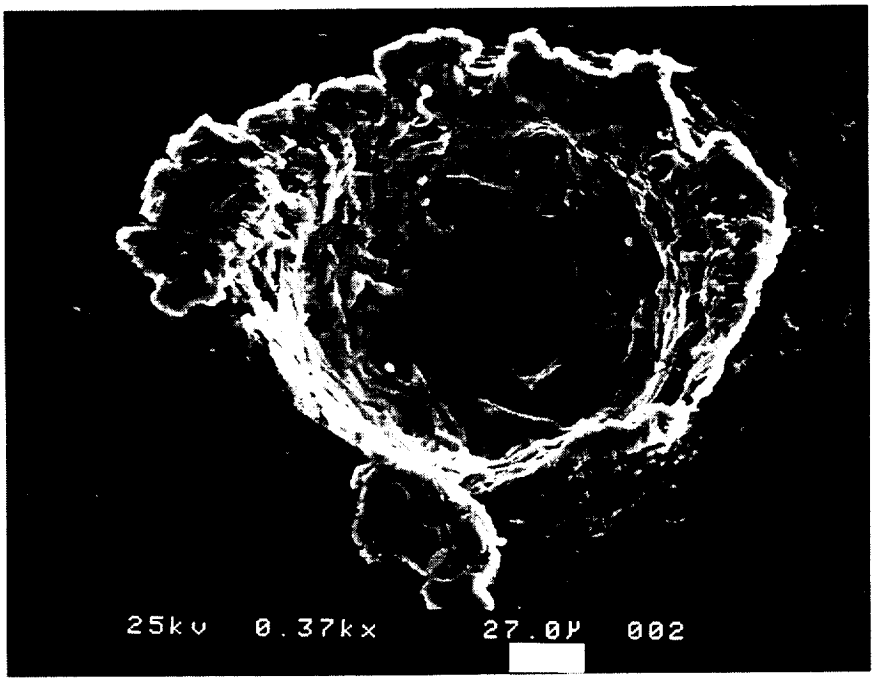
B04 - C03 004

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B05-C01	001	3	2	200	MICROMETEORITIC



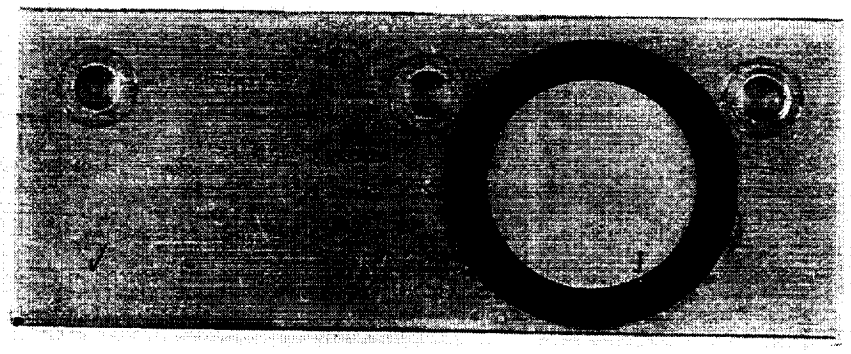
B05 - C01


Counts (×10³)
Al
Si
Mg
Na
S
K
Ca
Fe
Fe
2
1
0
2
4
6
8
10
Range (keV)
B05-C01, 001

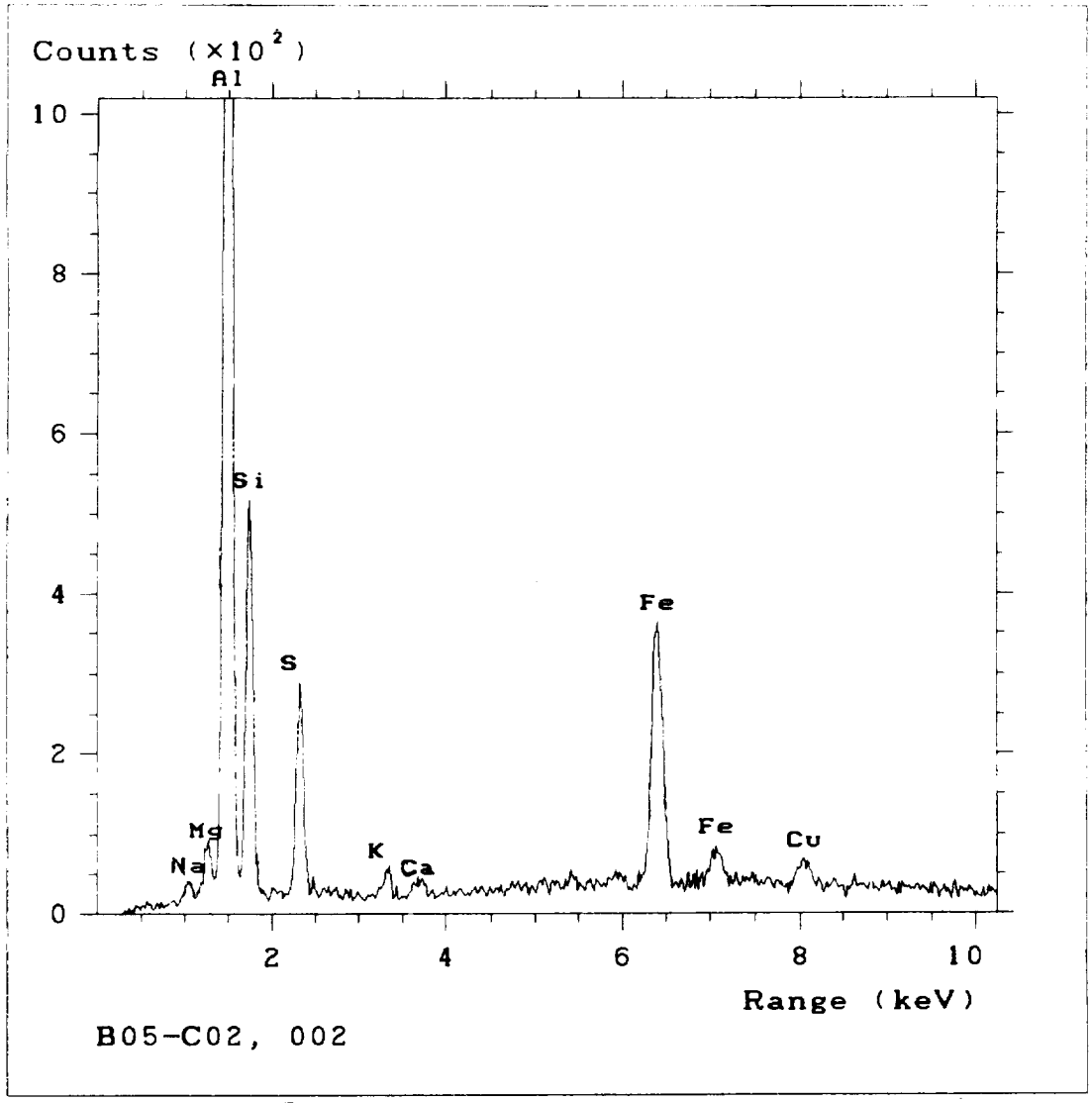

25kv 0.37kx 27.0µ 002

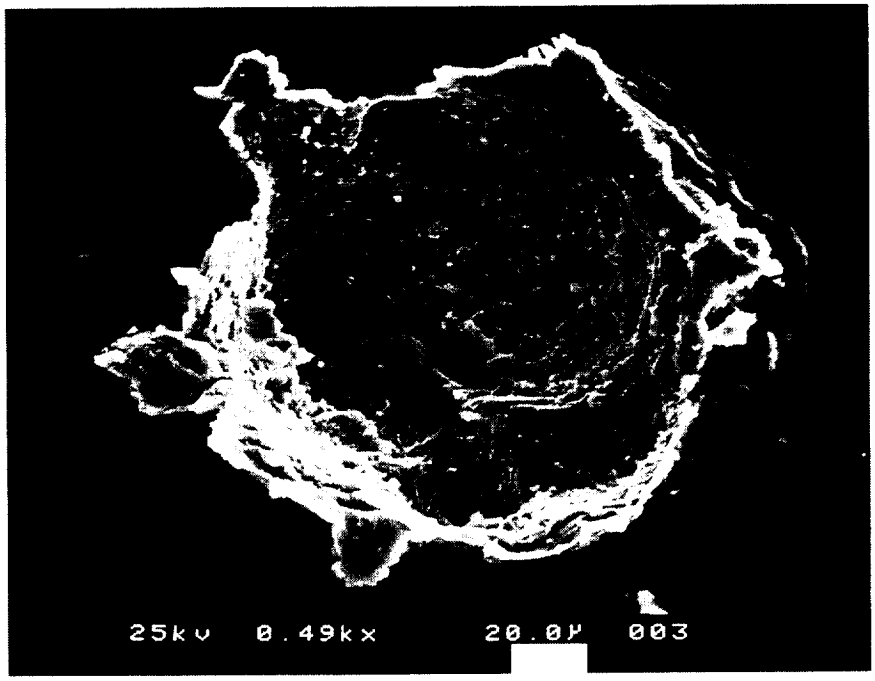
B05-C01 001

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B05-C02	001	6	94	150	PAINT PATCH
	002	10	7	16	MICROMETEORITIC



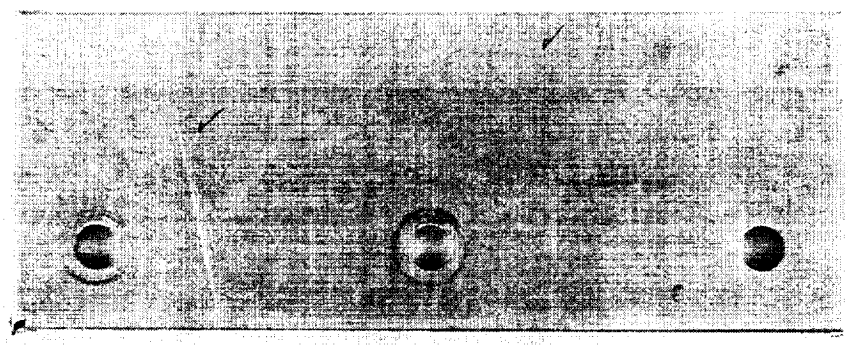
B05-C02



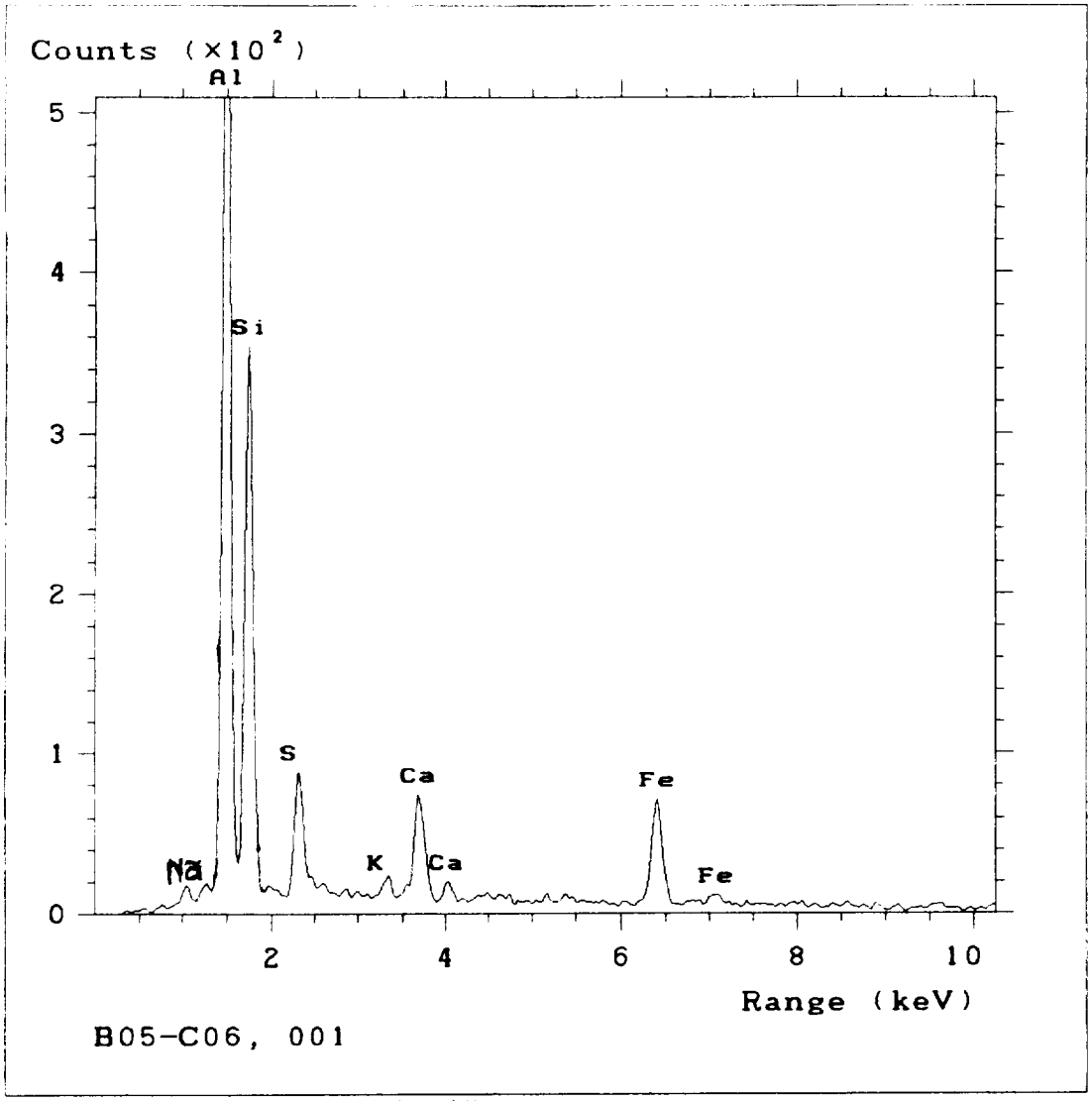


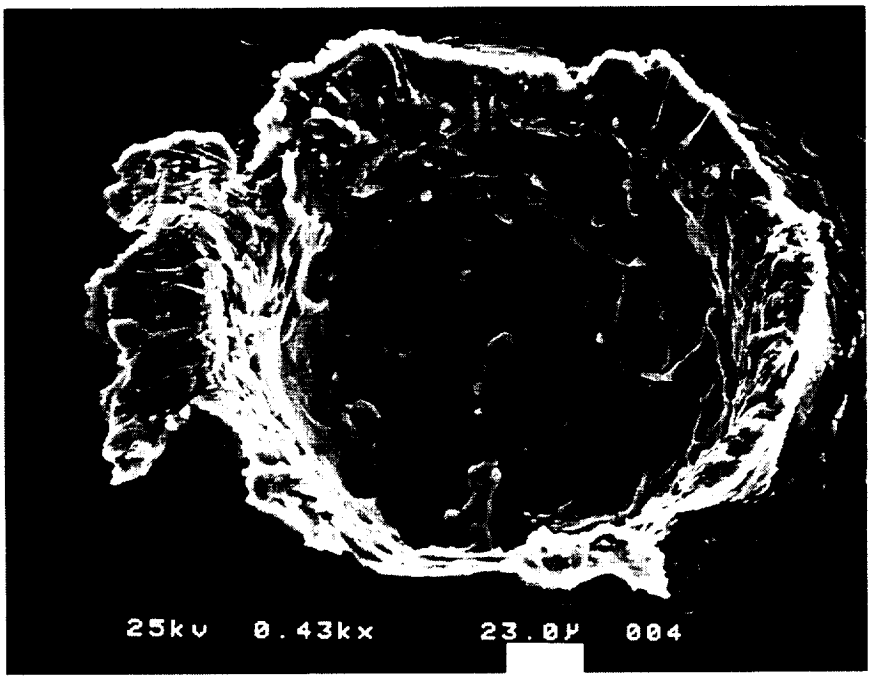
B05-C02 002 mm

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B05-C06	001	28	28	200	MICROMETEORITIC
	002	81	42	130	STAINLESS STEEL

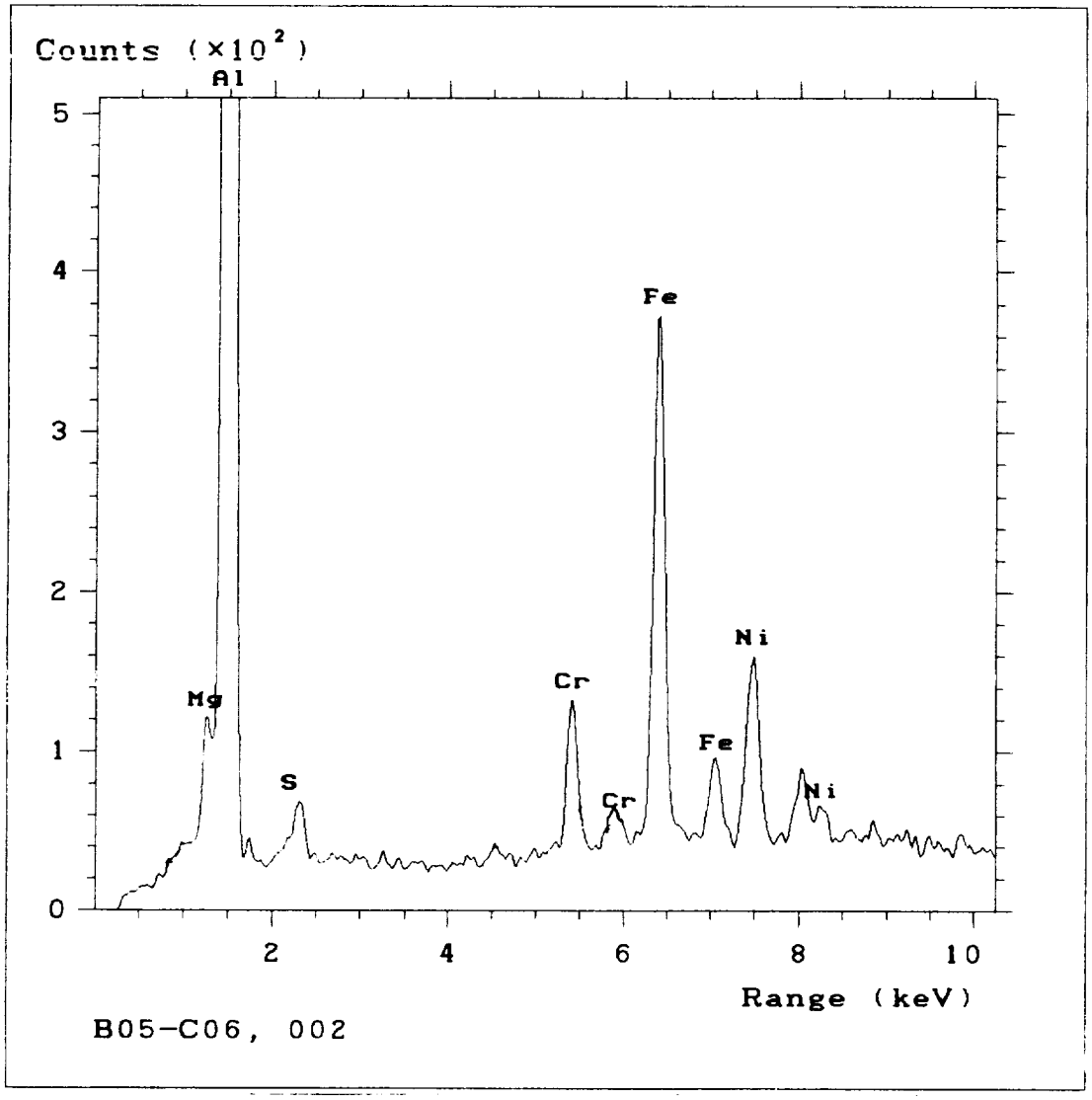


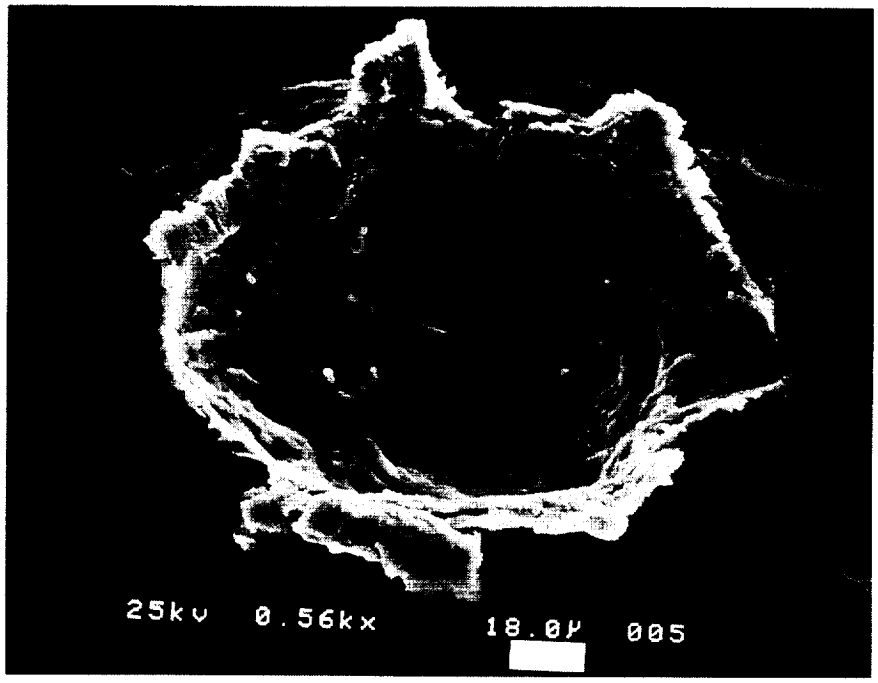
B05-C06


Counts (×10²)
Al
Si
S
Ca
Fe
Na
K
Ca
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B05-C06, 001


25kv 0.43kx 23.0μ 004

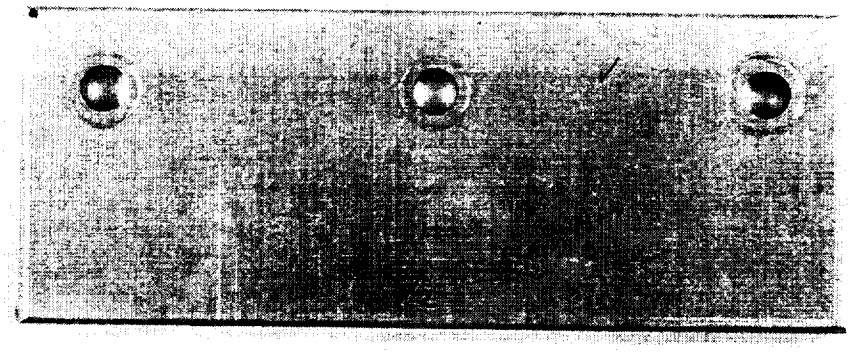
B05 C06 001



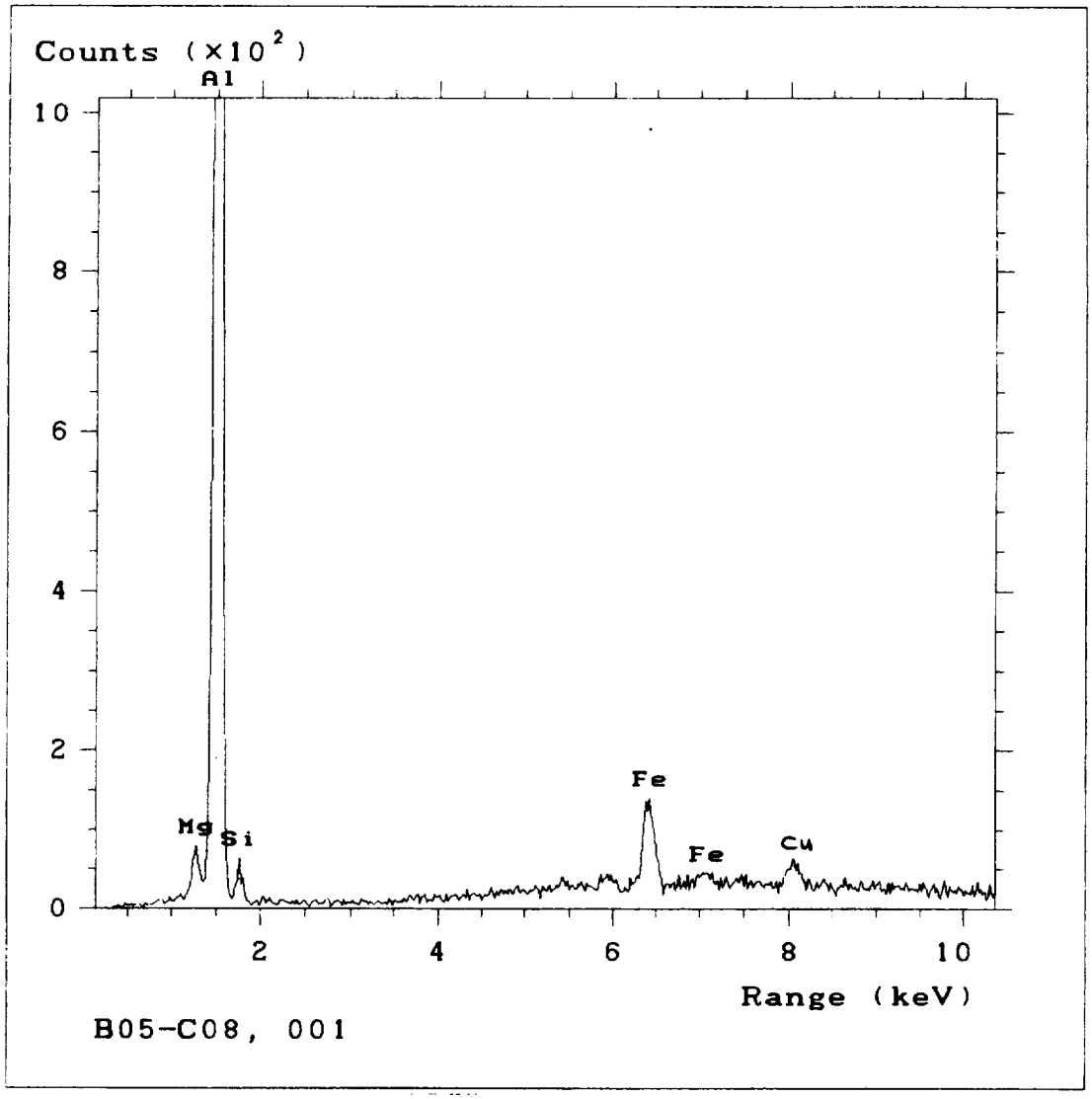


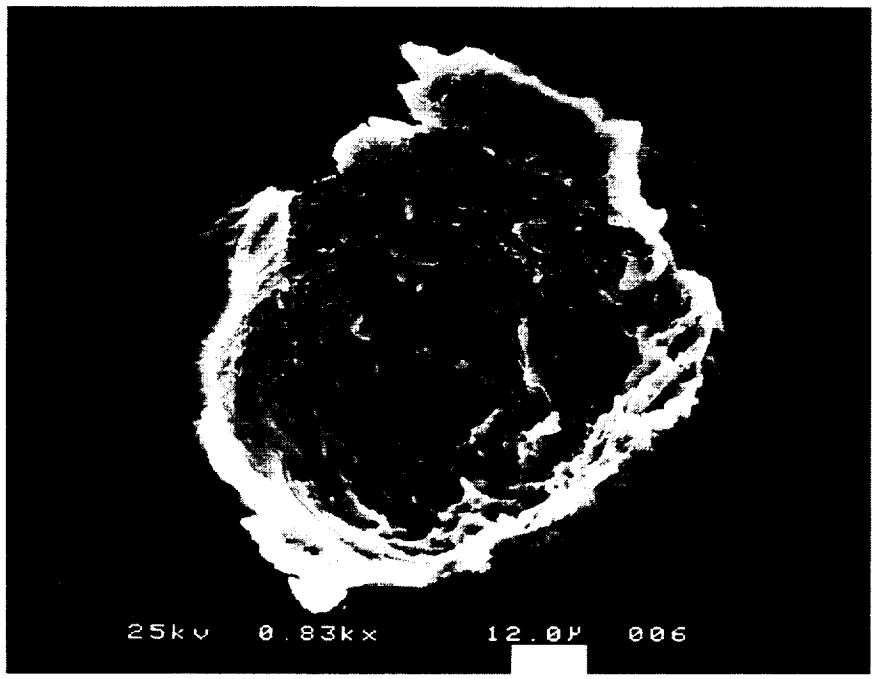
B05-C06 002 55

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B05-C08	001	10	86	80	MICROMETEORITIC
	002	44	57	140	MICROMETEORITIC

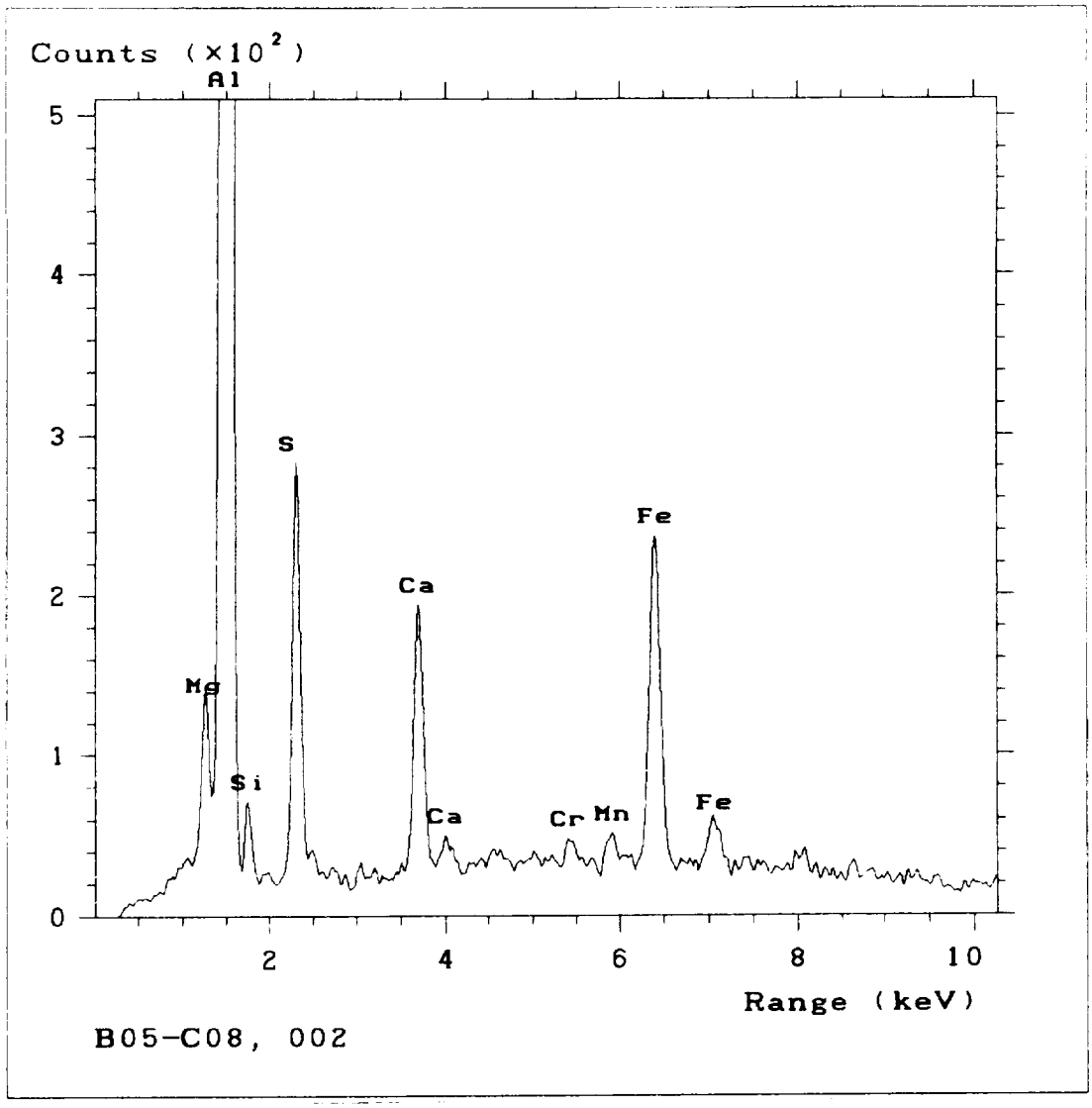


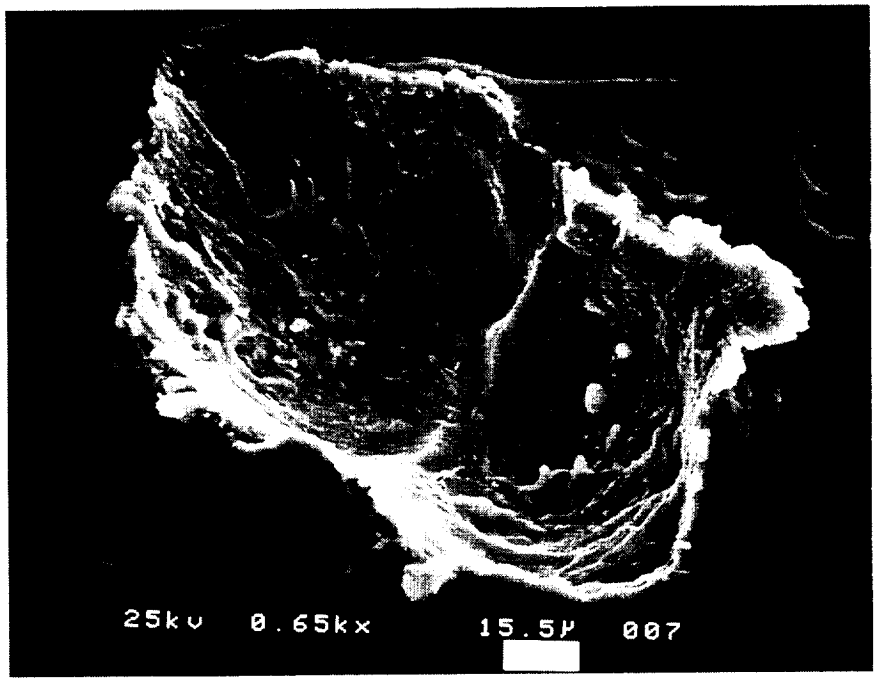
B05 - C08


Counts (×10²)
Al
Mg
Si
Fe
Fe
Cu
Range (keV)
B05-C08, 001


25kv 0.83kx 12.0µ 006

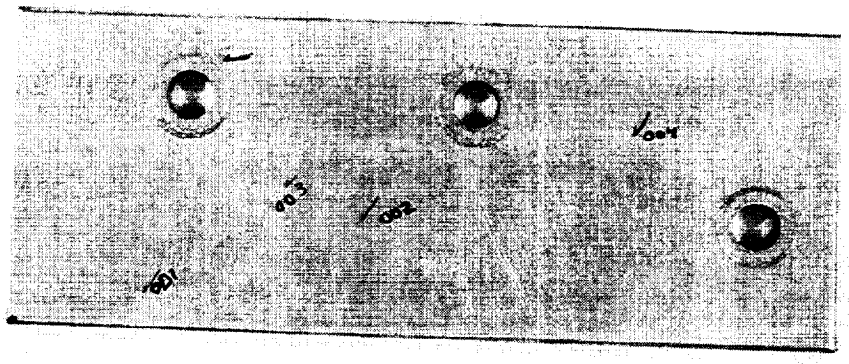
B05-C08 001


Counts (×10²)
Al
S
Fe
Ca
Mg
Si
Ca
Cr
Mn
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B05-C08, 002

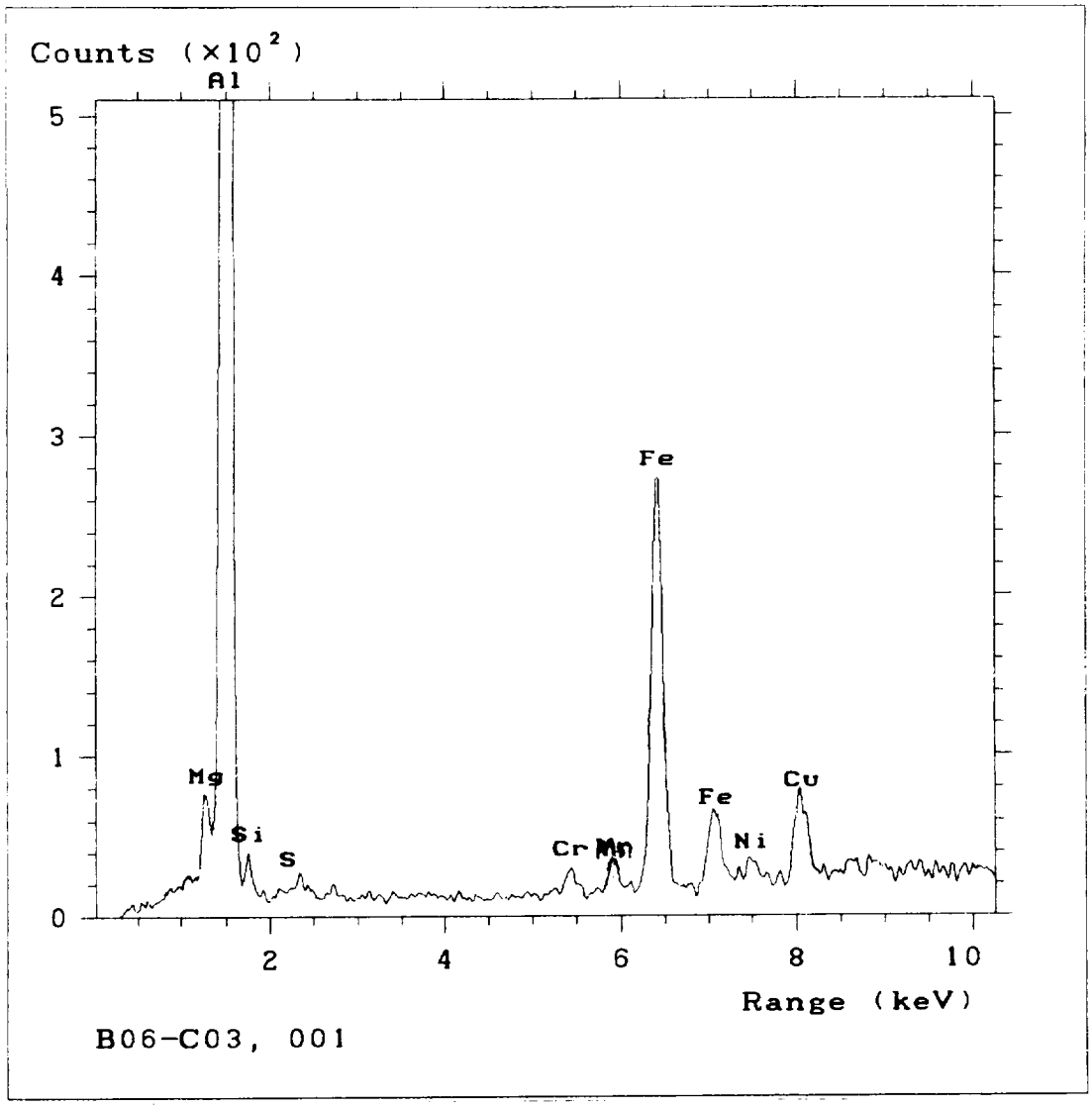

25kv 0.65kx 15.5μ 007

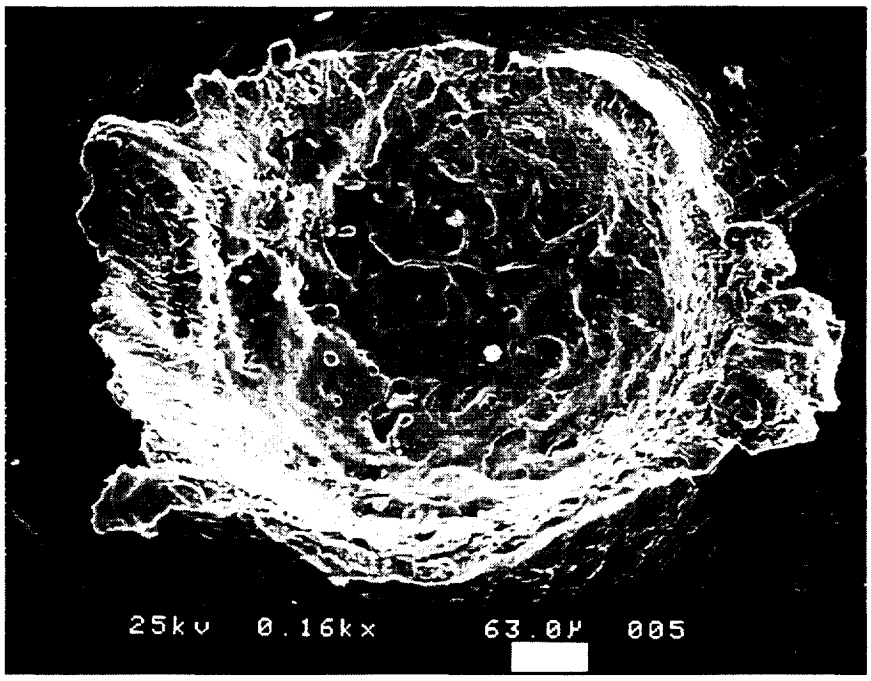
B05 - C08 002

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B06-C03	001	19	3	600	MICROMETEORITIC
	002	53	15	60	STAINLESS STEEL
	003	41	20	120	MICROMETEORITIC
	004	94	30	100	NOT AN IMPACT
	005	31	40	70	NOT AN IMPACT

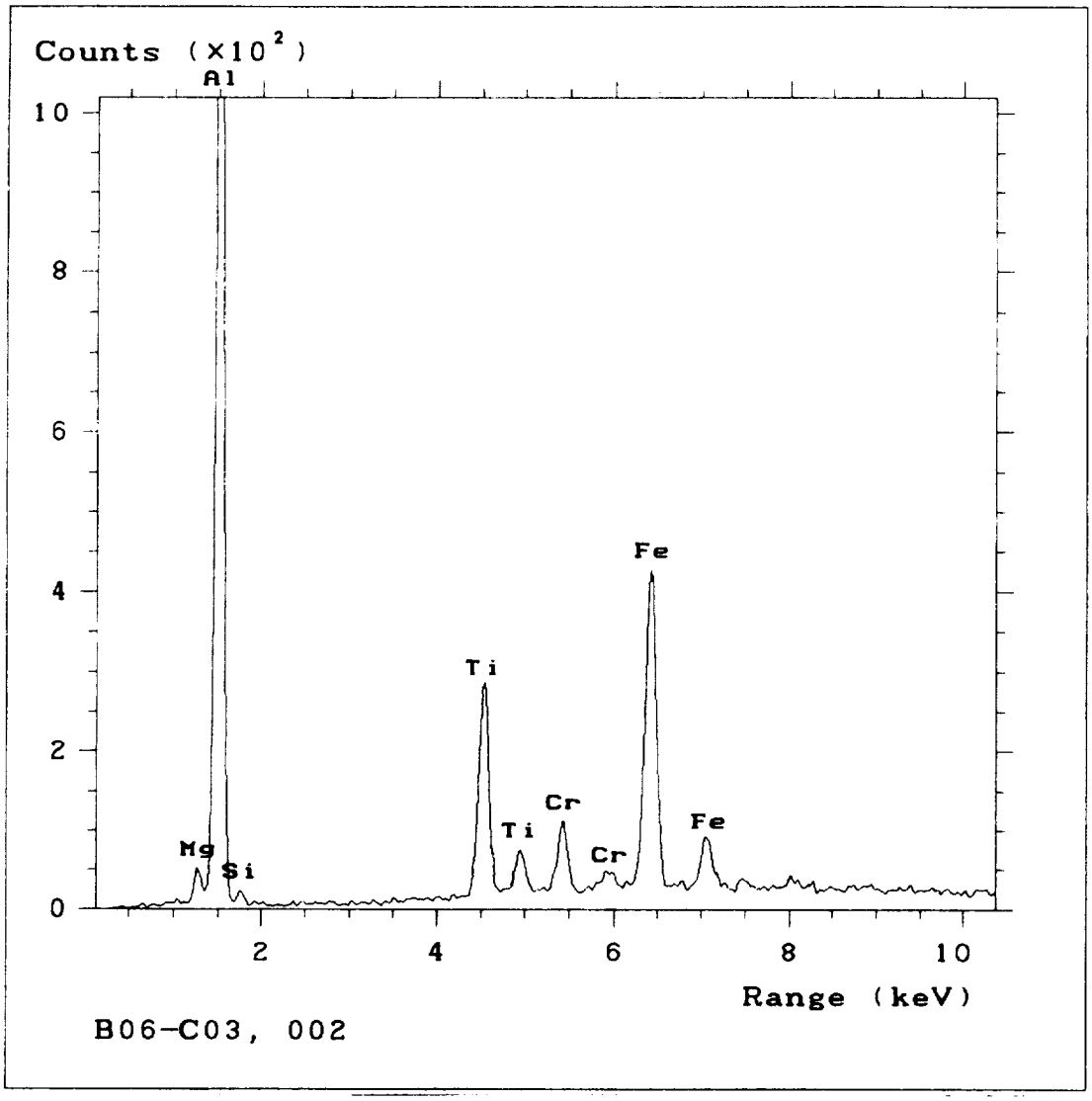


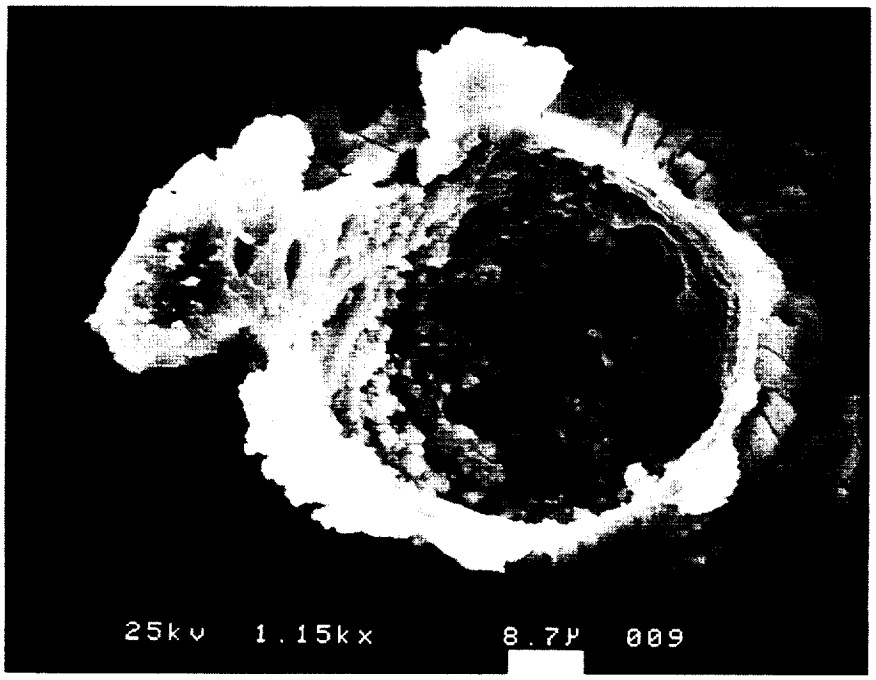
B06 C03



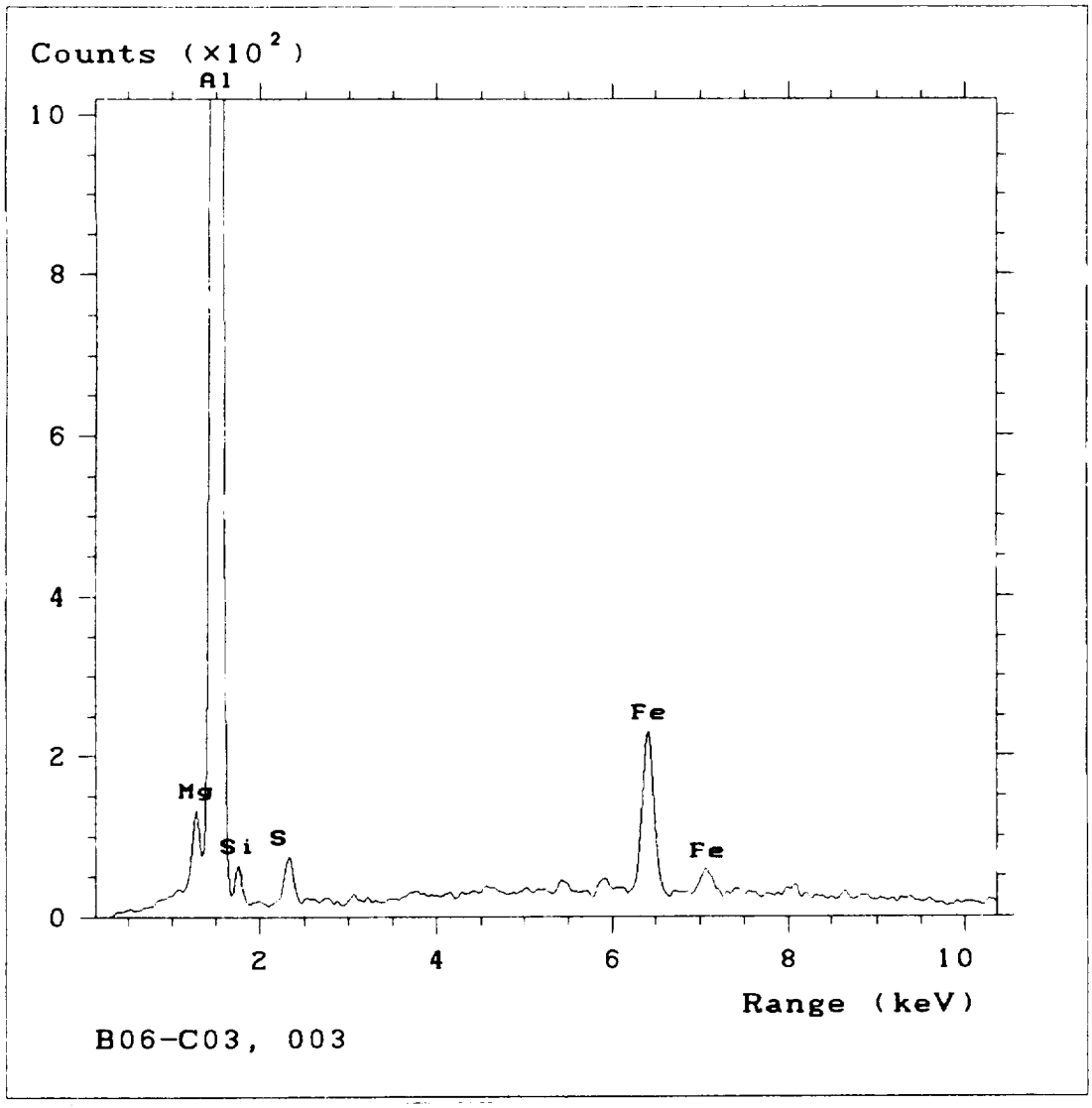


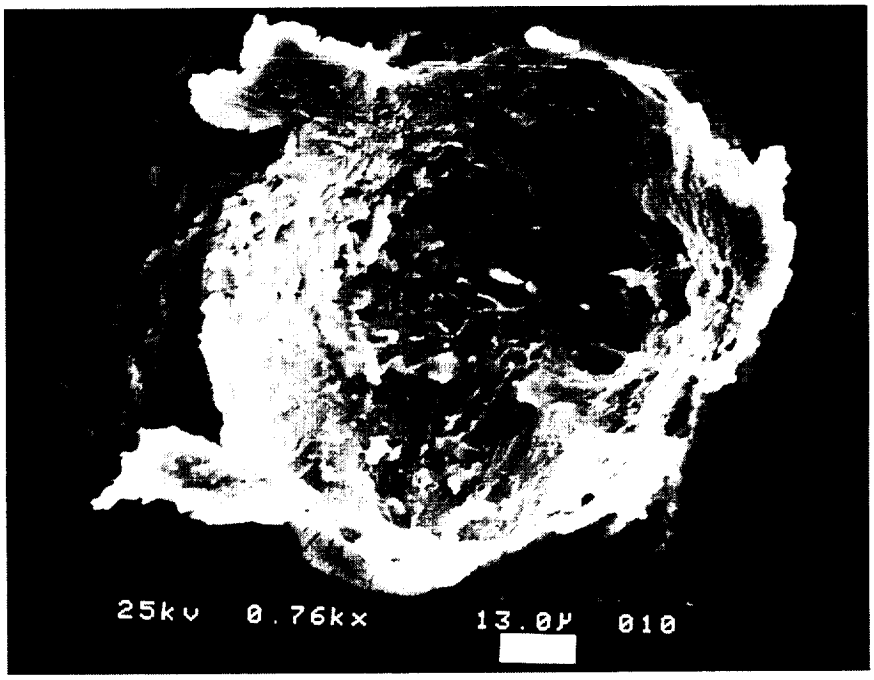
B06-C03 001 MM





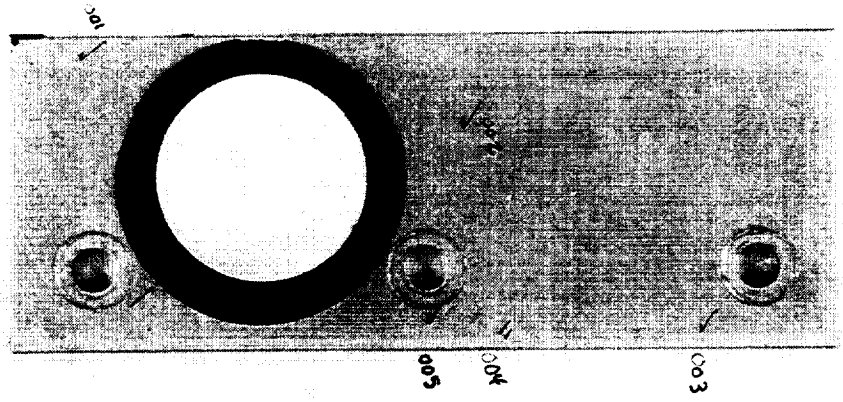
B06 -C03 002 SS



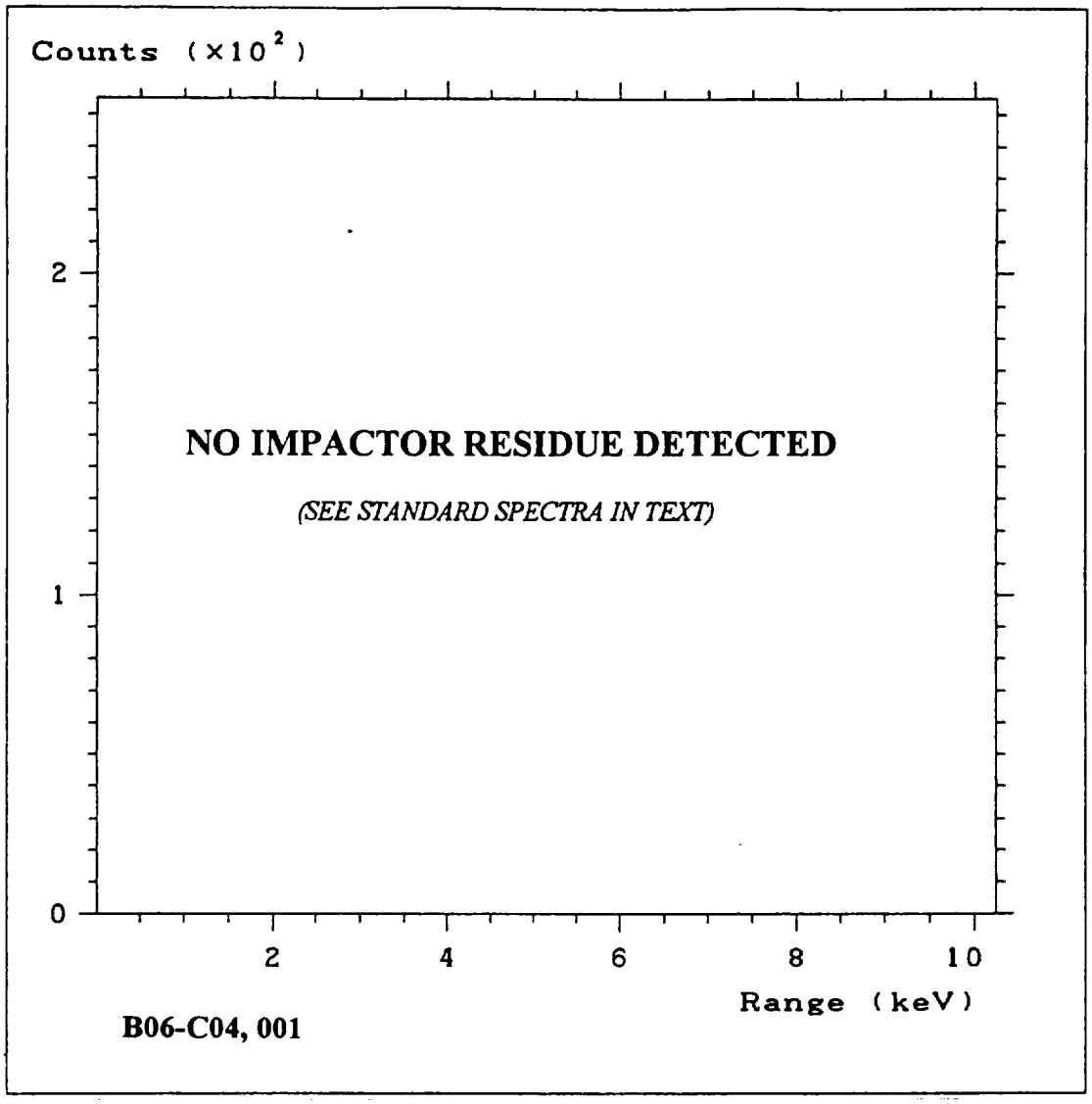


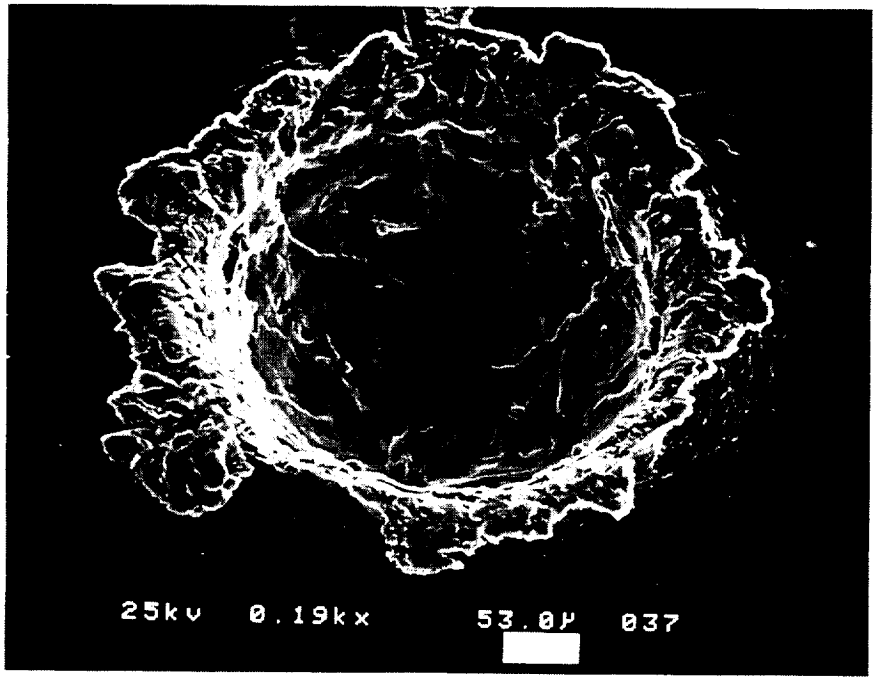
B06-C03 003 mm!

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B06-C04	001	3	9	360	UNKNOWN
	002	14	67	110	PAINT
	003	46	104	200	MICROMETEORITIC
	004	46	74	190	UNKNOWN
	005	44	62	80	UNKNOWN
	006	38	21	100	MICROMETEORITIC

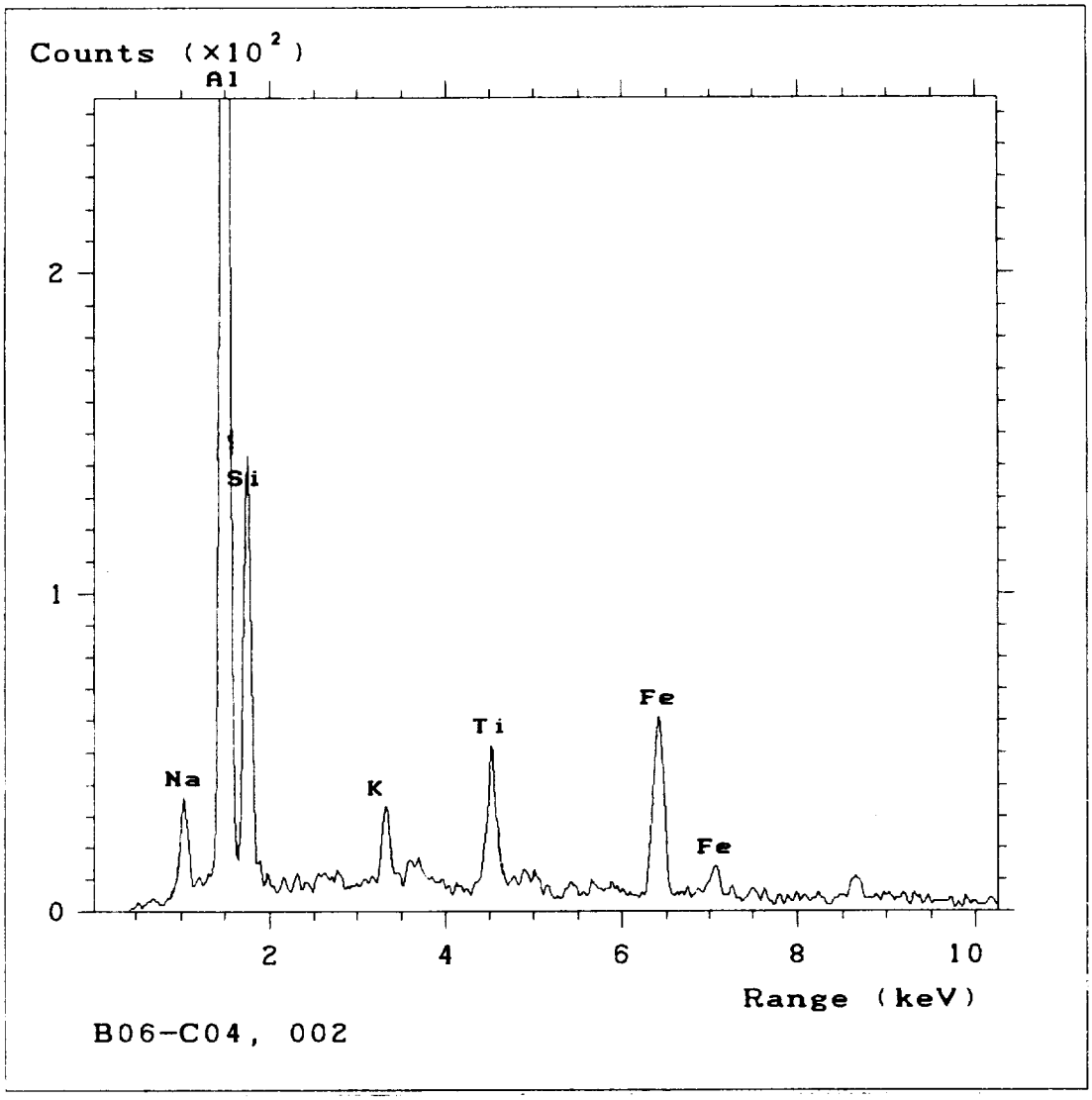


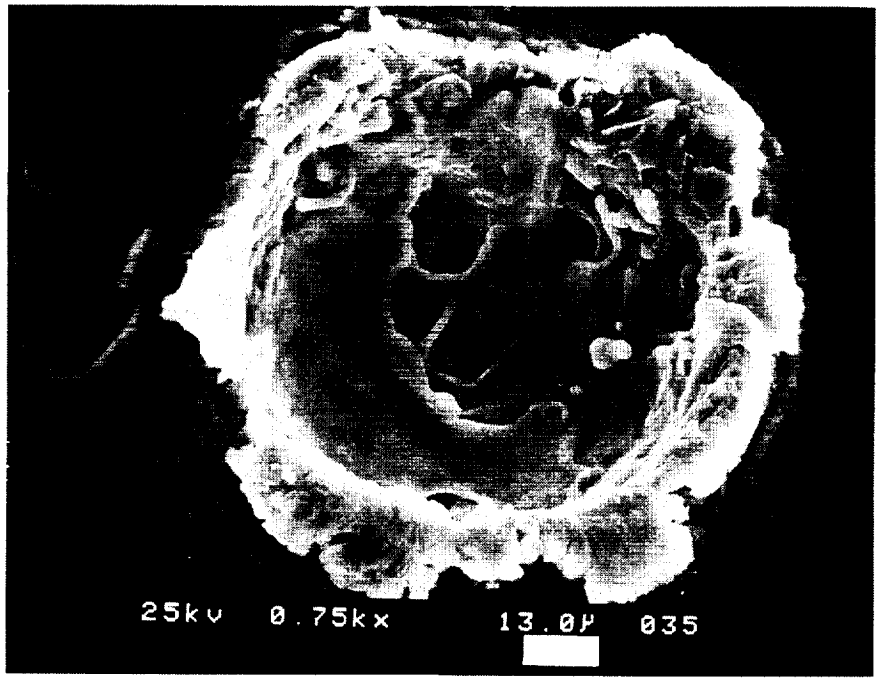
B06 CUT


Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B06-C04, 001

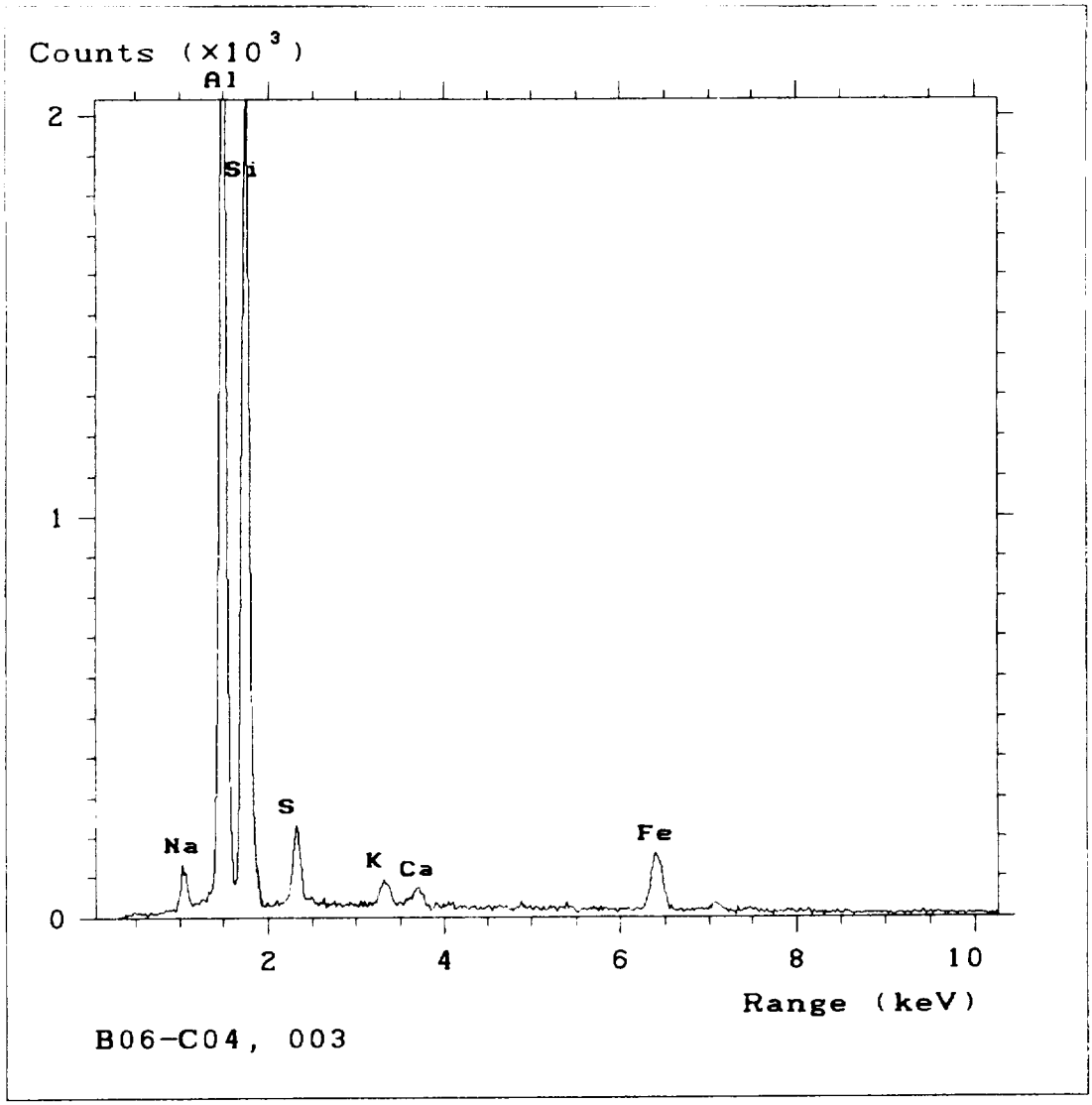

25kv 0.19kx 53.0μ 037

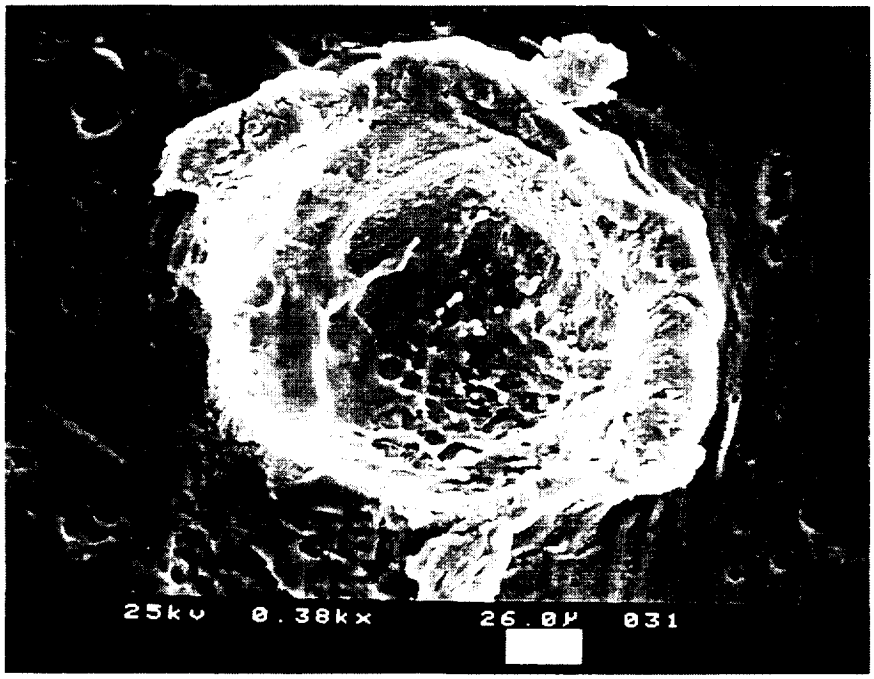
B06-C04 001



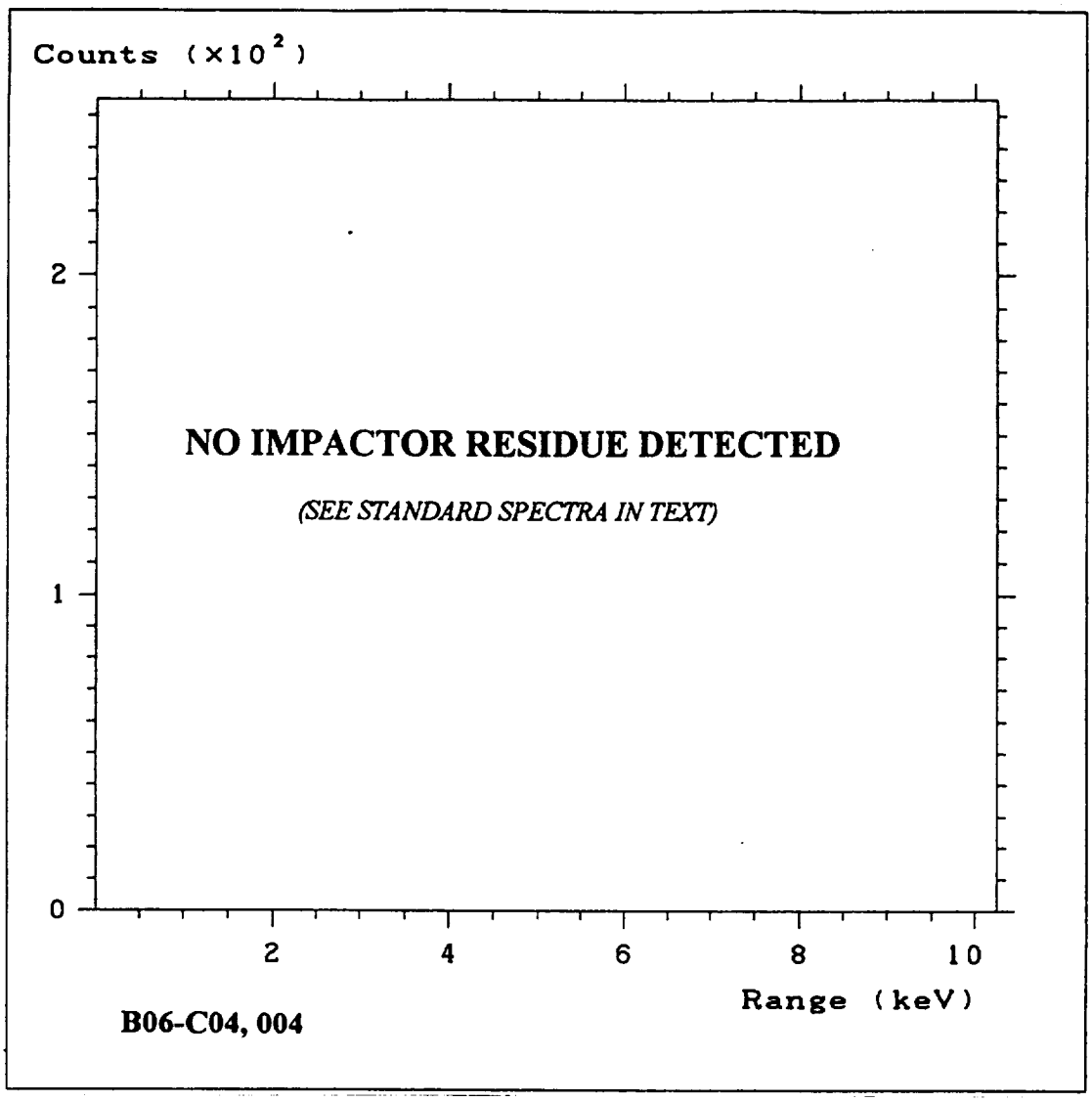


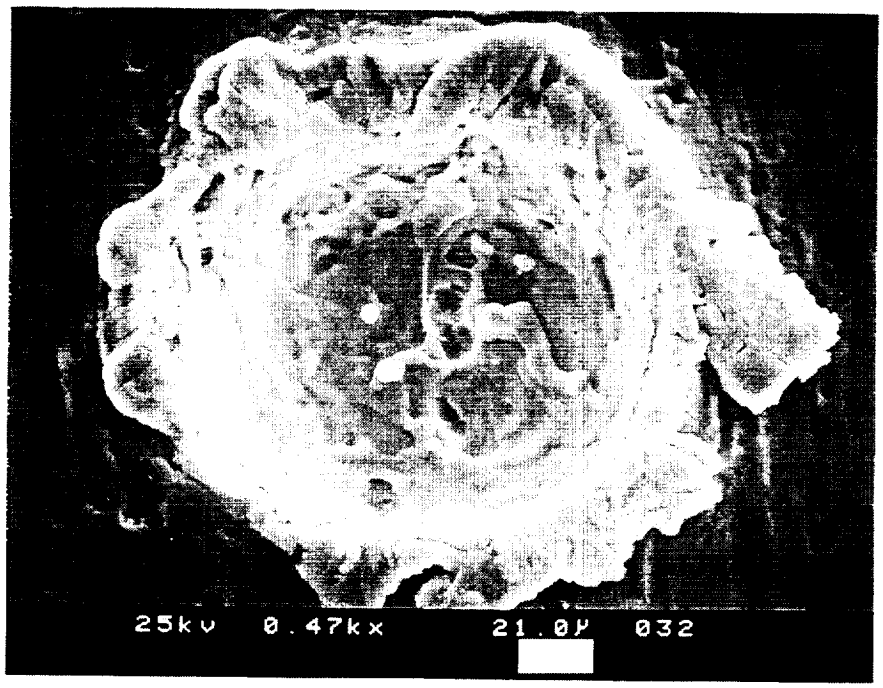
B06-C04 002 Zn



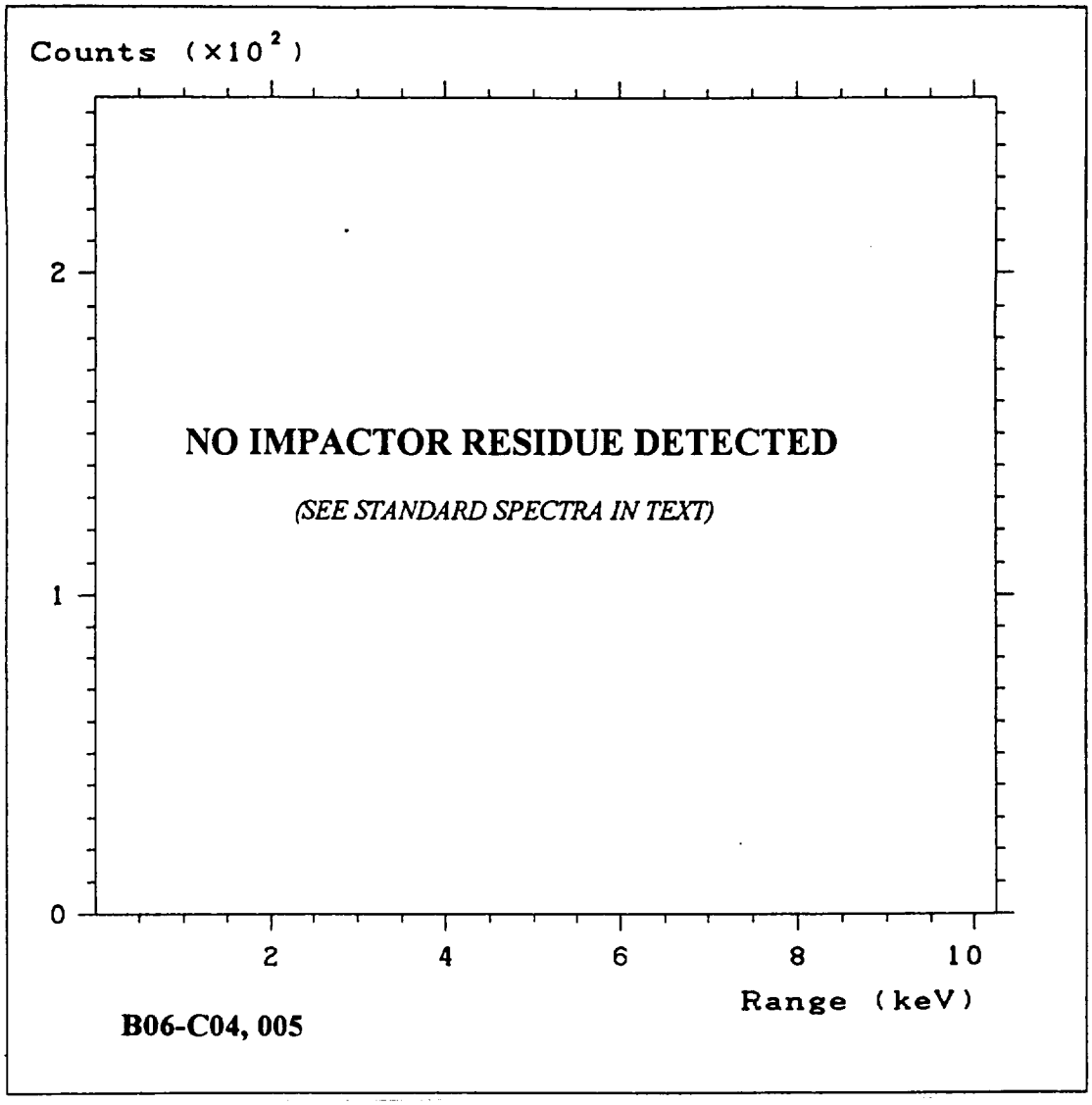


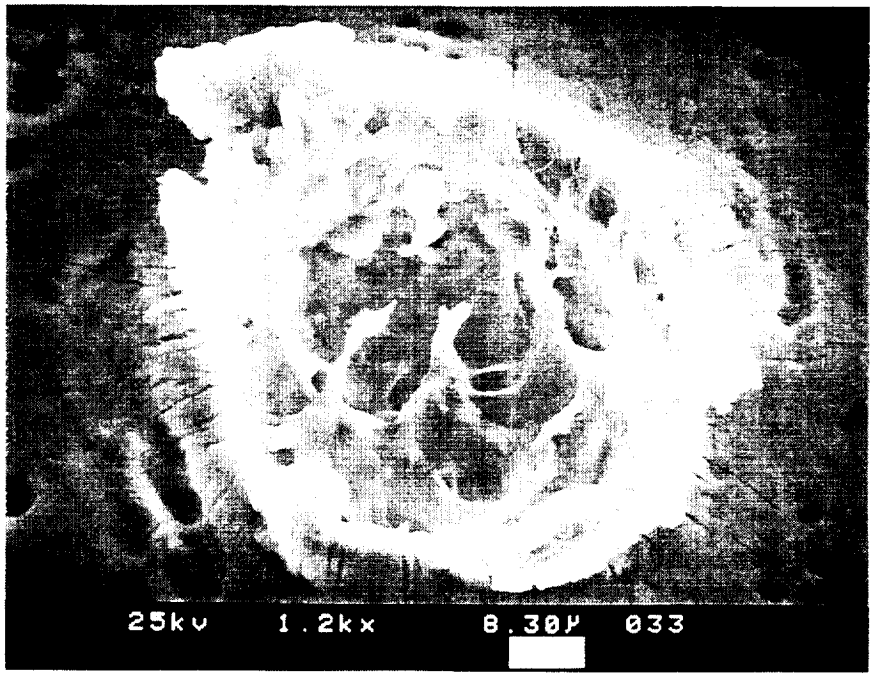
B06 - C04 003 mm


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B06-C04, 004

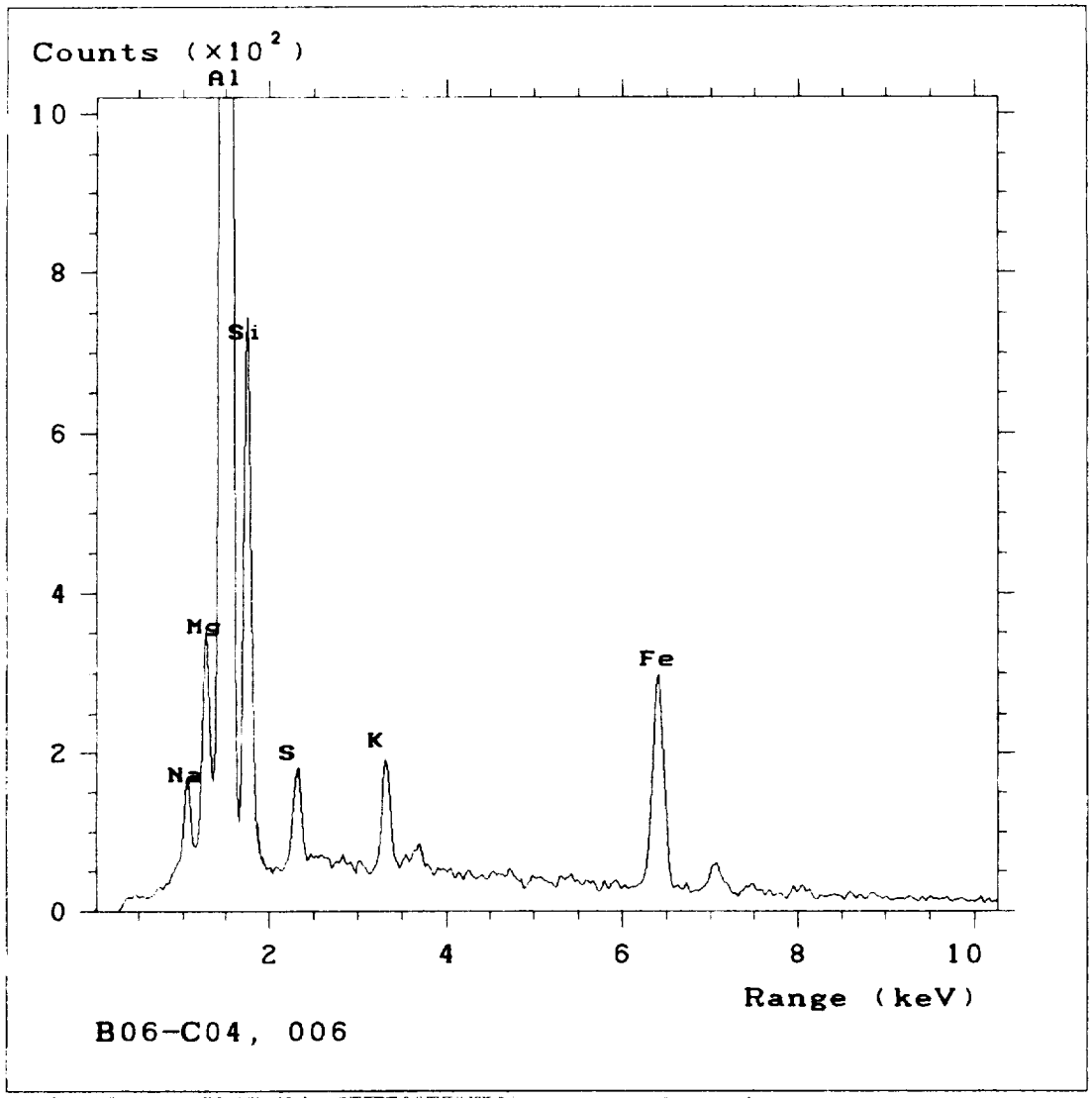

25kv 0.47kx 21.0µ 032

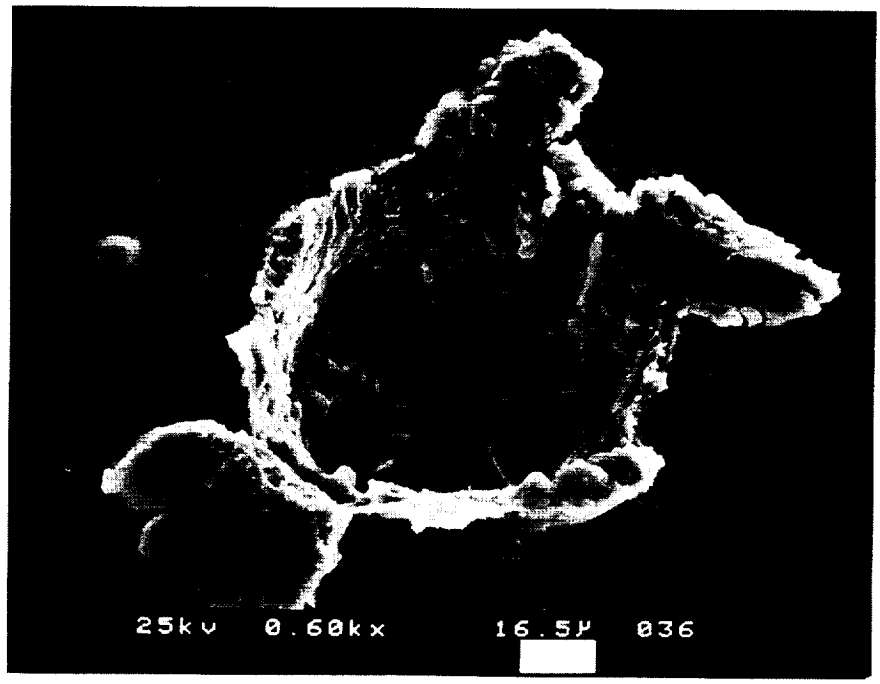
B06 - C04 004


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B06-C04, 005


25kv 1.2kx 8.30μ 033

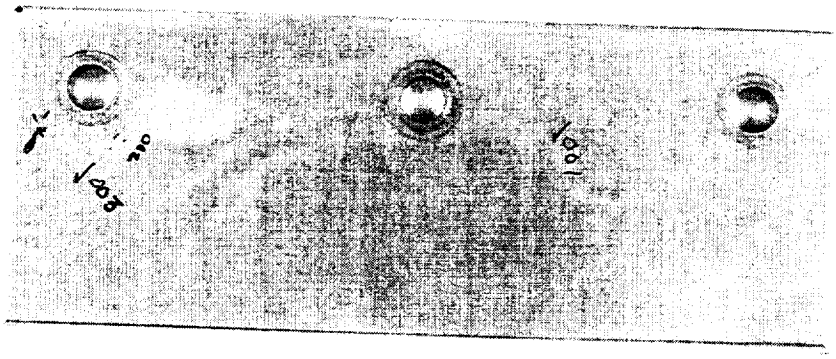
B06-C04 005


Counts (×10²)
Al
Si
Mg
Na
S
K
Fe
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B06-C04, 006

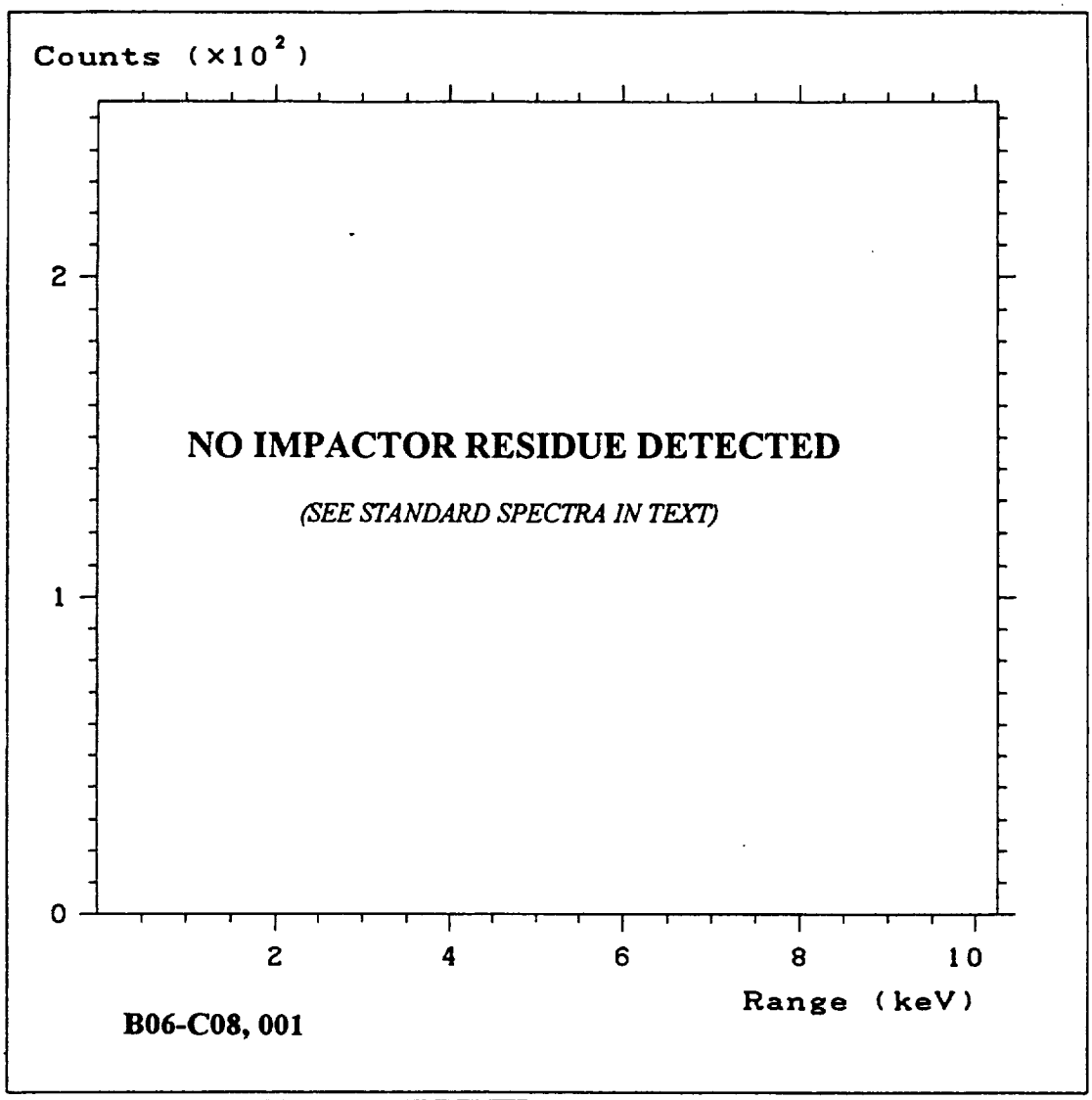

25kv 0.60kx 16.5μ 036

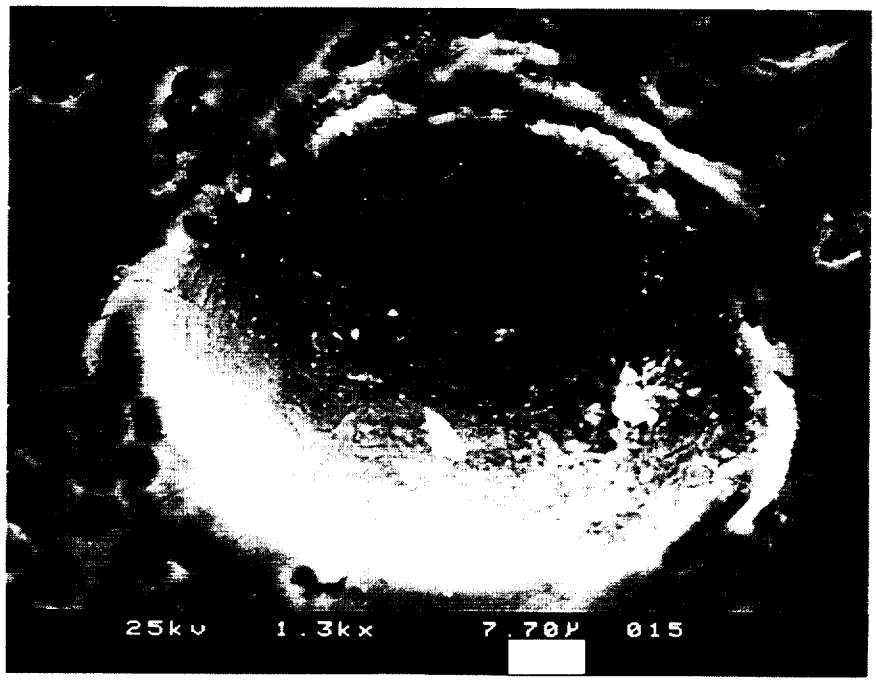
B06-C04 006

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B06-C08	001	18	83	70	UNKNOWN
	002	19	16	90	UNKNOWN
	003	27	10	400	MICROMETEORITIC

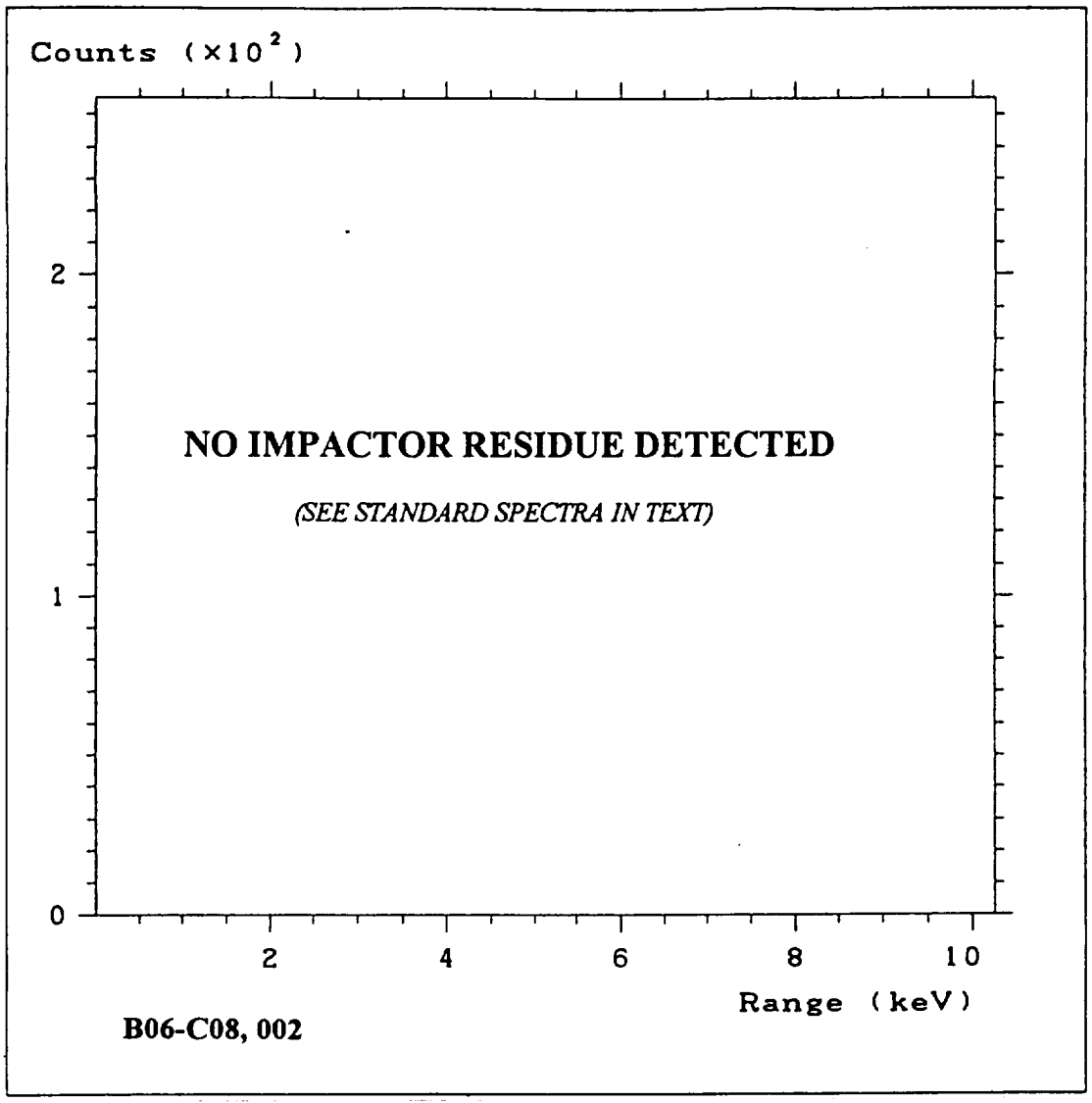


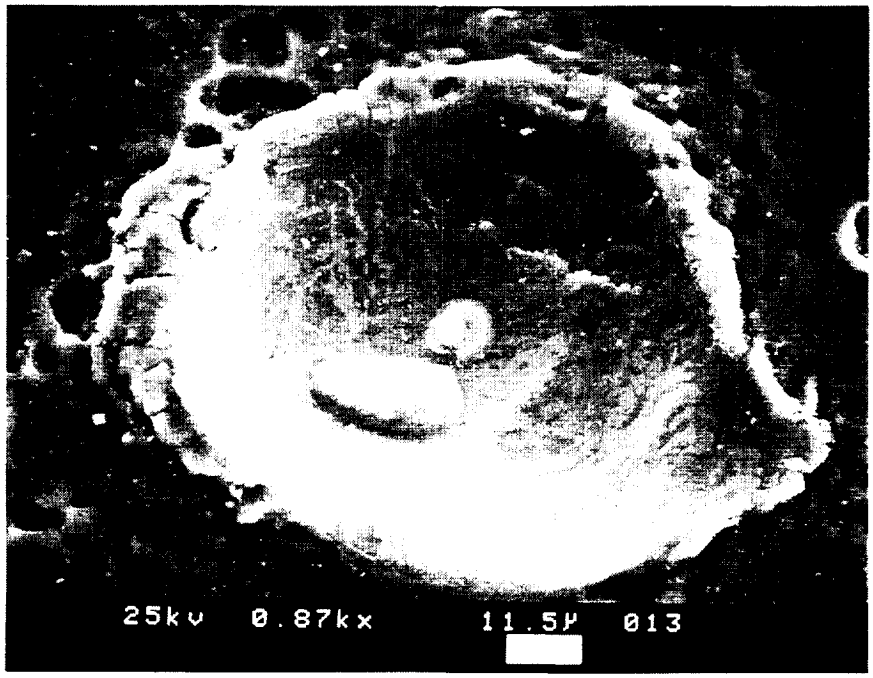
B06-C08



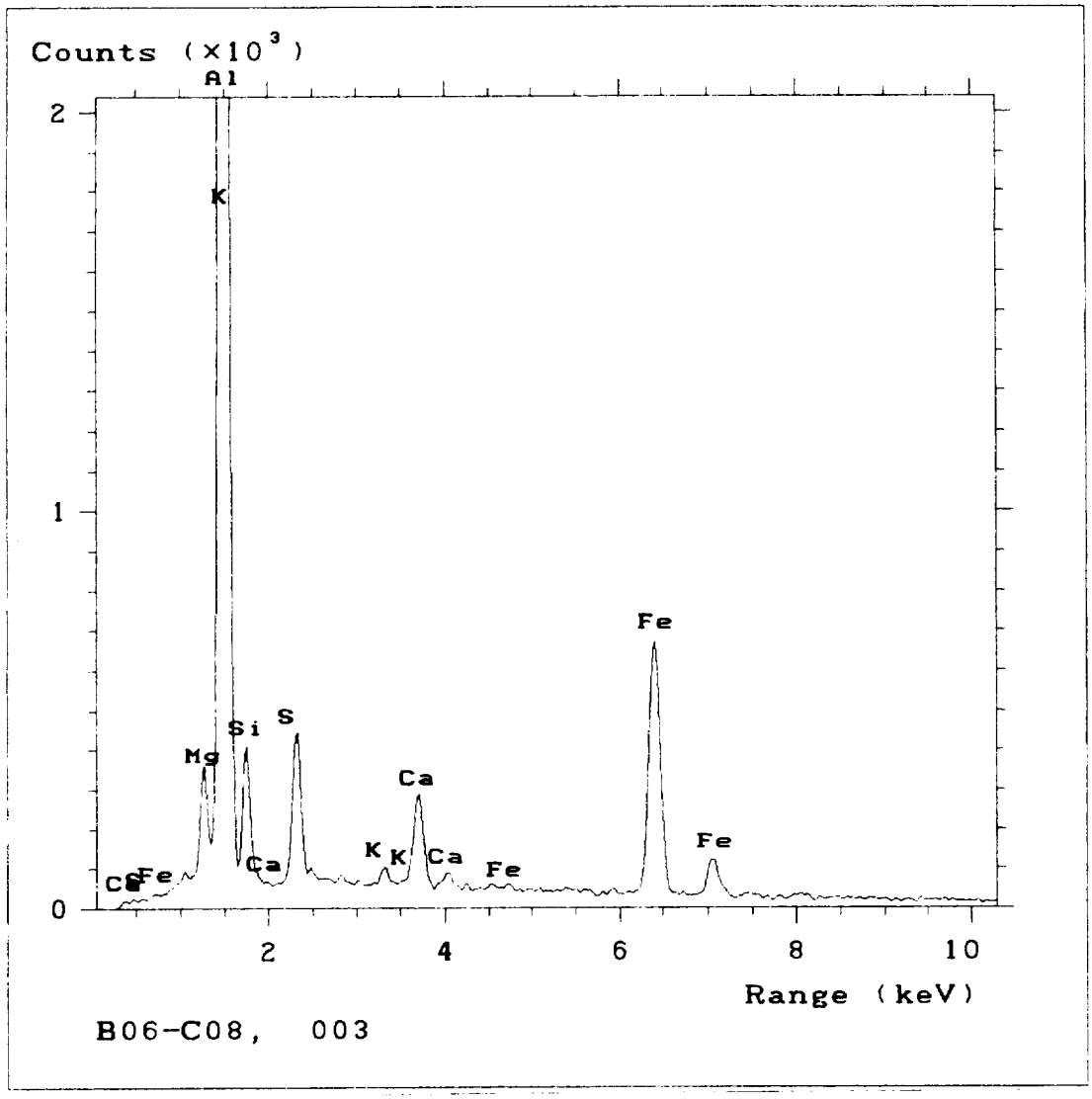


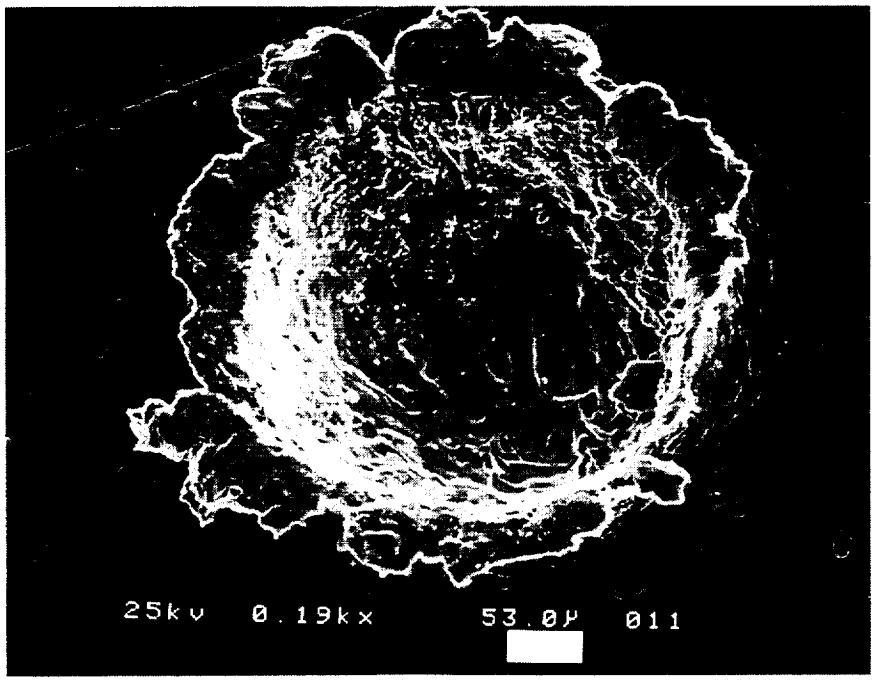
B06-C08 001 Si, S, K,


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B06-C08, 002


25kv 0.87kx 11.5μ 013

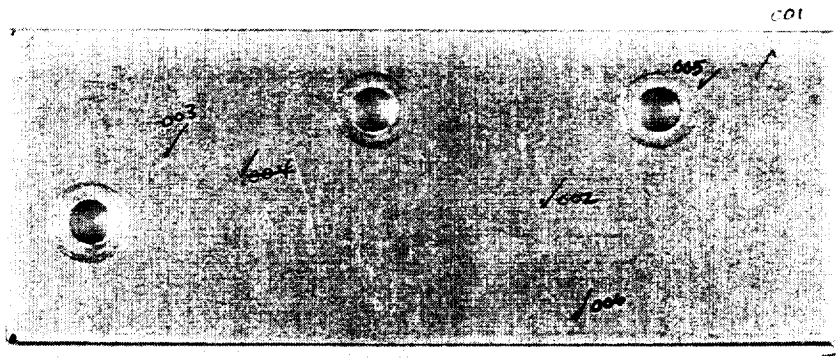
306-C08 002



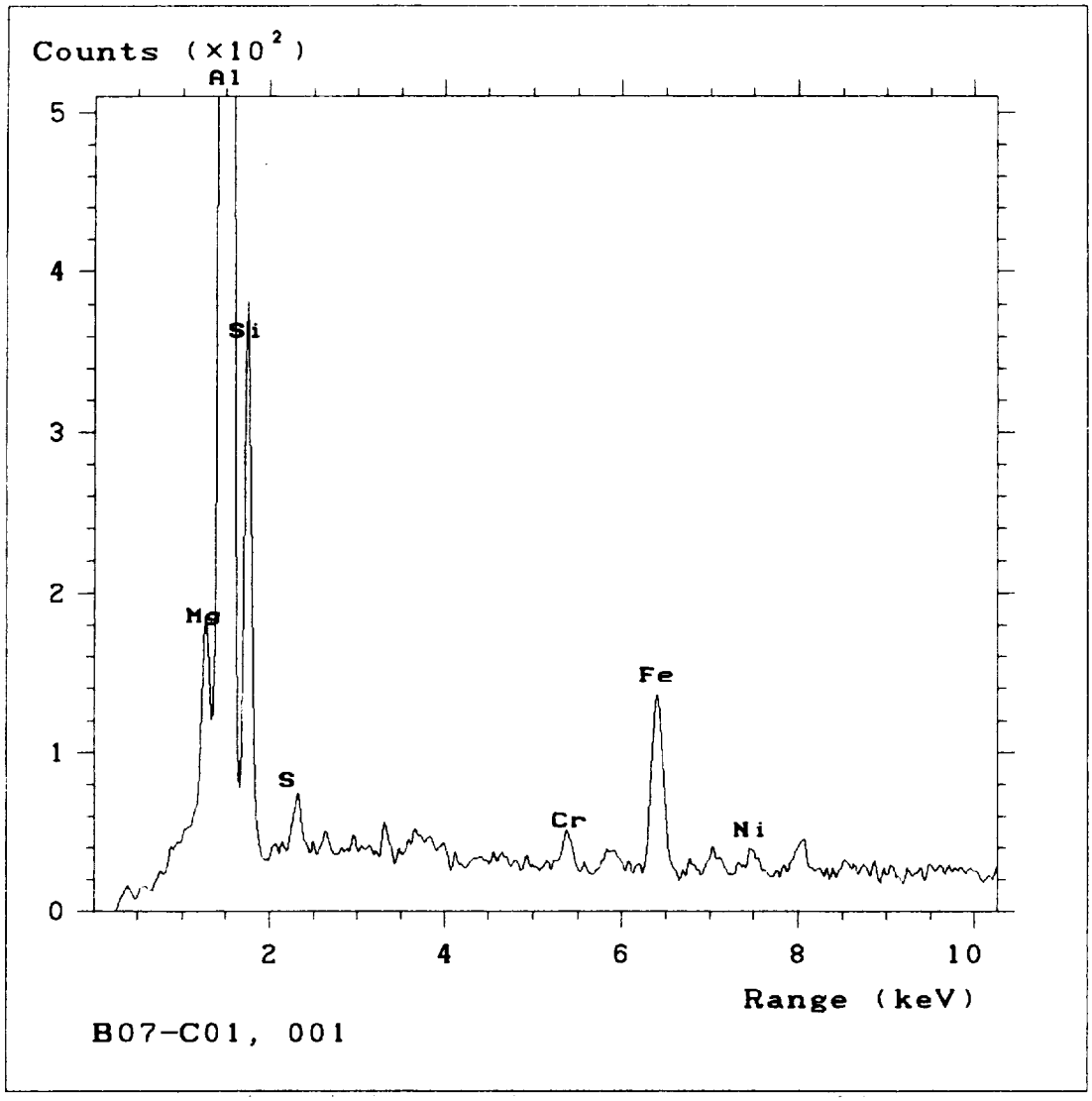


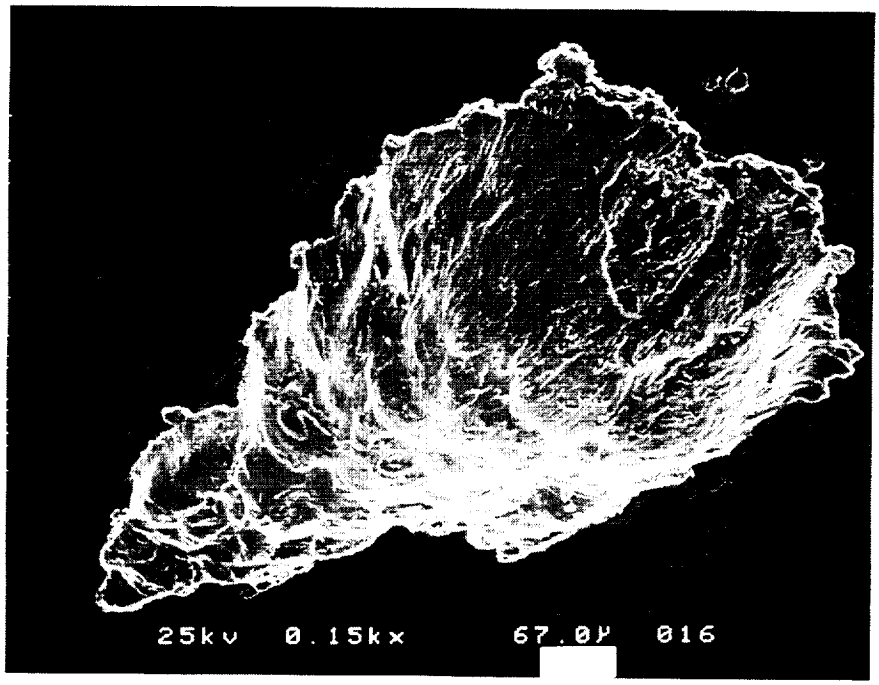
B06 - C08 003 mm

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B07-C01	001	118	47	700	MICROMETEORITIC
	002	81	20	160	UNKNOWN
	003	24	27	150	STAINLESS STEEL
	004	35	24	100	NOT AN IMPACT
	005	106	37	160	MICROMETEORITIC
	006	87	4	60	NOT AN IMPACT

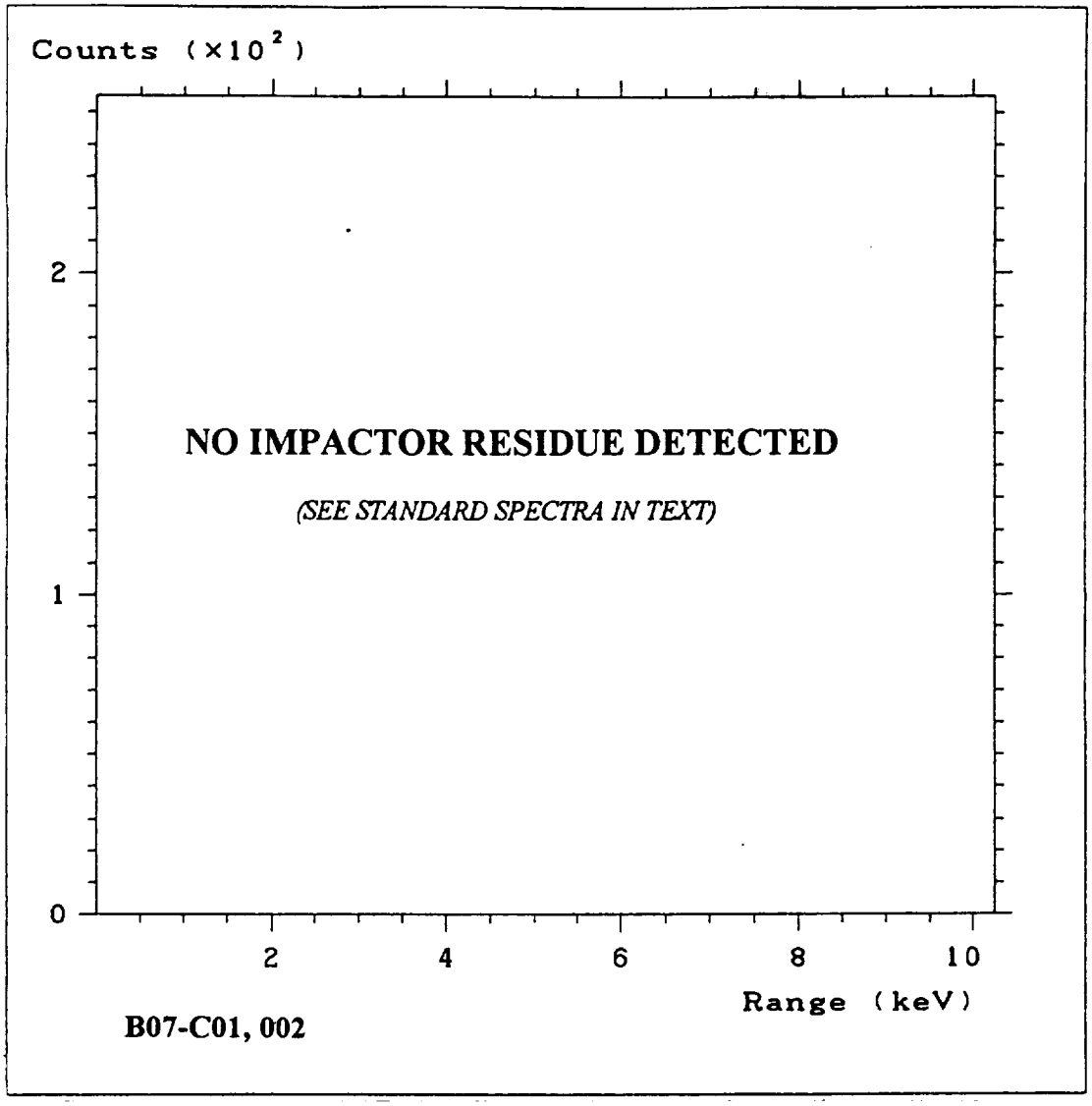


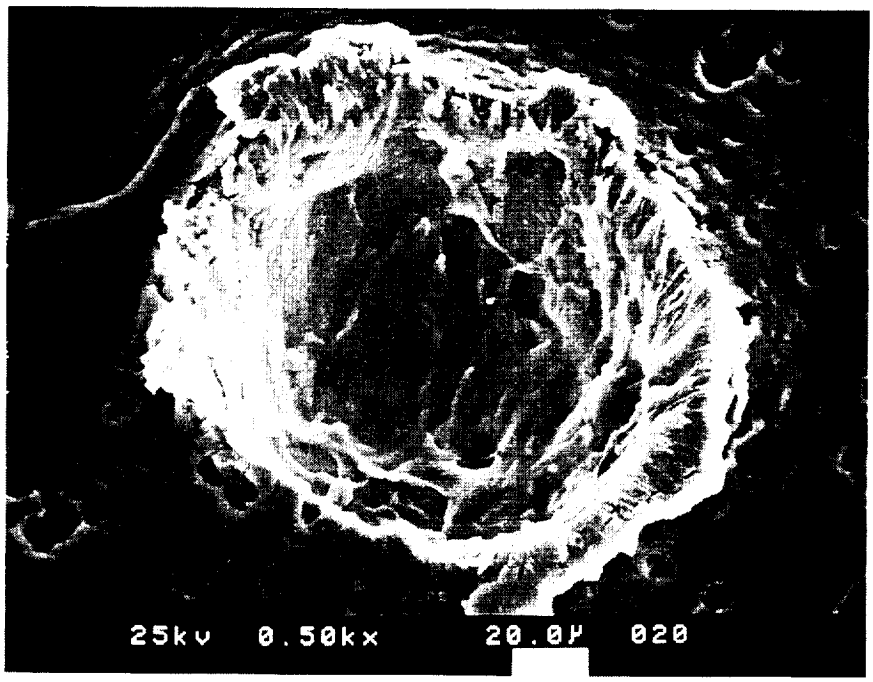
B07-C01


Counts (×10²)
Al
Si
Mg
S
Cr
Fe
Ni
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B07-C01, 001

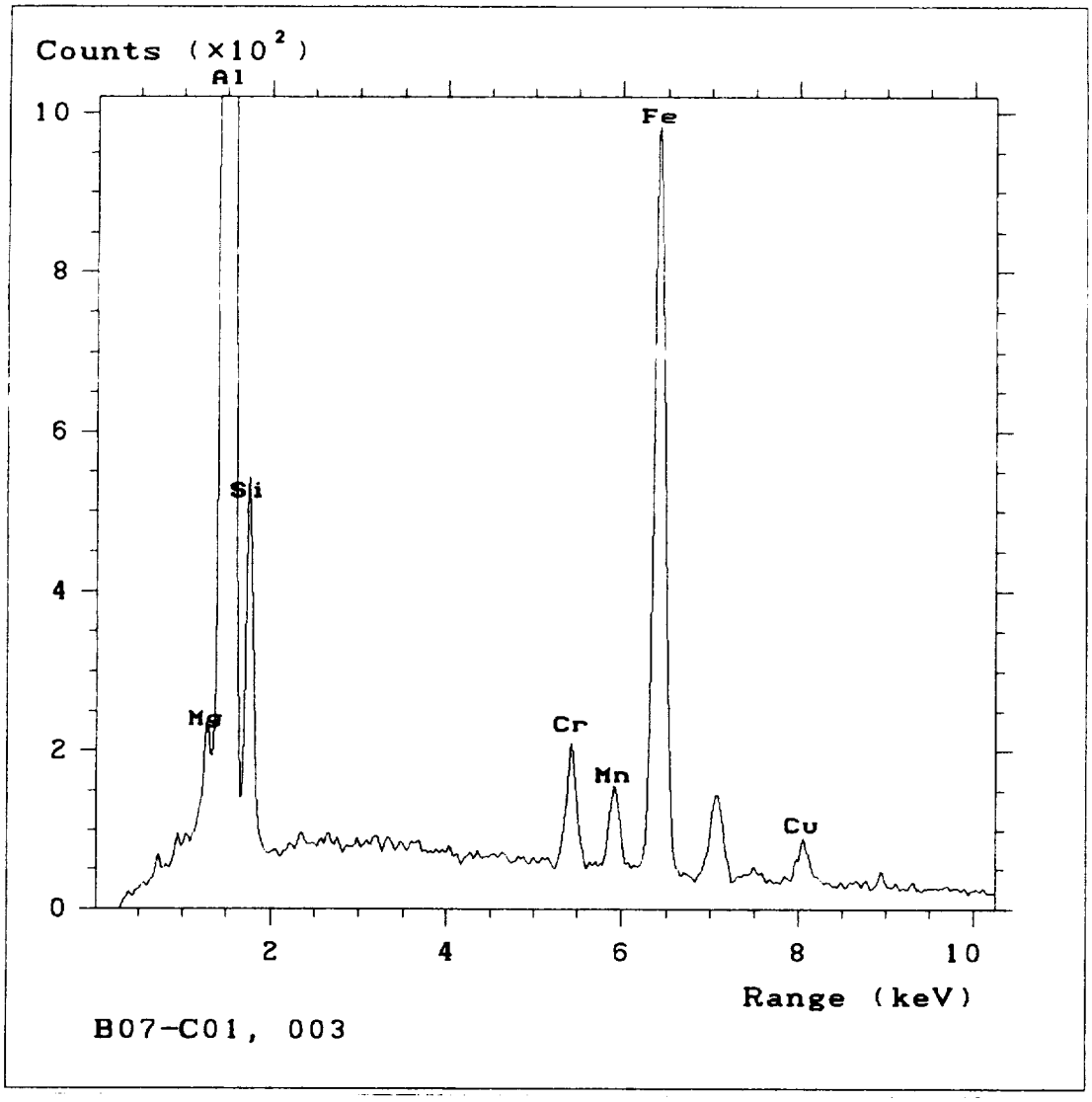

25kv 0.15kx 67.0µ 016

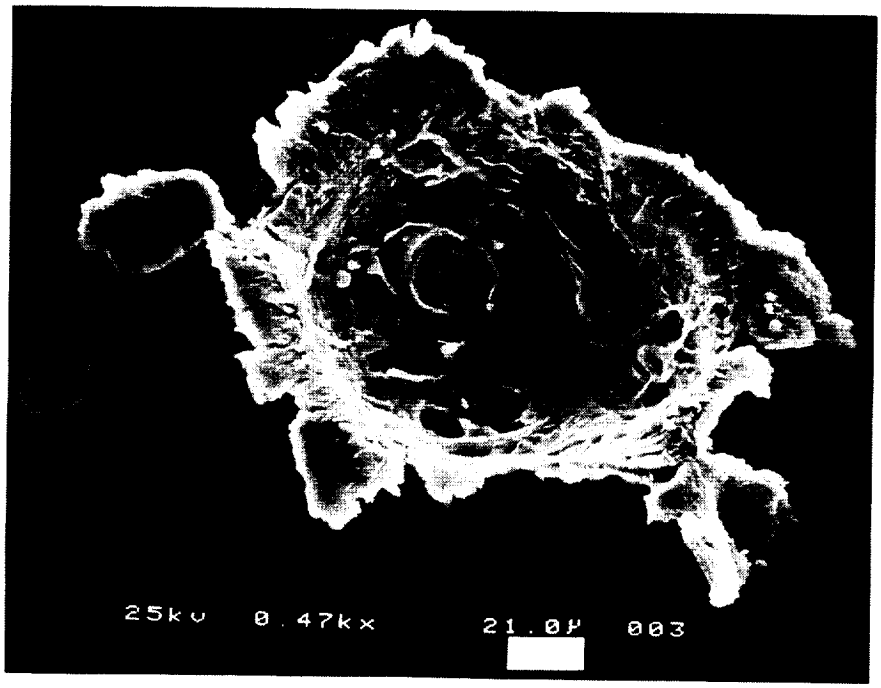
B07-C01 001


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B07-C01, 002

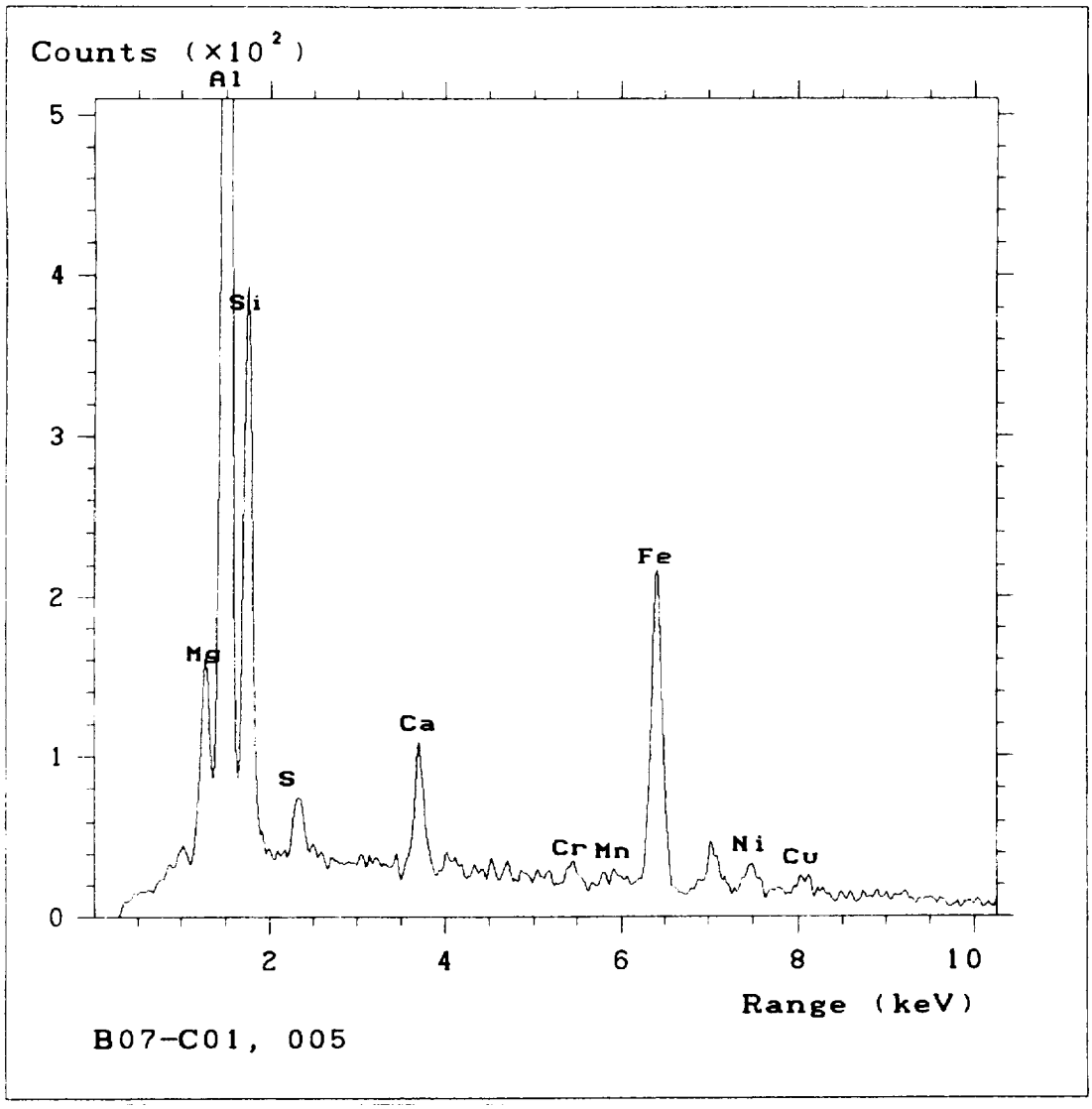

25kv 0.50kx 20.0µ 020

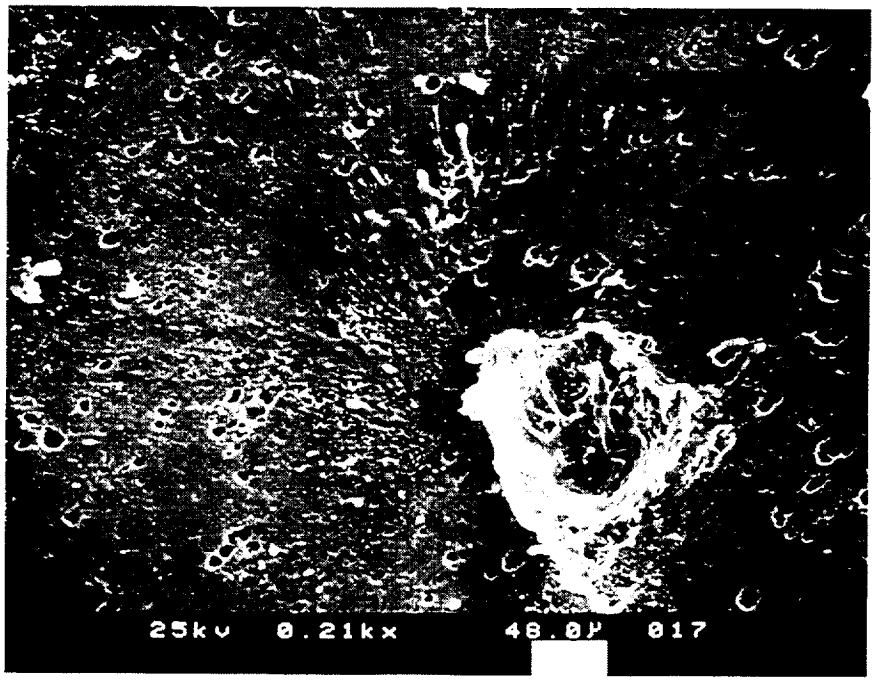
B07-C01 002





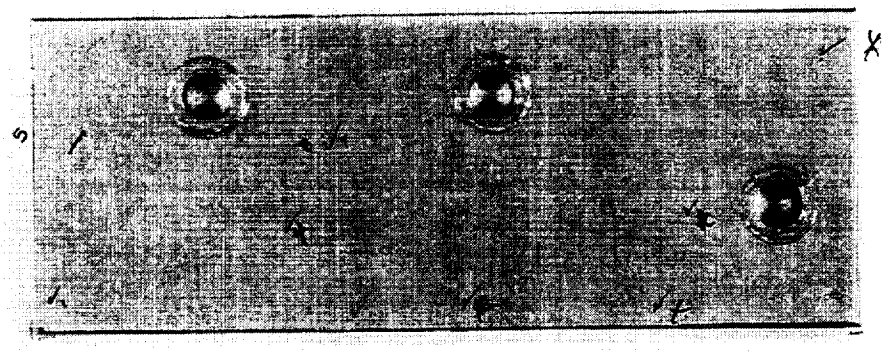
B07-C01 003 SS


Counts (×10²)
Al
Si
Mg
S
Ca
Cr
Mn
Fe
Ni
Cu
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B07-C01, 005

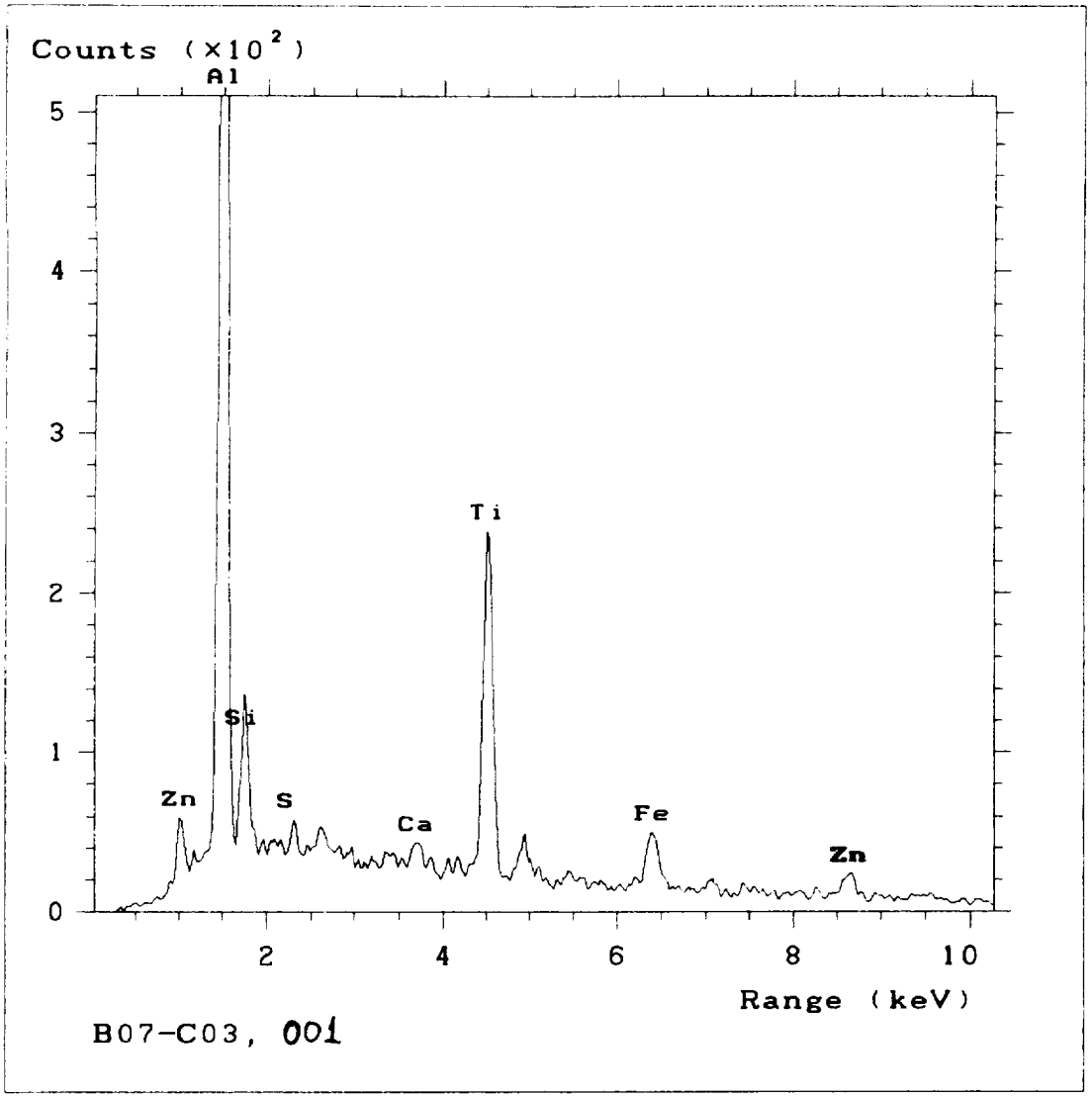

25kv 0.21kx 48.0µ 017

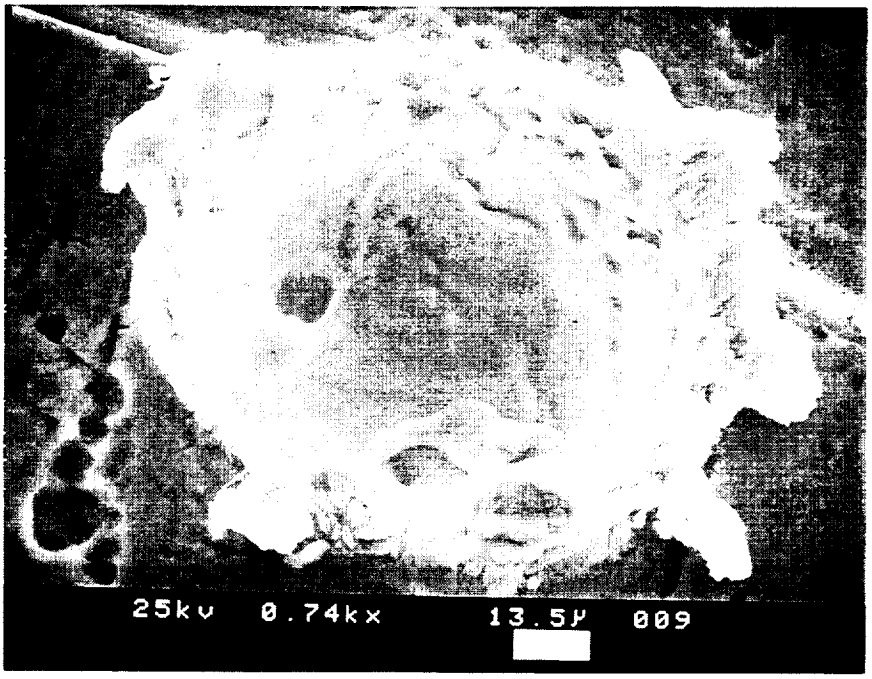
B07-C01 005

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B07-C03	001	2	3	100	PAINT
	002	66	2	70	NOT AN IMPACT
	003	101	16	40	NOT AN IMPACT
	004	40	13	50	PAINT
	005	13	28	50	UNKNOWN
	006	124	37	60	NOT AN IMPACT
	007	44	26	350	MICROMETEORITIC
	008	43	27	35	MICROMETEORITIC

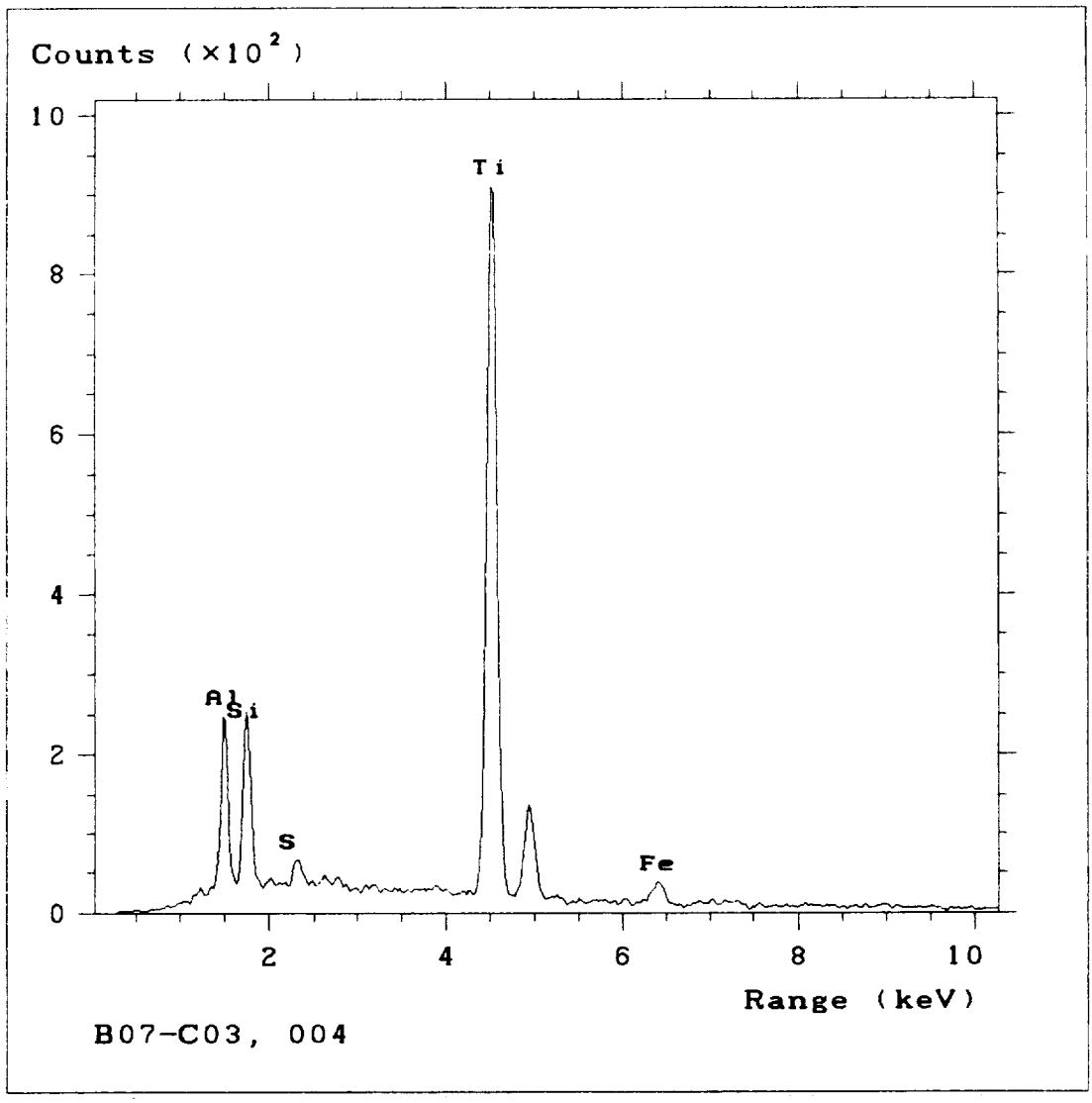


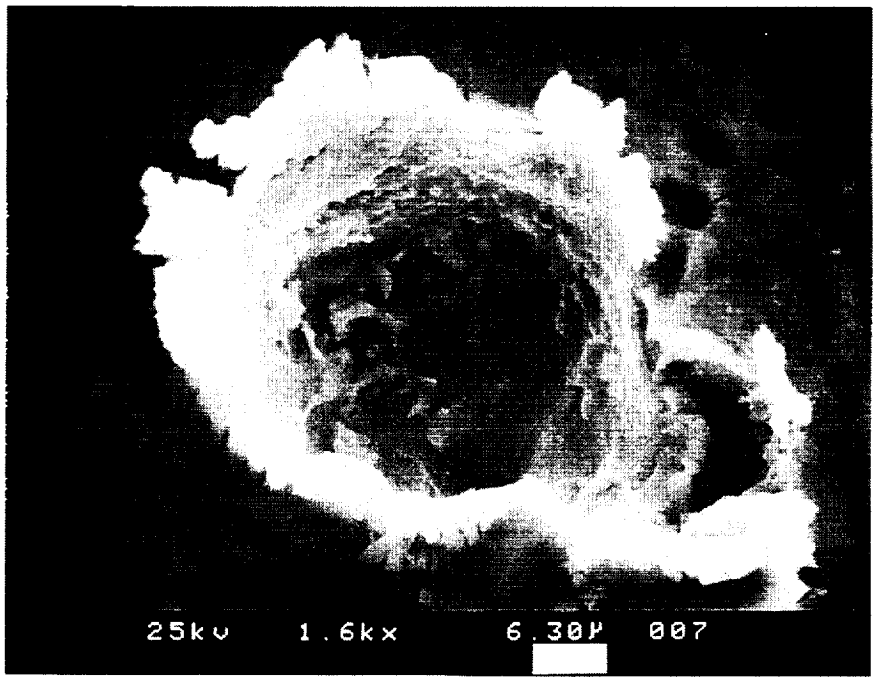
B07-C03


Counts (×10²)
Al
Ti
Si
Zn
S
Ca
Fe
Zn
Range (keV)
B07-C03, 001

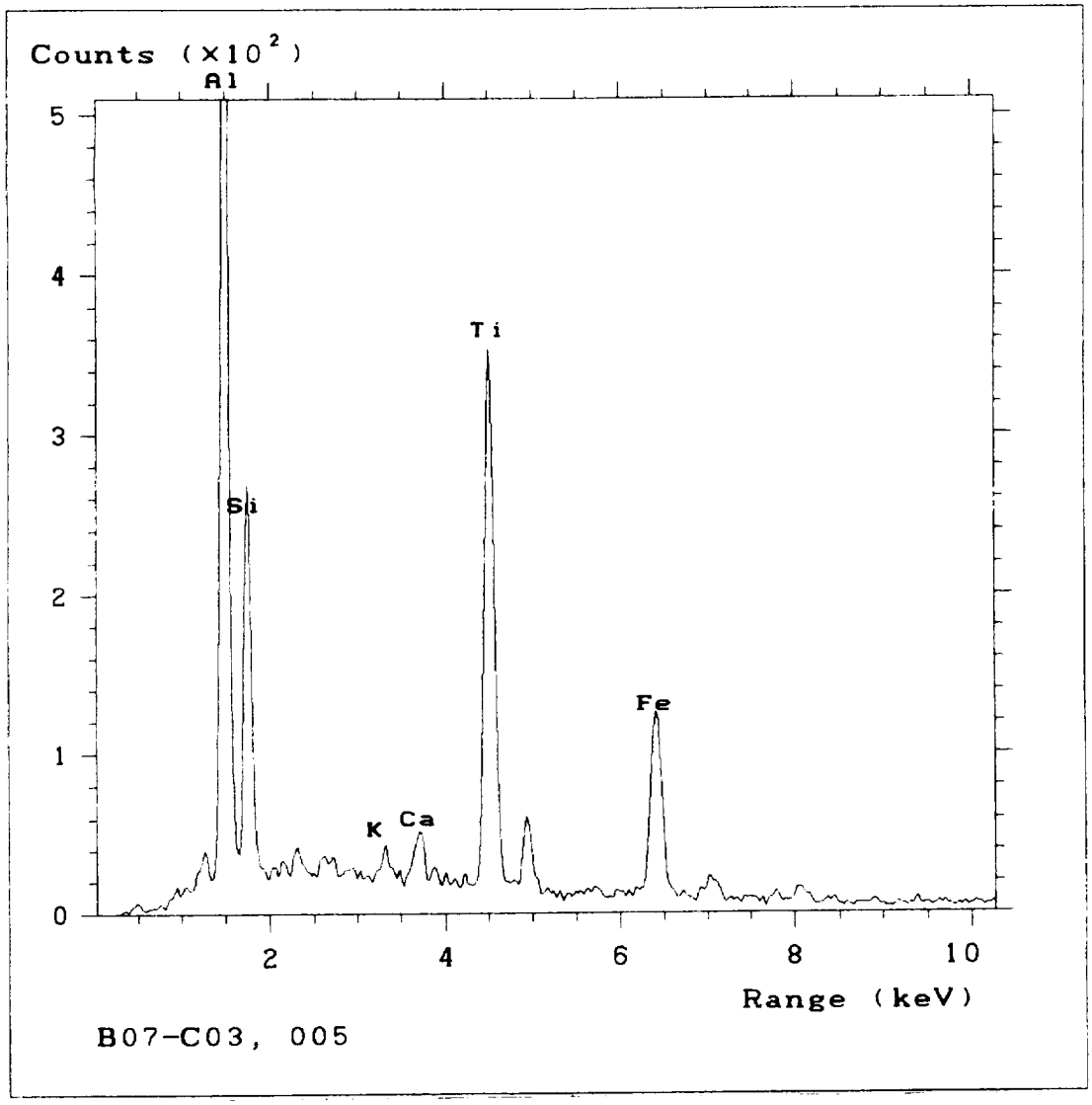

25kv 0.74kx 13.5μ 009

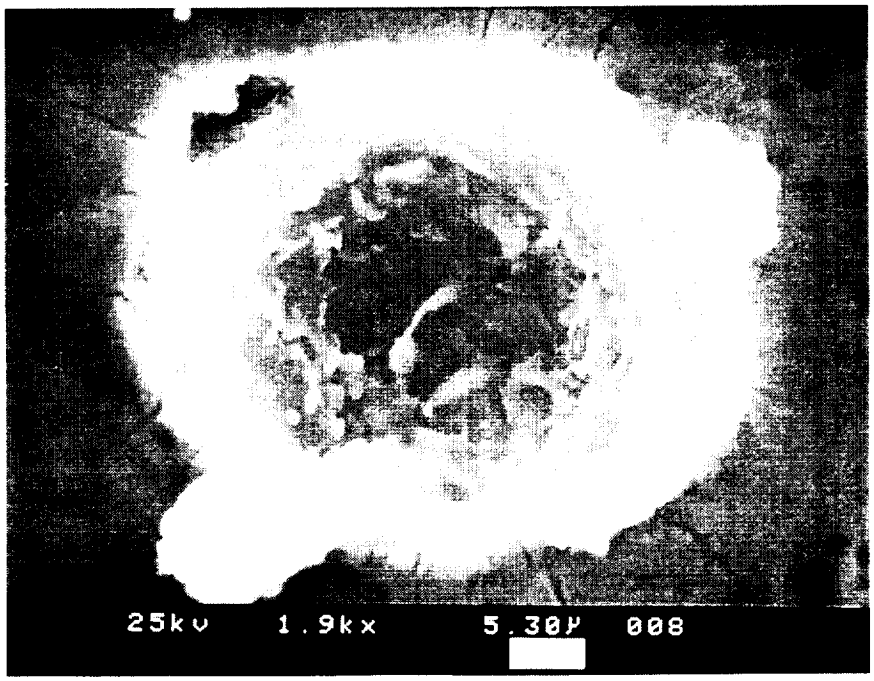
B07 - C03 001



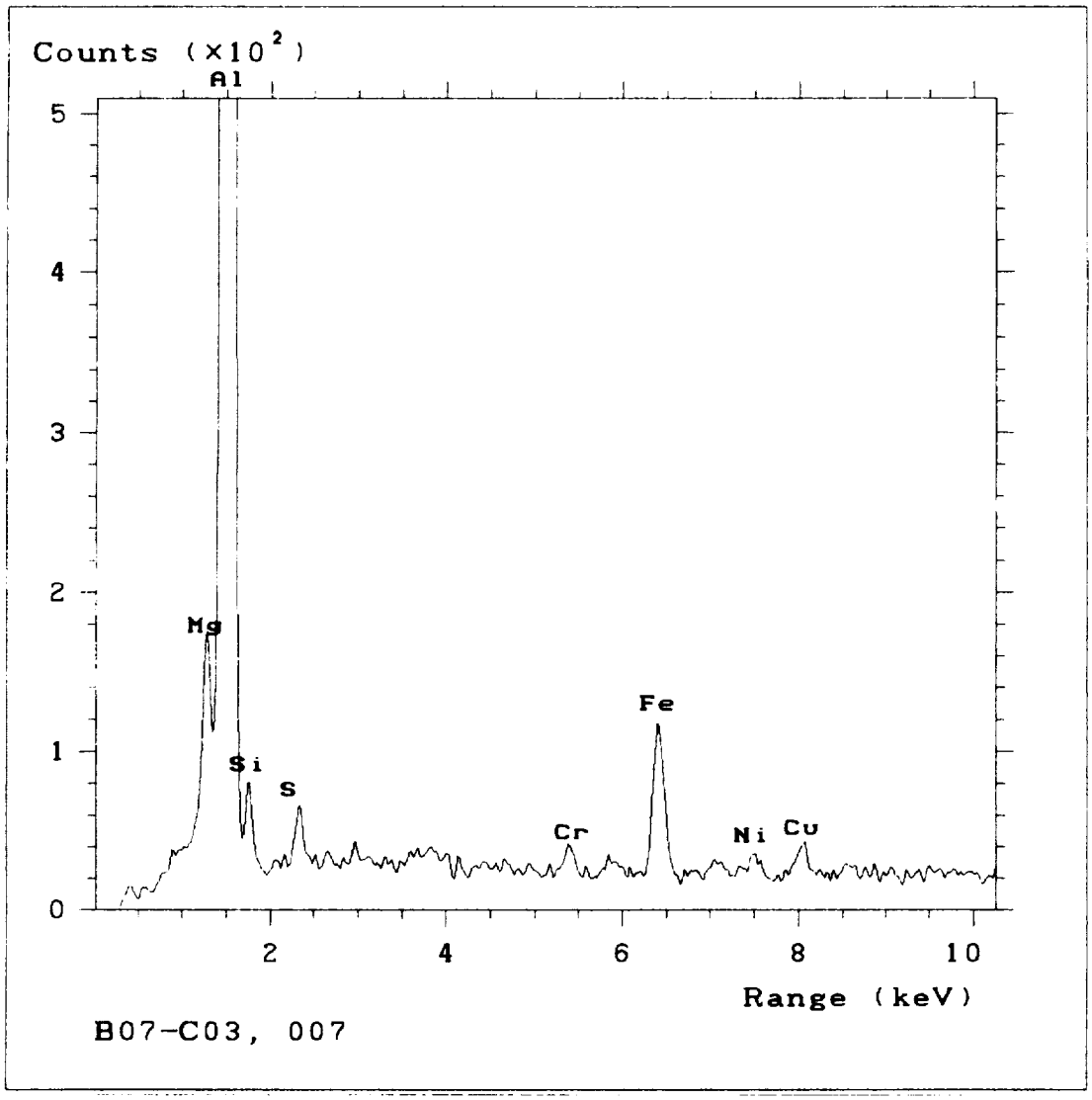


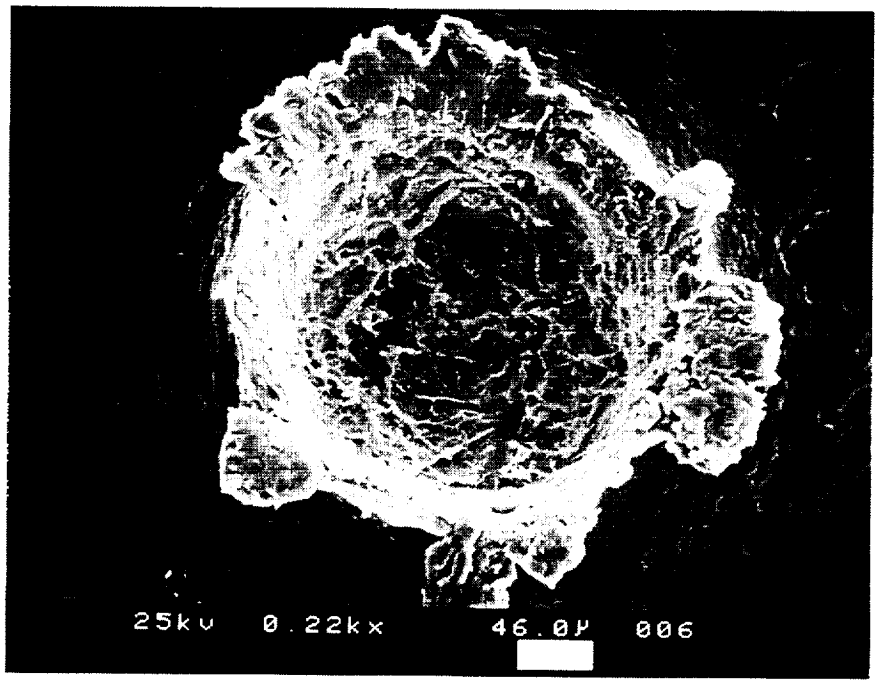
B07-C03 004 PAINT


Counts (×10²)
Al
Si
K
Ca
Ti
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B07-C03, 005

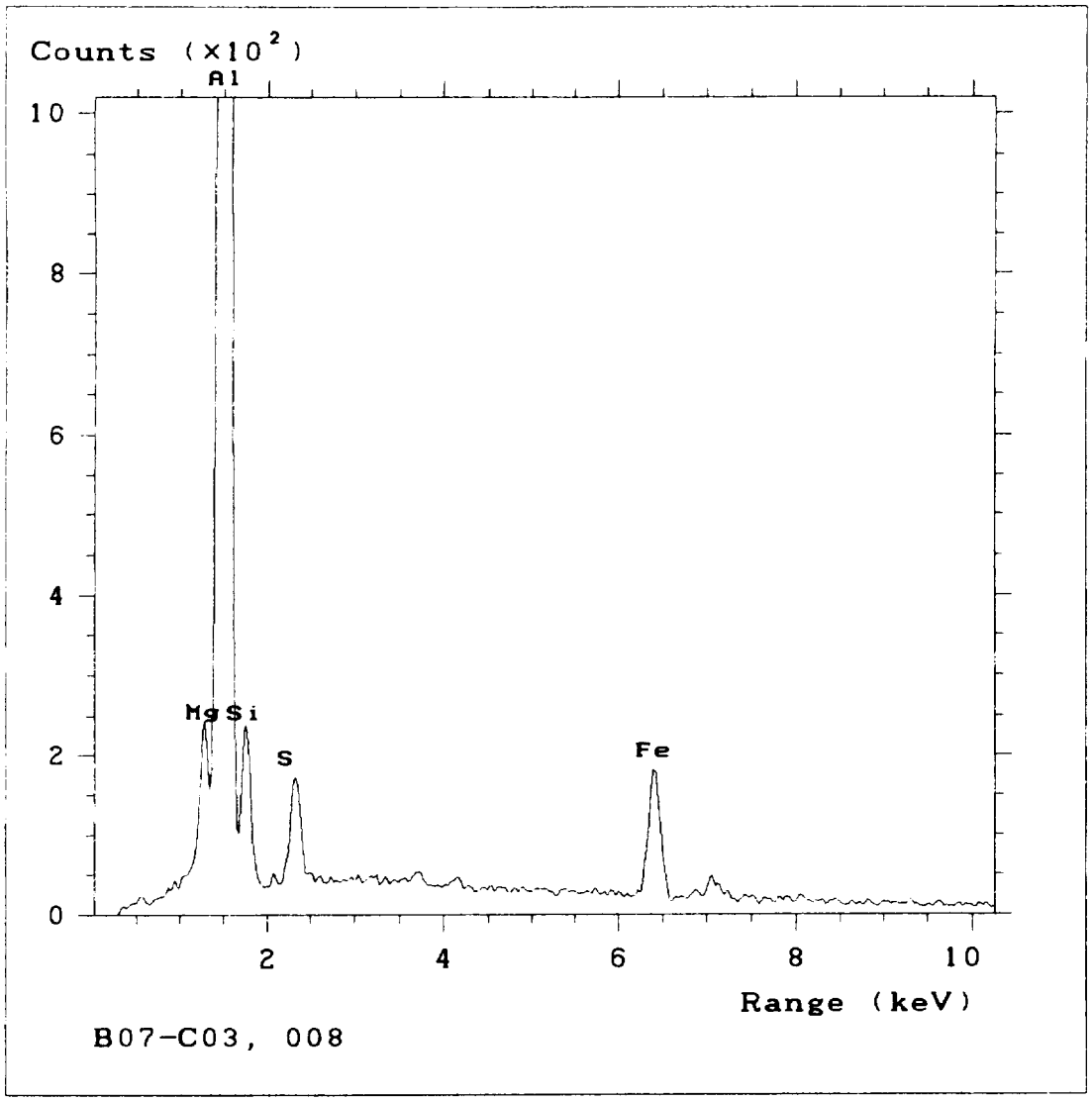

25kv 1.9kx 5.30μ 008

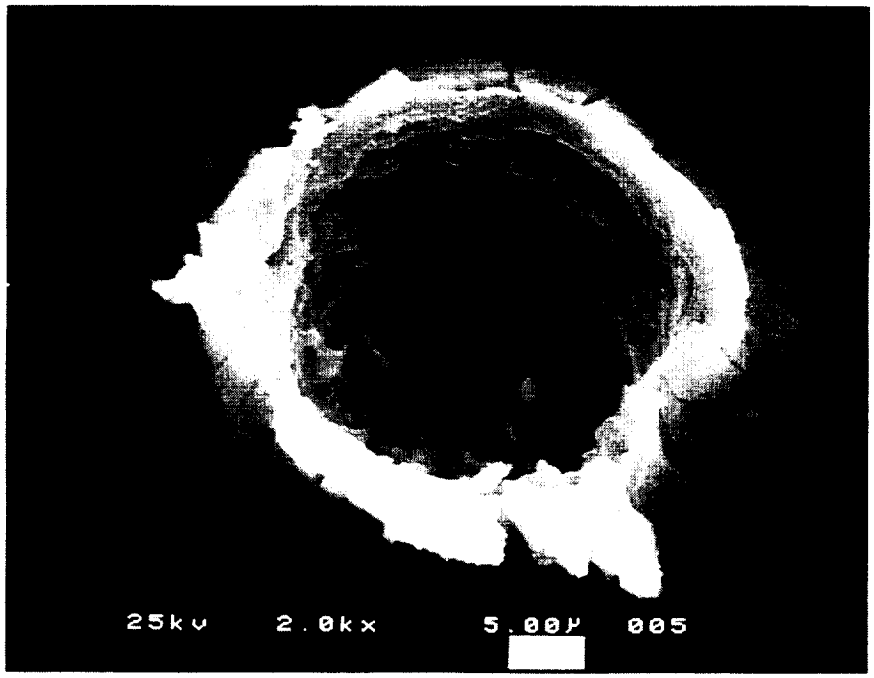
B07-C03 005


Counts (×10²)
Al
Mg
Si
S
Cr
Fe
Ni
Cu
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B07-C03, 007


25kv 0.22kx 46.0μ 006

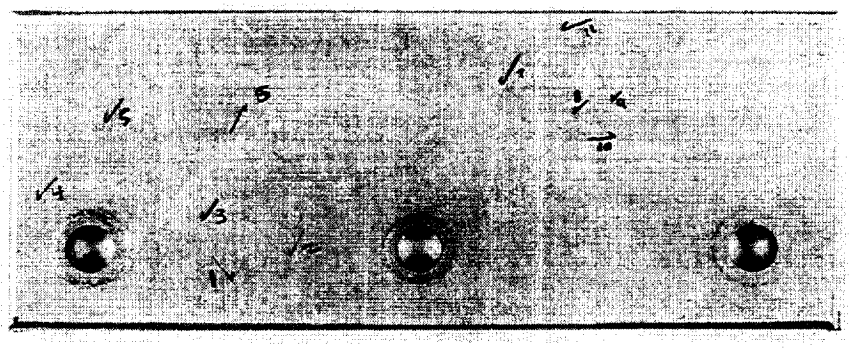
B07 - C03 007


Counts (×10²)
Al
Mg
Si
S
Fe
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B07-C03, 008

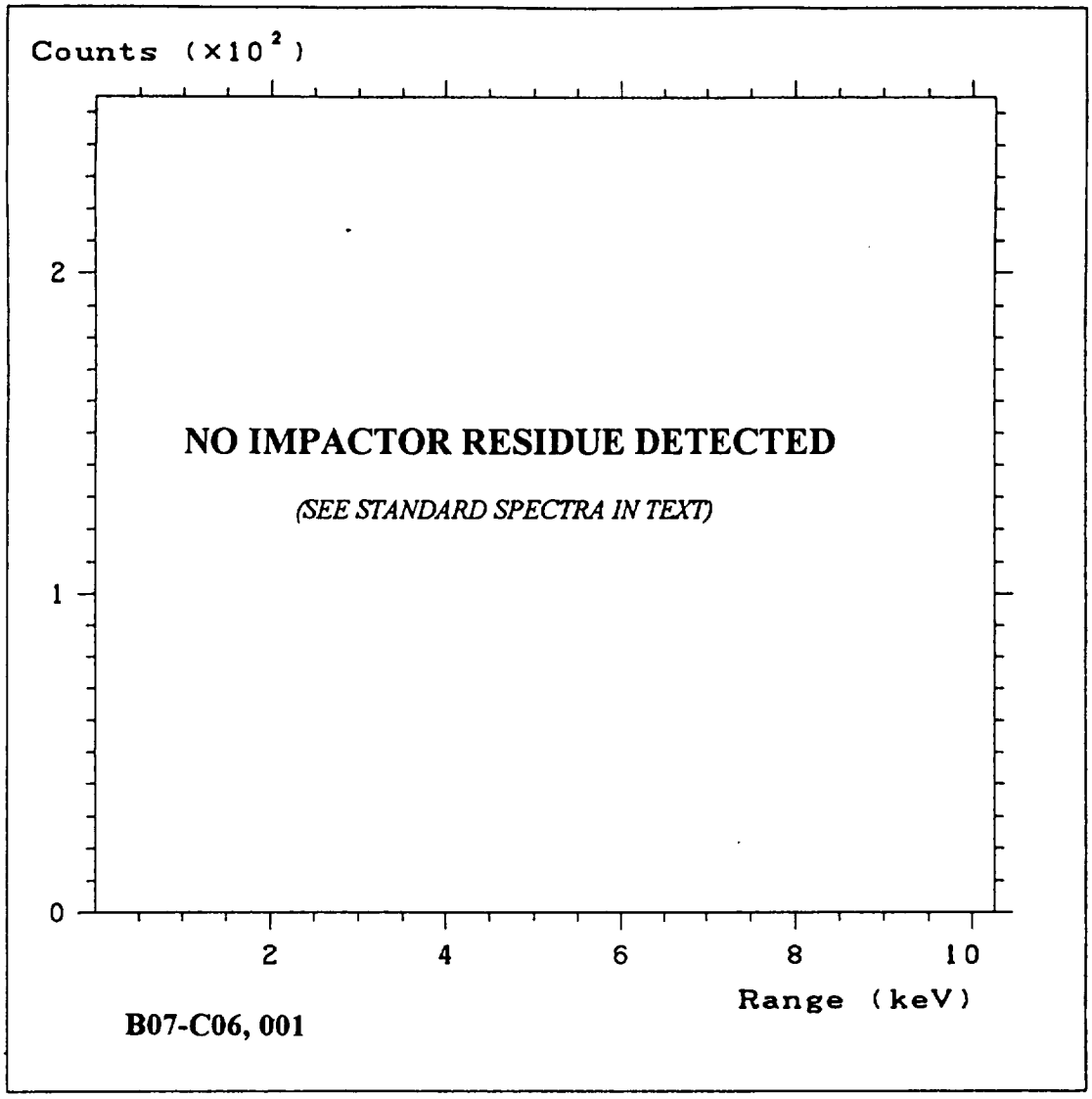

25kv 2.0kx 5.00μ 005

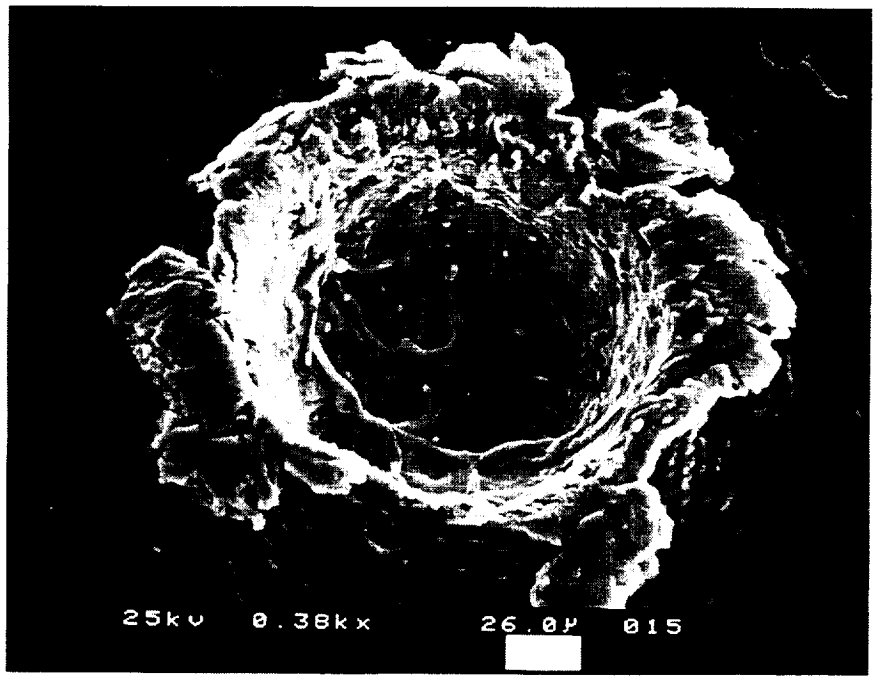
307- C03 008

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B07-C06	001	34	53	170	UNKNOWN
	002	42	8	100	MICROMETEORITIC
	003	29	14	130	PAINT
	004	4	17	140	UNKNOWN
	005	15	29	40	IRON
	006	37	33	260	MICROMETEORITIC
	007	76	36	120	UNKNOWN
	008	87	30	70	UNKNOWN
	009	94	32	150	MICROMETEORITIC
	010	95	27	90	MICROMETEORITIC
	011	86	43	180	UNKNOWN

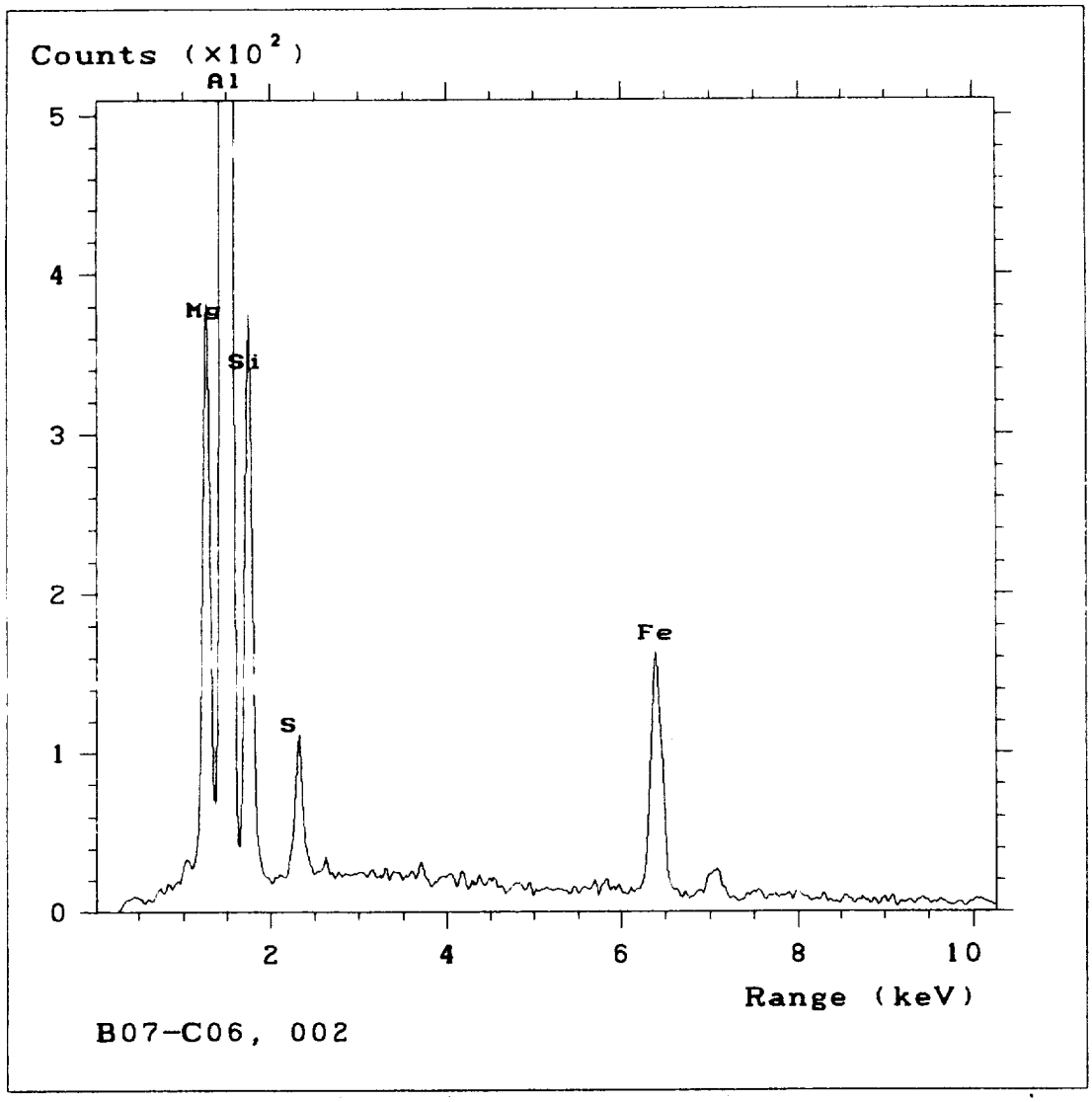


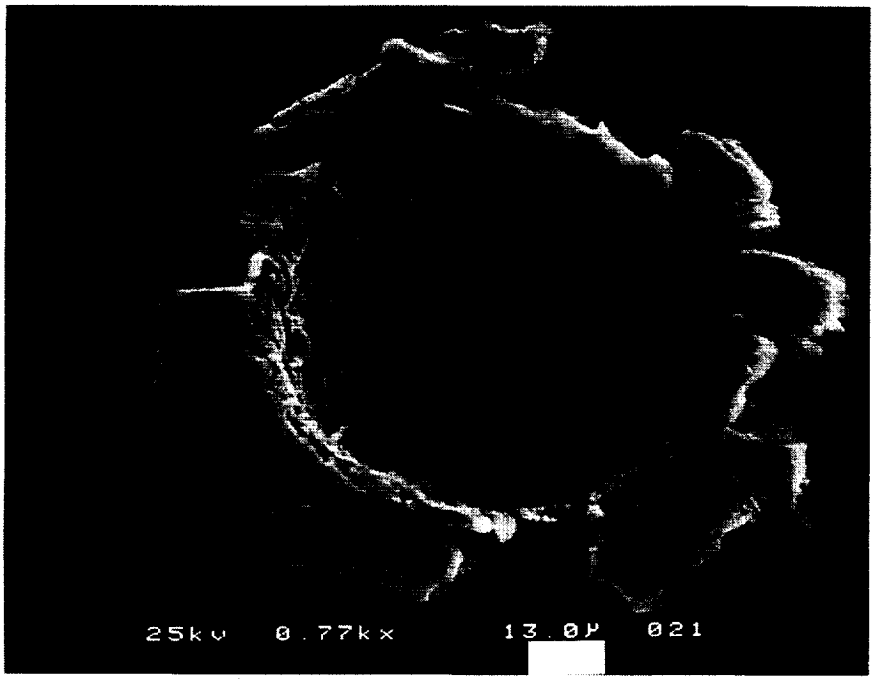
B07-C06


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B07-C06, 001

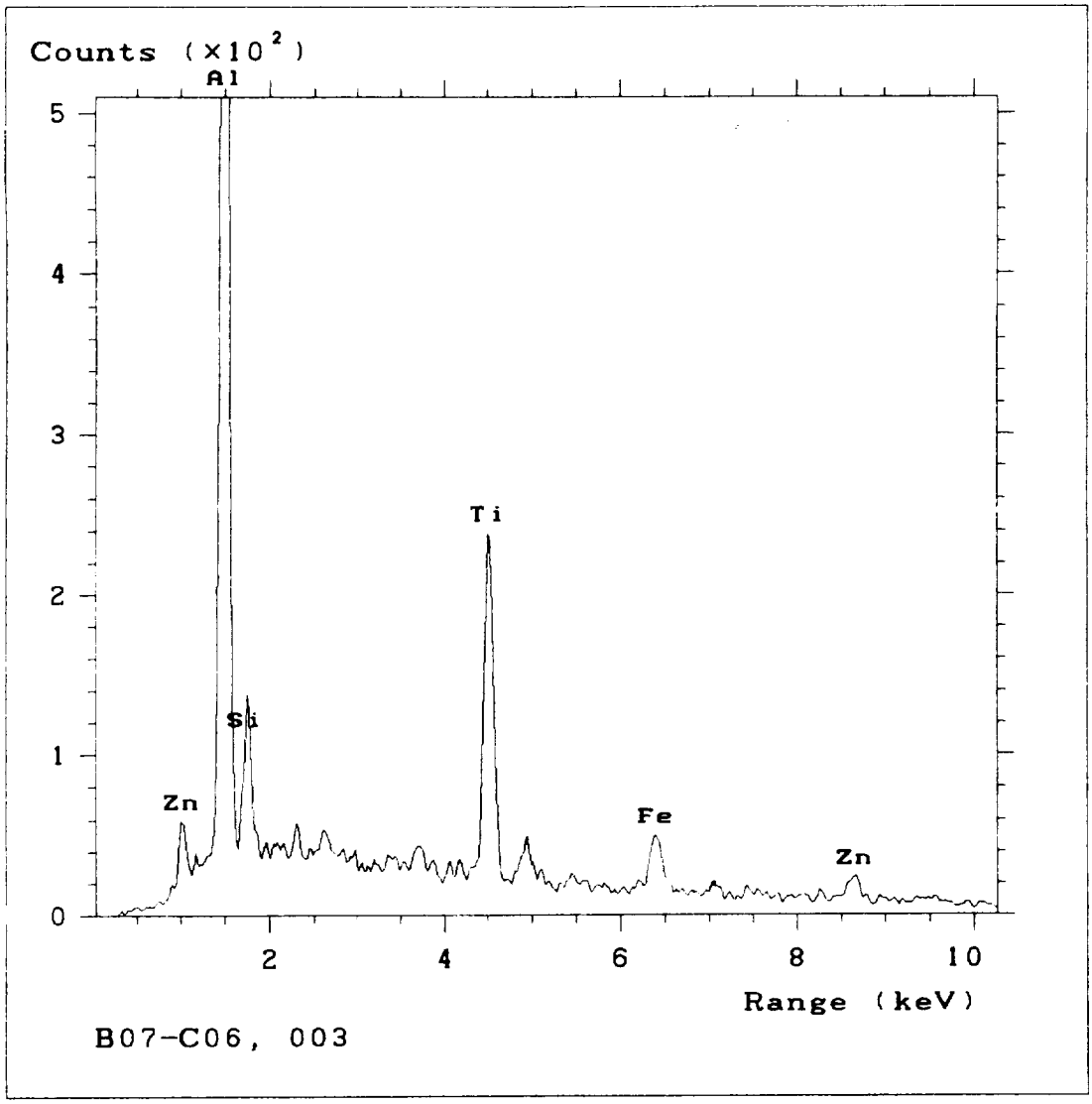

25kv 0.38kx 26.0µ 015

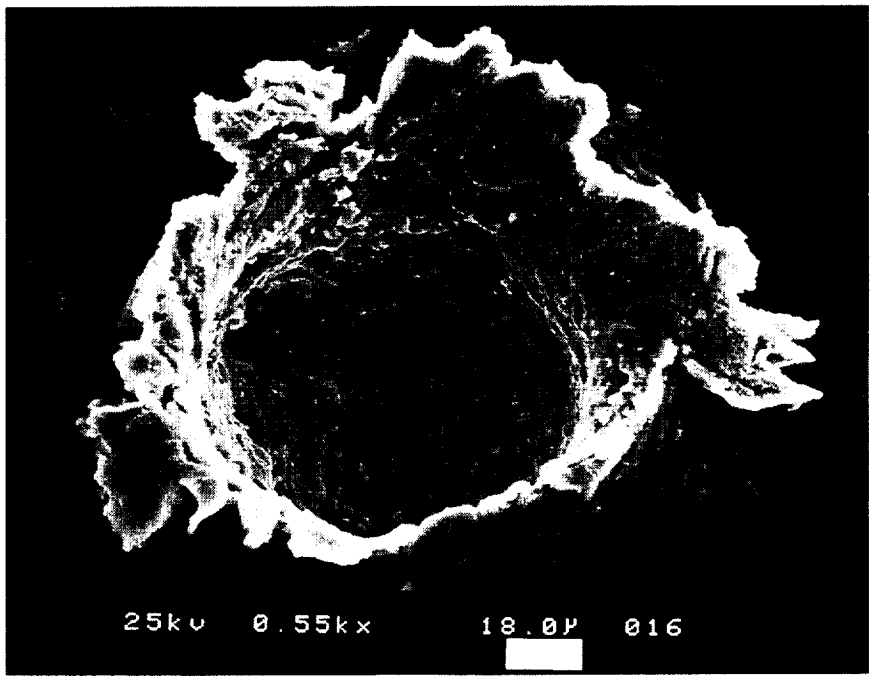
B07-C06 001


Counts (×10²)
Al
Mg
Si
S
Fe
5
4
3
2
1
0
2
4
6
8
10
Range (keV)
B07-C06, 002

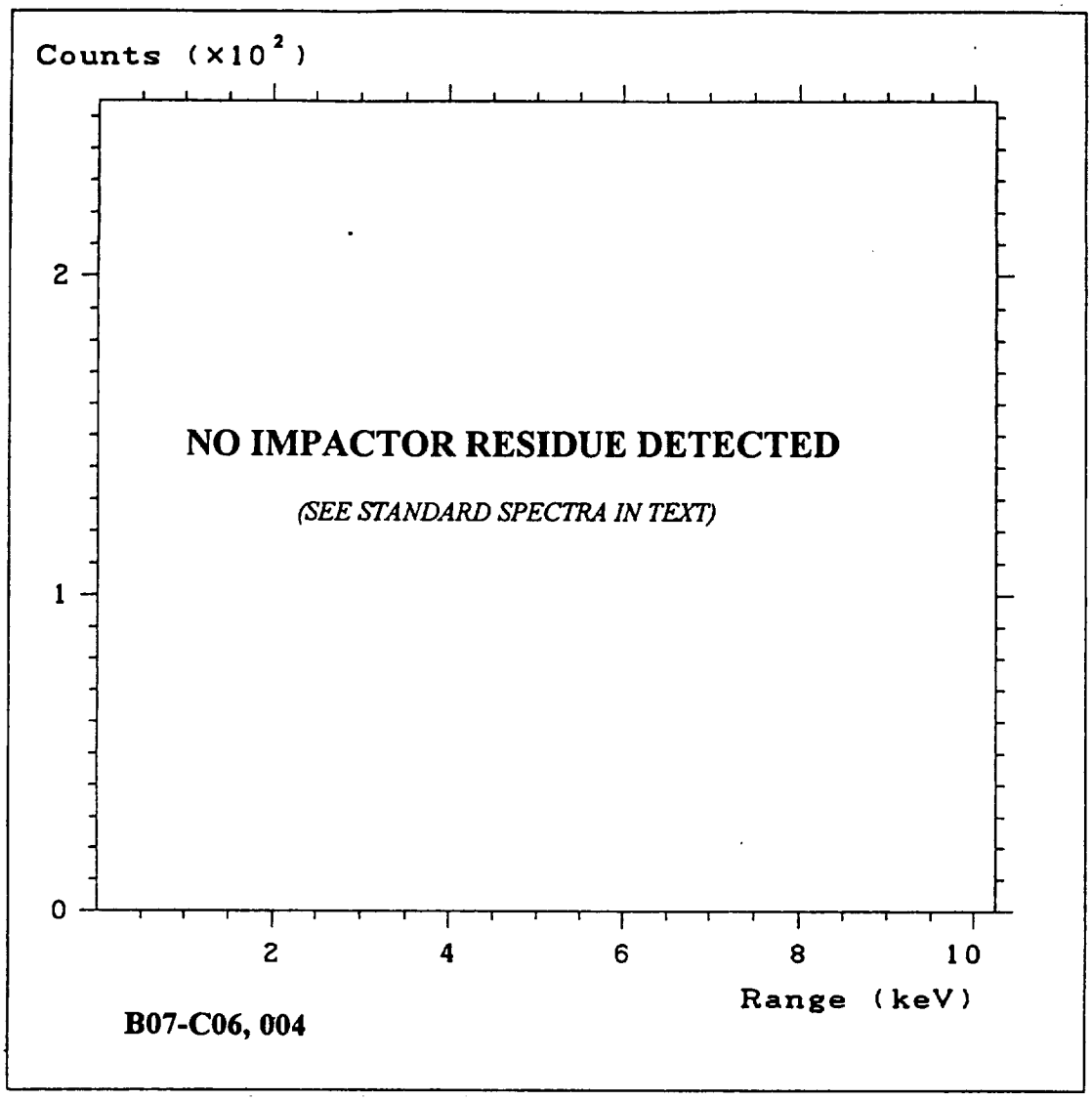

25kv 0.77kx 13.0µ 021

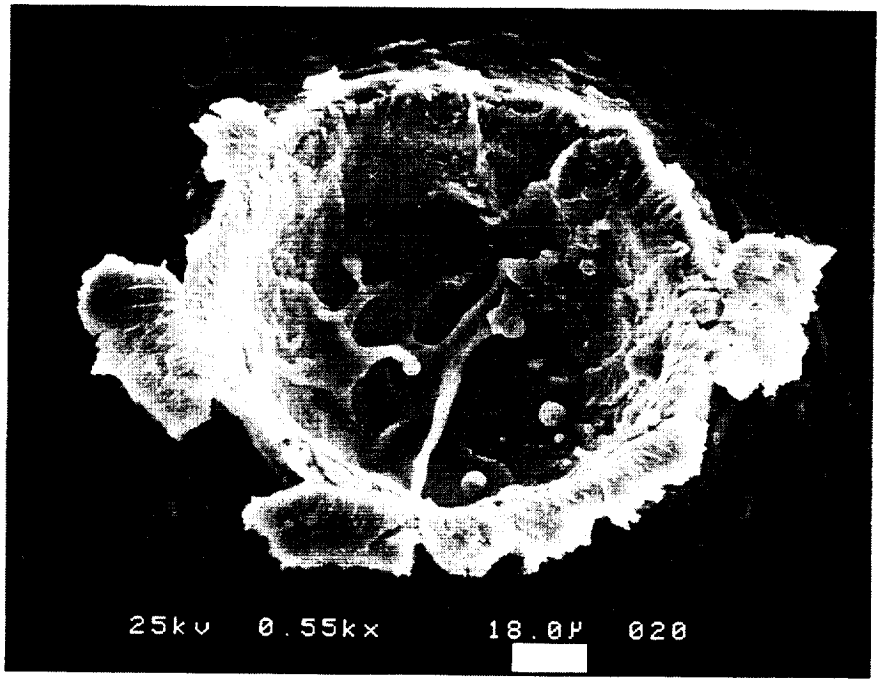
B07-C06 002



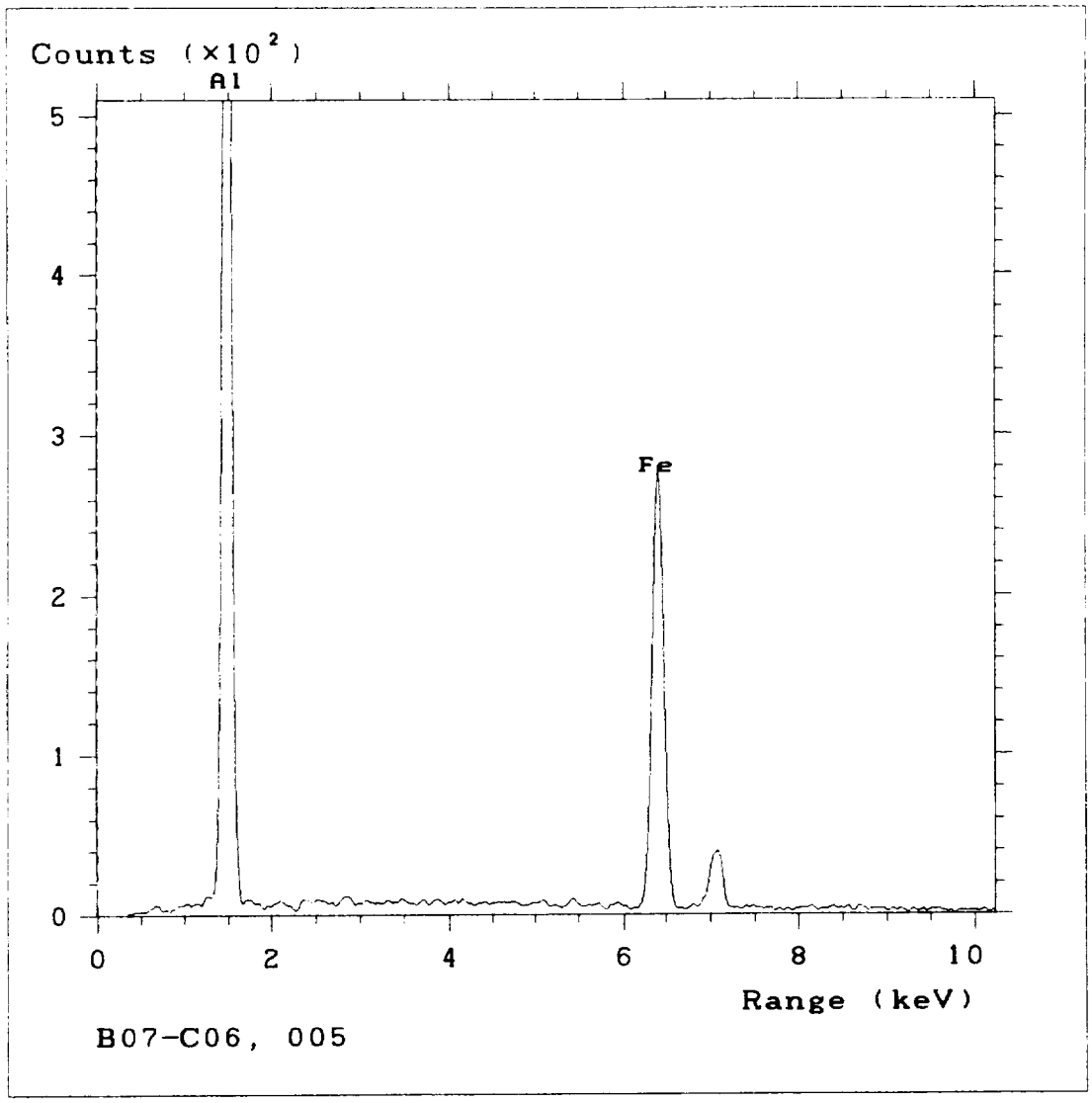


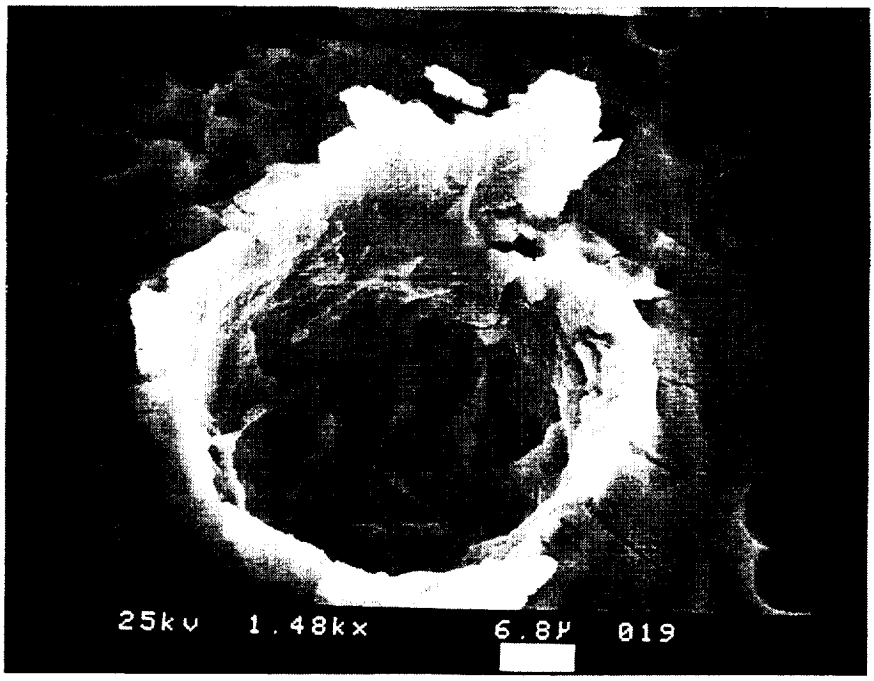
B07-C06 003 PANT


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B07-C06, 004

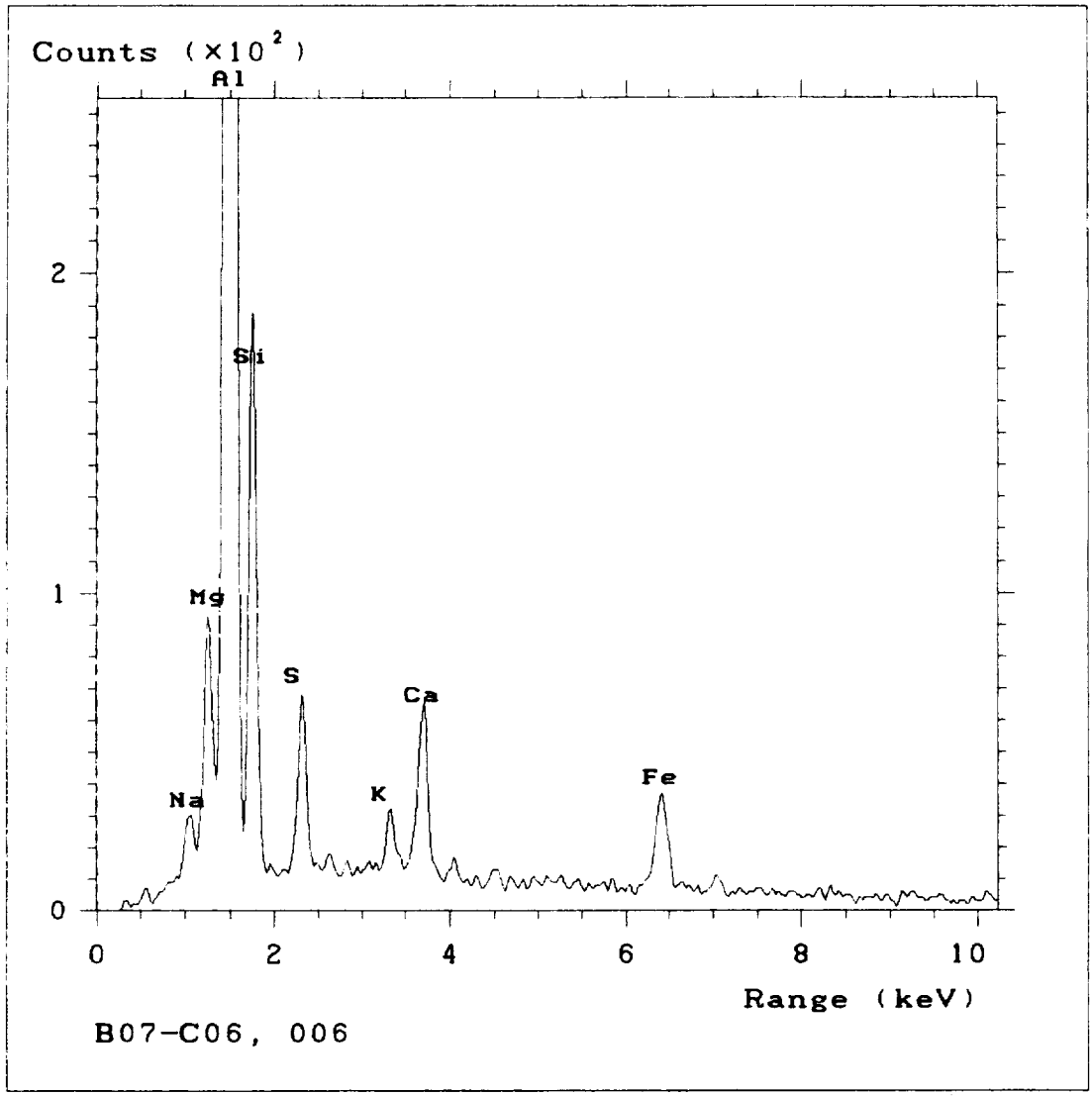

25kv 0.55kx 18.0µ 020

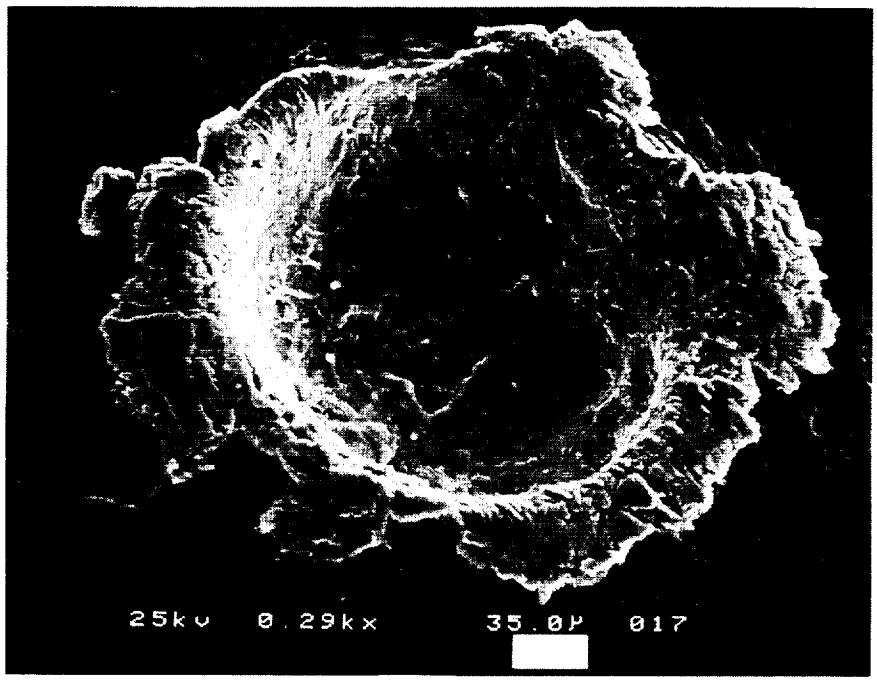
B07-C06 004


Counts (×10²)
Al
Fe
5
4
3
2
1
0
0
2
4
6
8
10
Range (keV)
B07-C06, 005

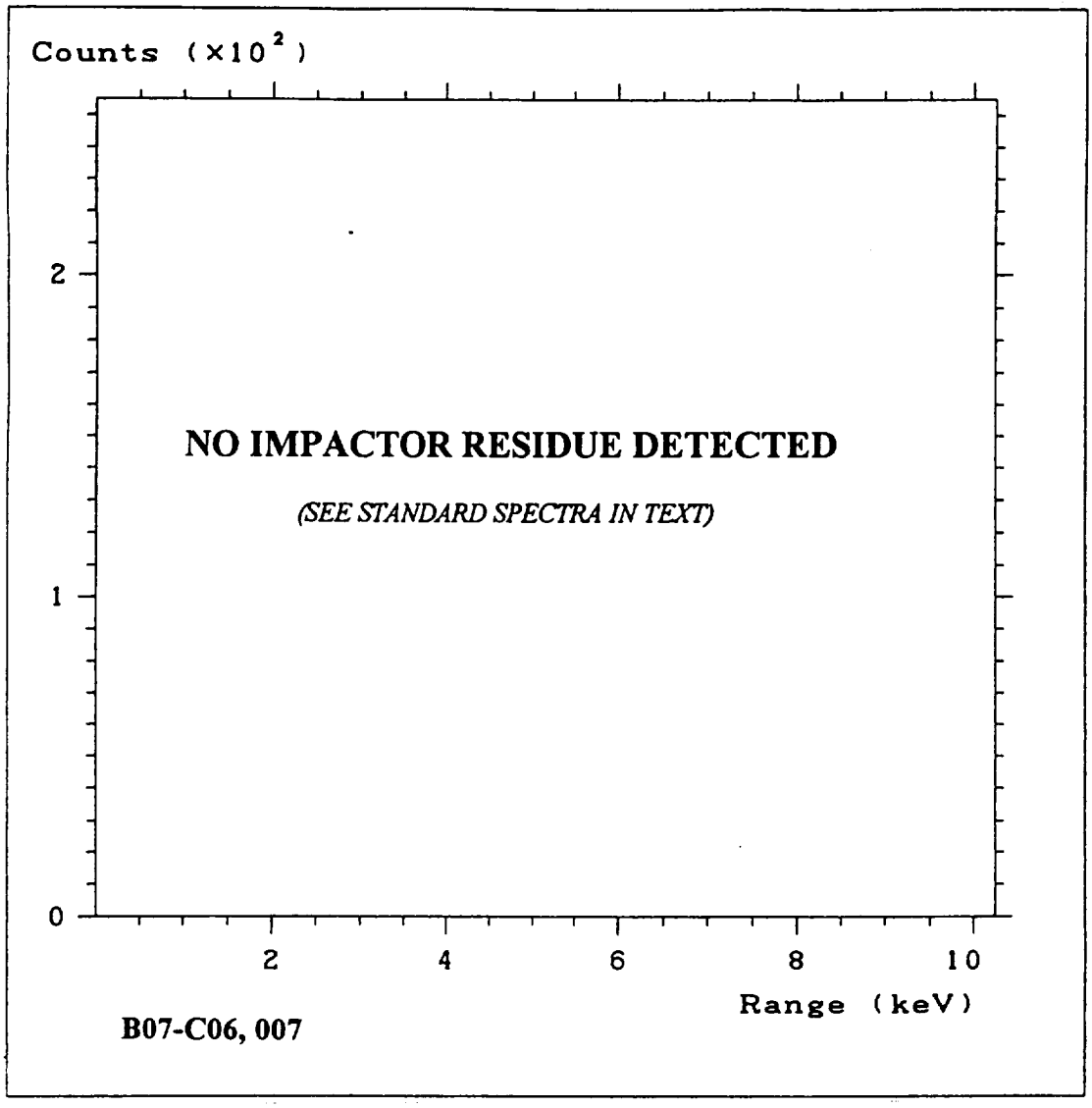

25kv 1.48kx 6.8μ 019

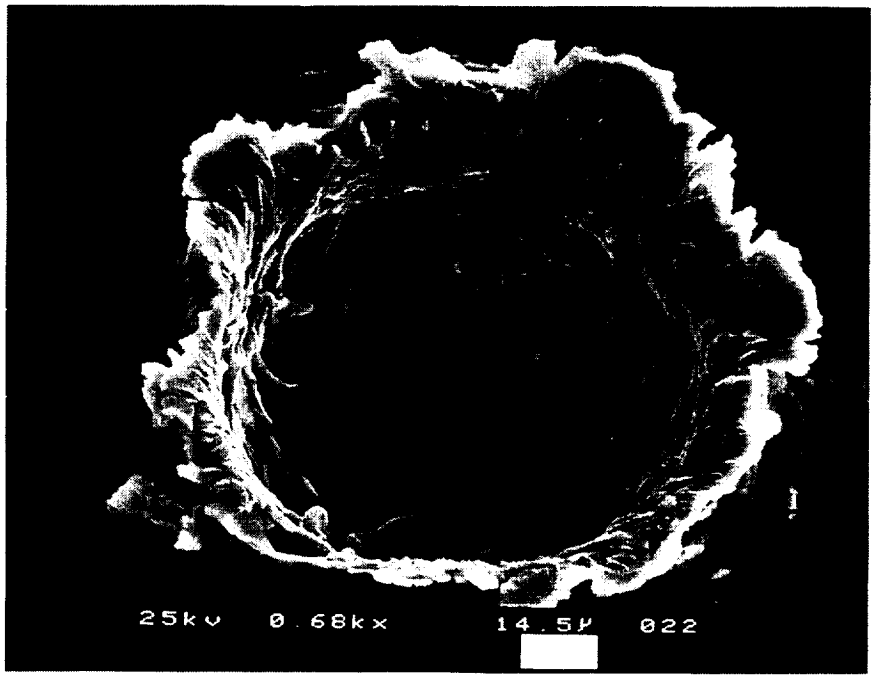
B07-C06 005


Counts (x10²)
Al
Si
Mg
S
Ca
K
Na
Fe
0
1
2
0
2
4
6
8
10
Range (keV)
B07-C06, 006

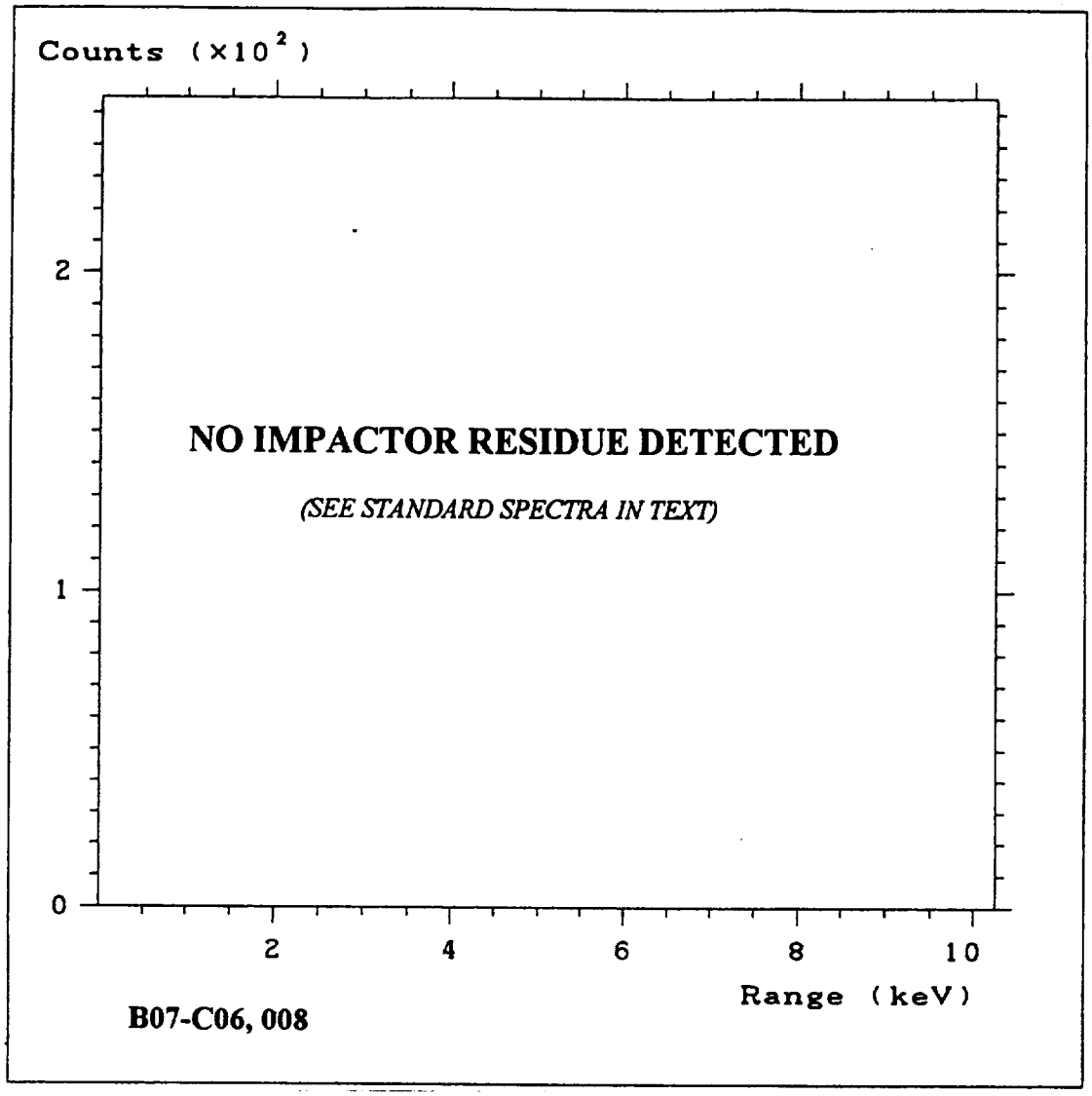

25kv 0.29kx 35.0µ 017

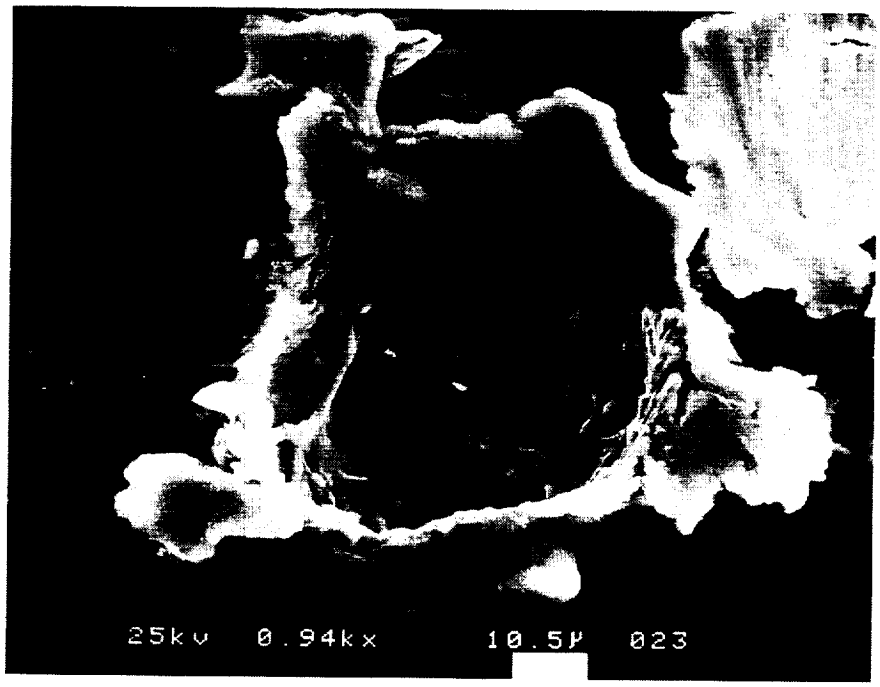
B07- C06 35 MM


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B07-C06, 007

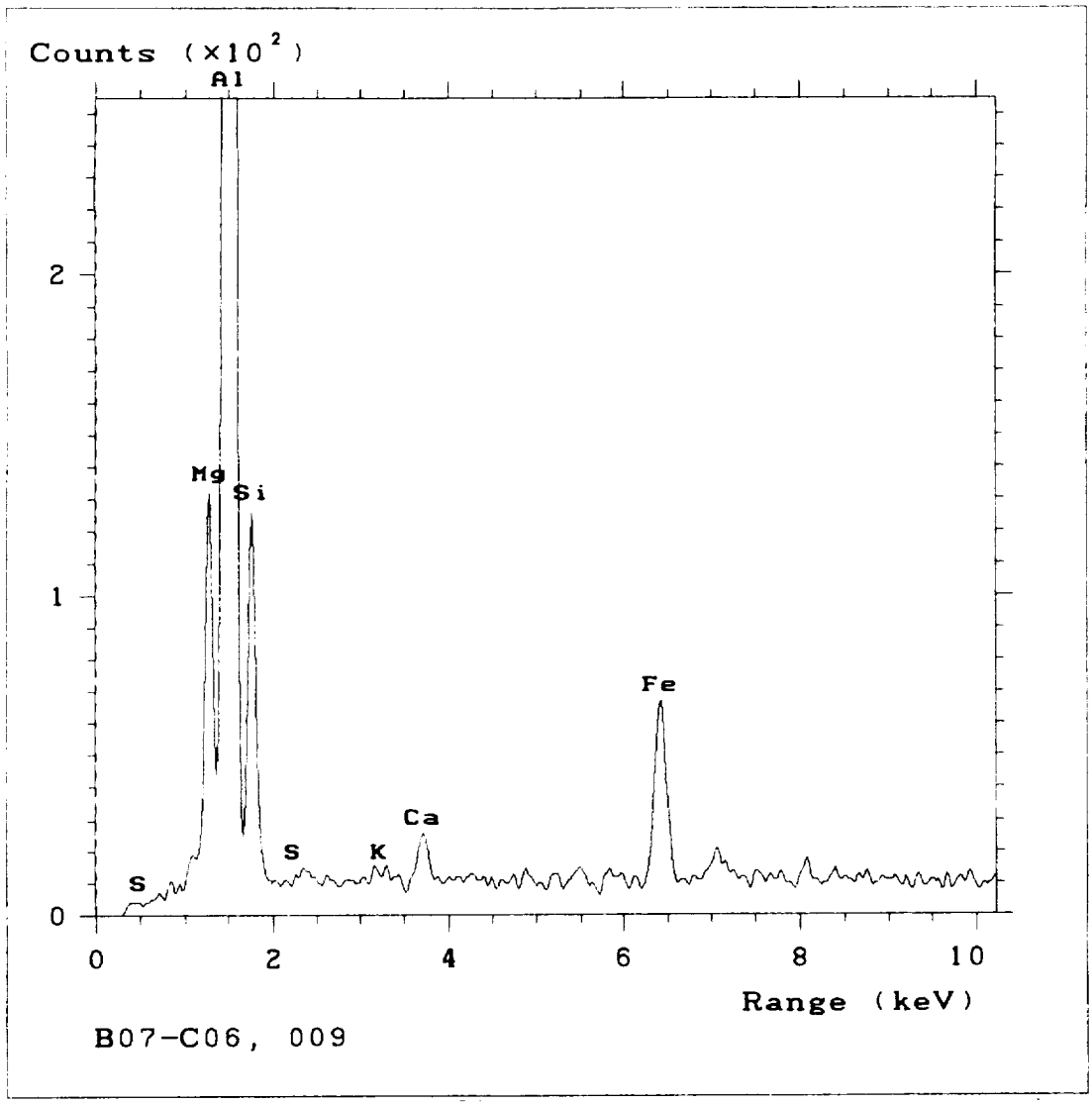

25kv 0.68kx 14.5μ 022

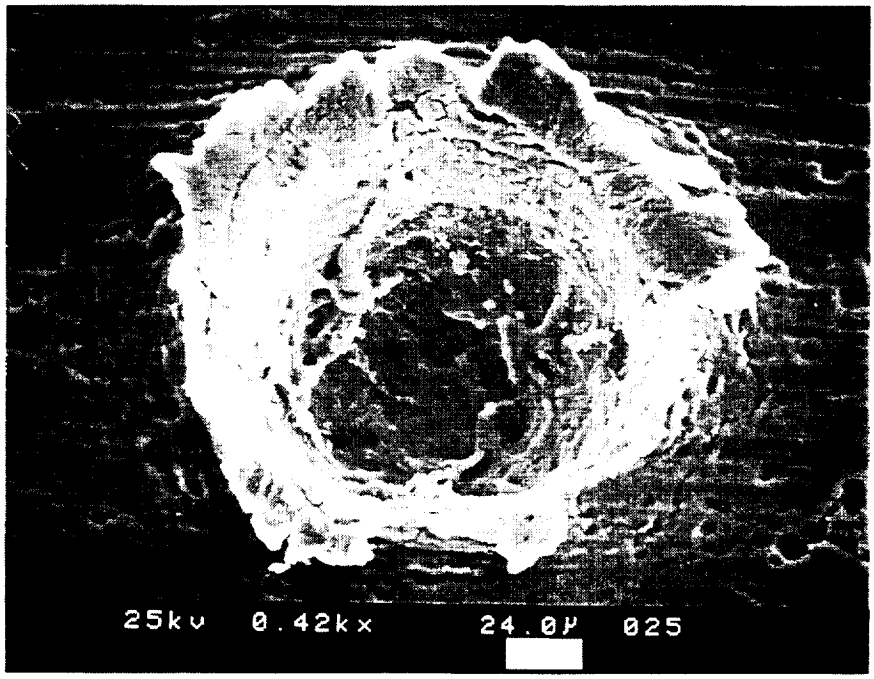
B07-C06 007


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B07-C06, 008


25kv 0.94kx 10.5µ 023

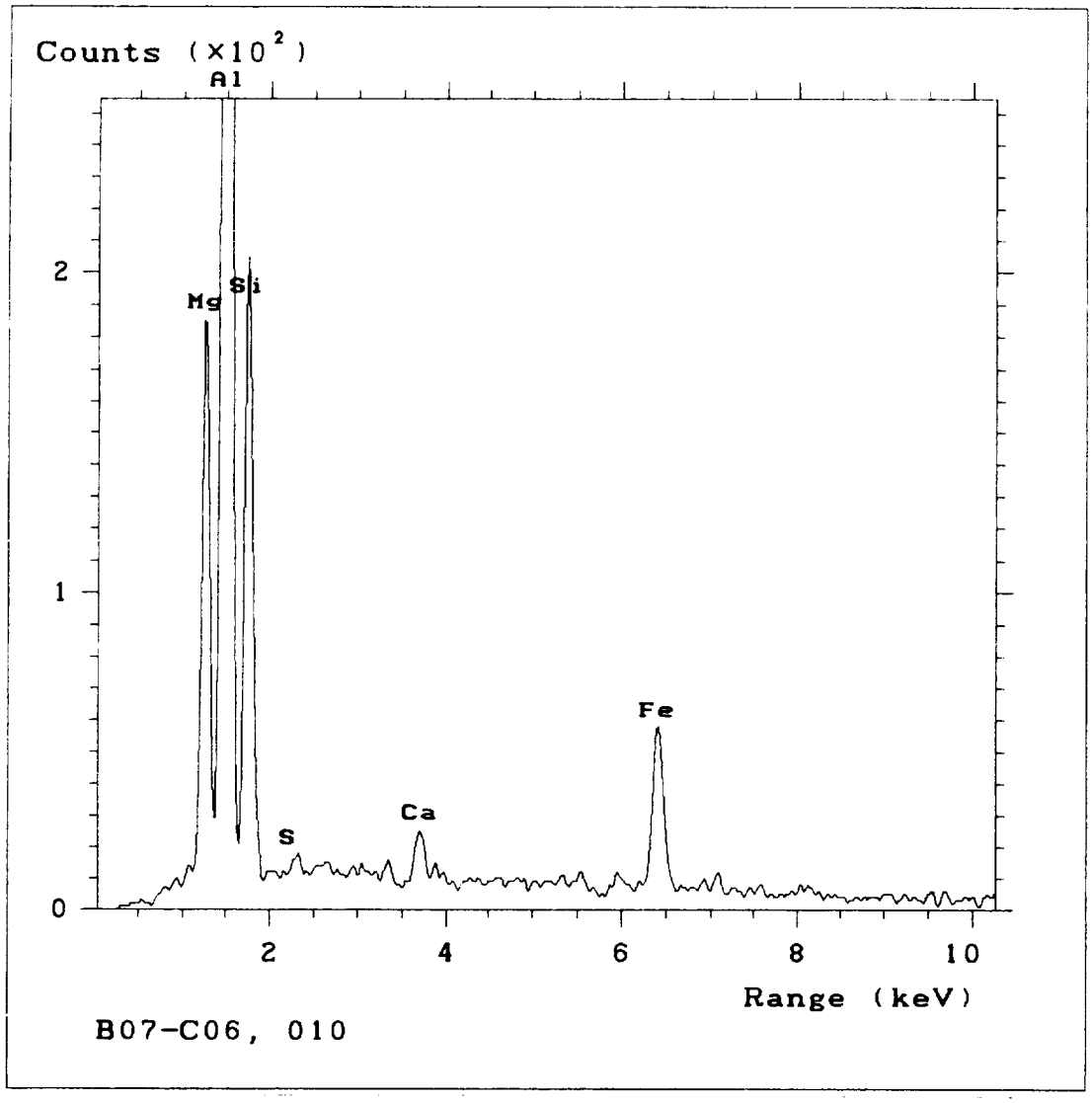
B07-C06 008

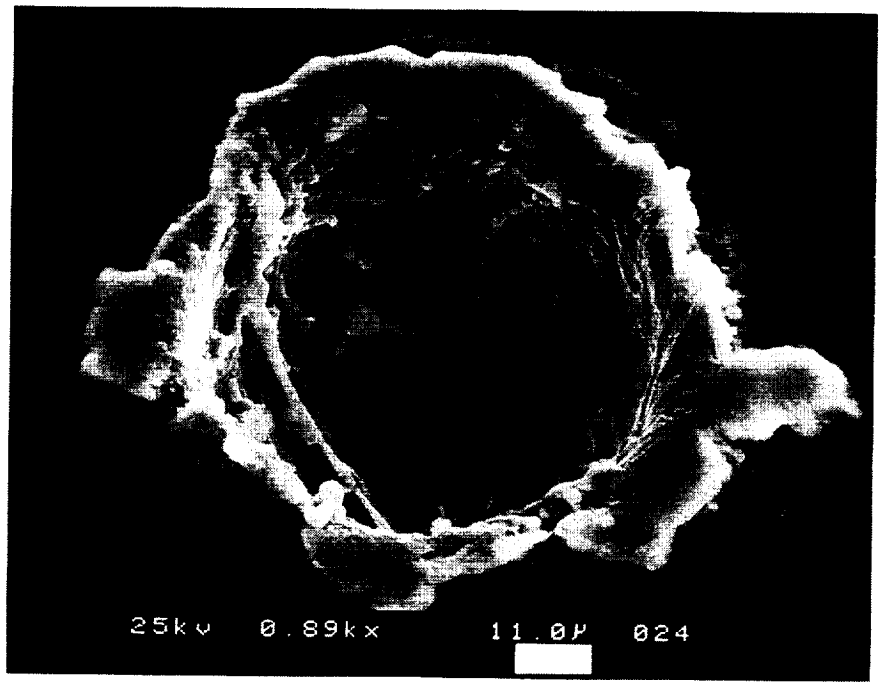




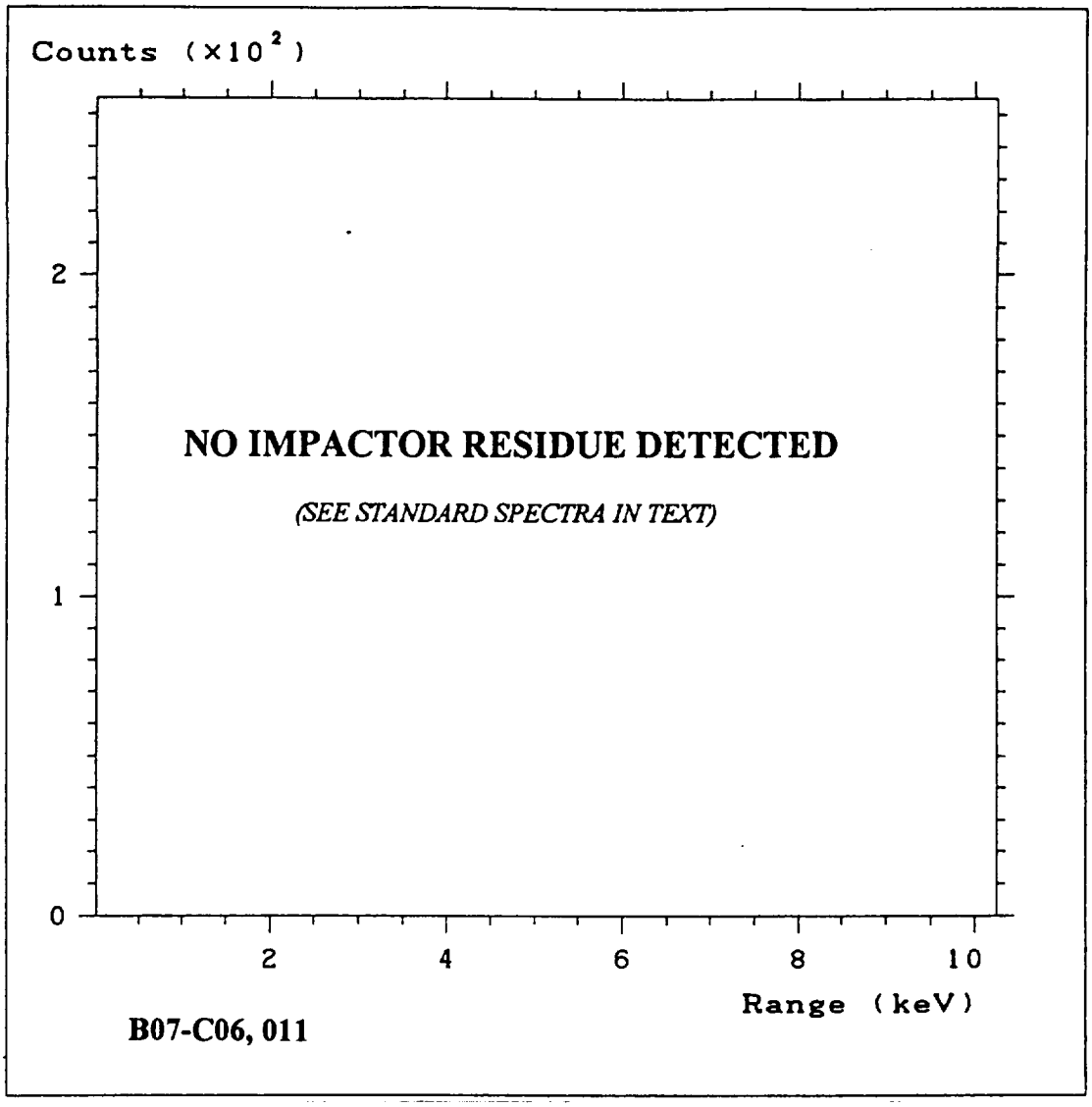
B07-C06 009 inm

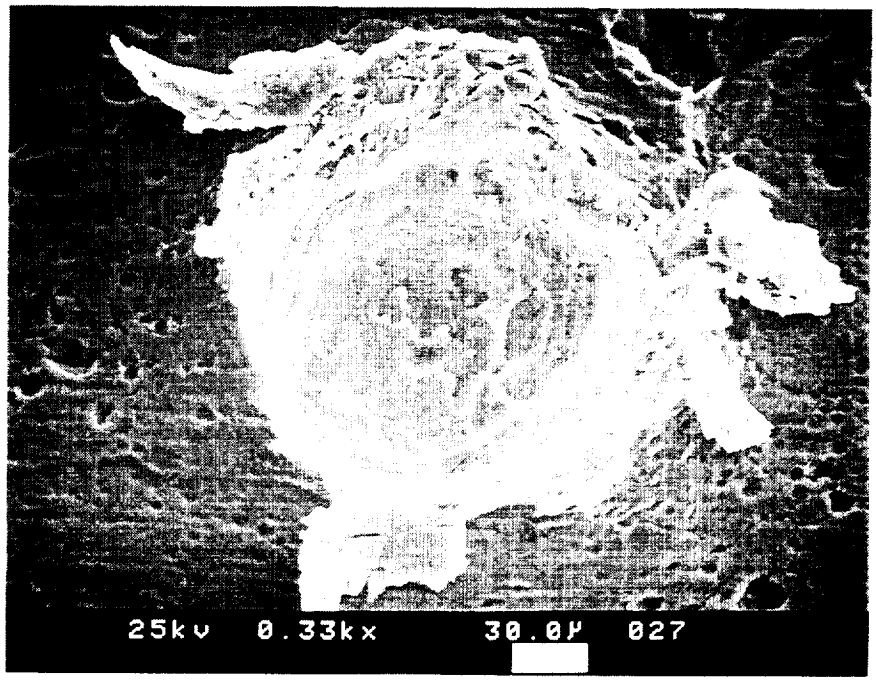
C-2


Counts (×10²)
Al
Mg
Si
S
Ca
Fe
0
1
2
2
4
6
8
10
Range (keV)
B07-C06, 010


25kv 0.89kx 11.0μ 024

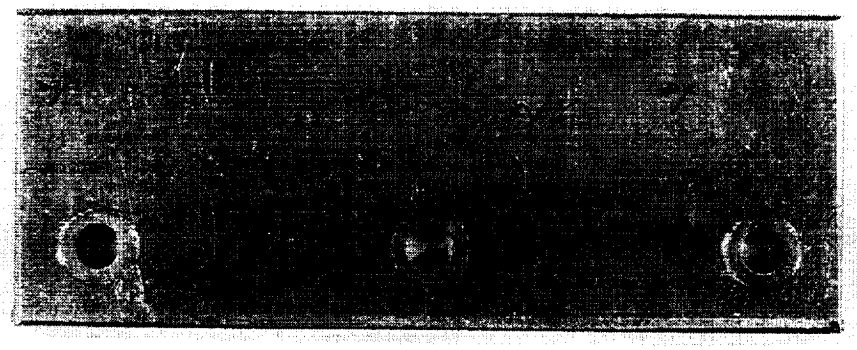
B07-C06 010


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B07-C06, 011

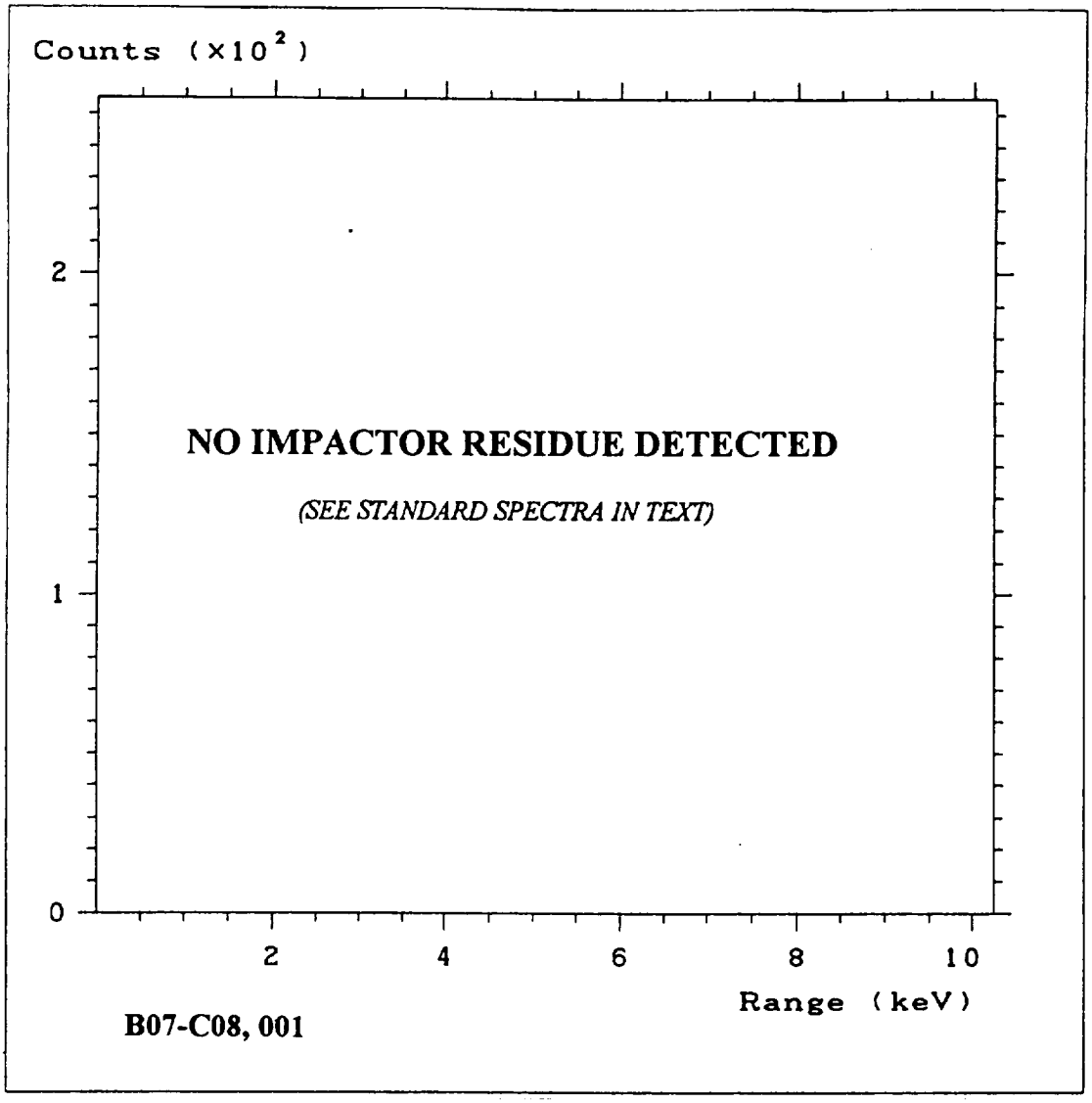

25kv 0.33kx 30.0µ 027

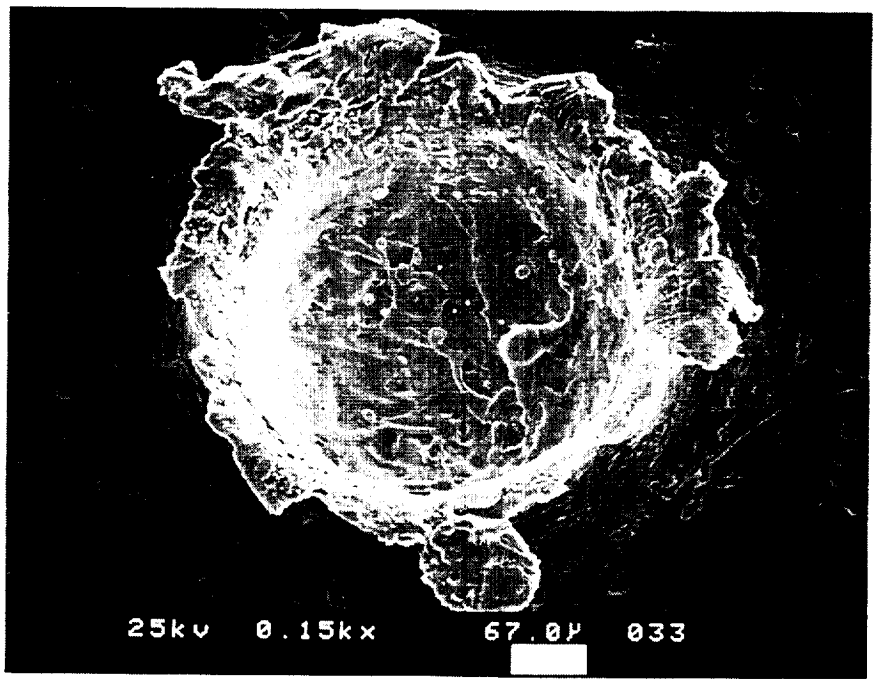
B07-C06 011

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B07-C08	001	3	8	500	UNKNOWN
	002	8	105	140	MICROMETEORITIC
	003	17	44	50	PAINT
	004	28	16	270	MICROMETEORITIC
	005	34	48	150	UNKNOWN
	006	30	111	120	UNKNOWN
	007	37	120	250	MICROMETEORITIC
	008	39	26	200	STAINLESS STEEL

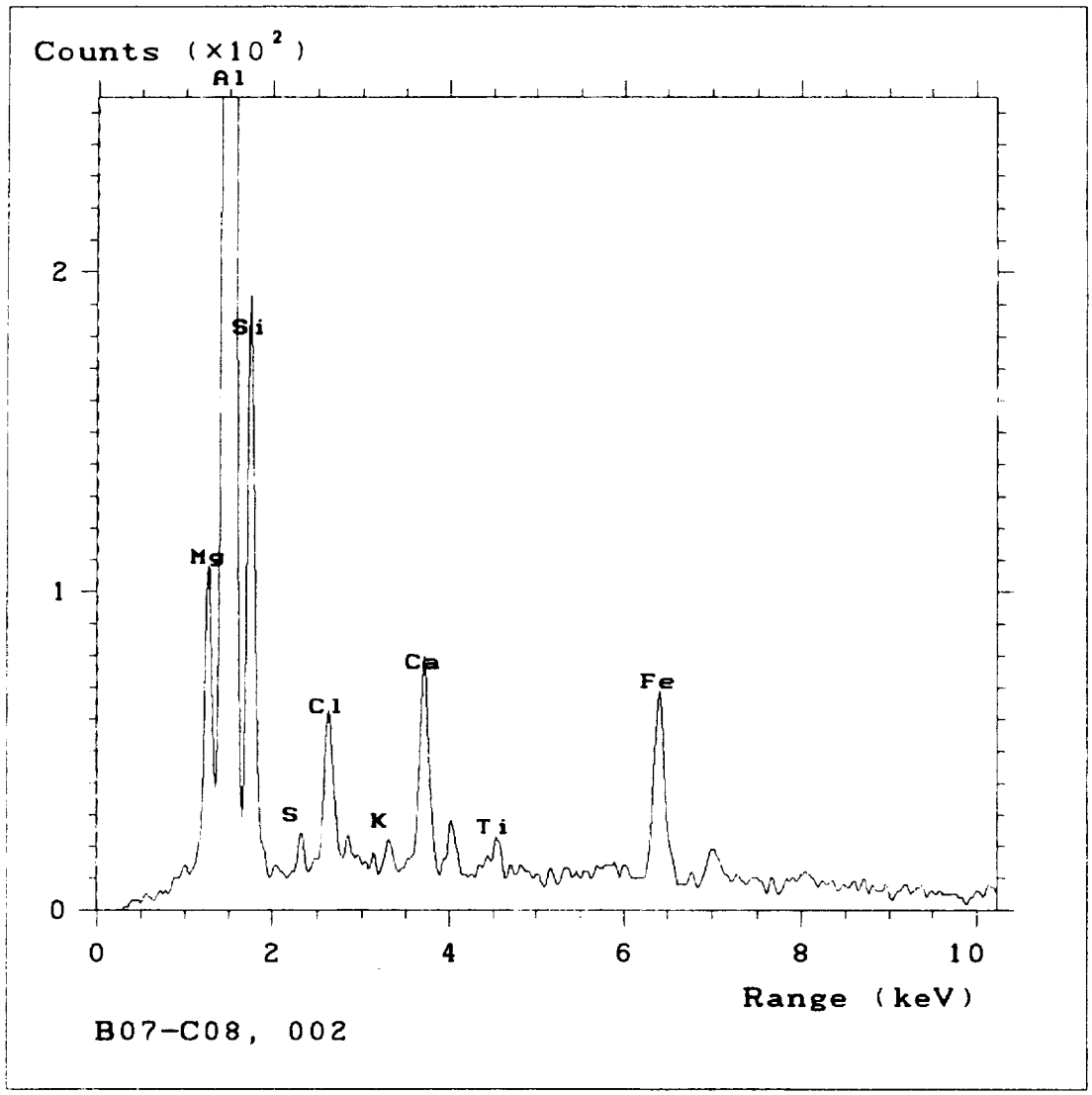


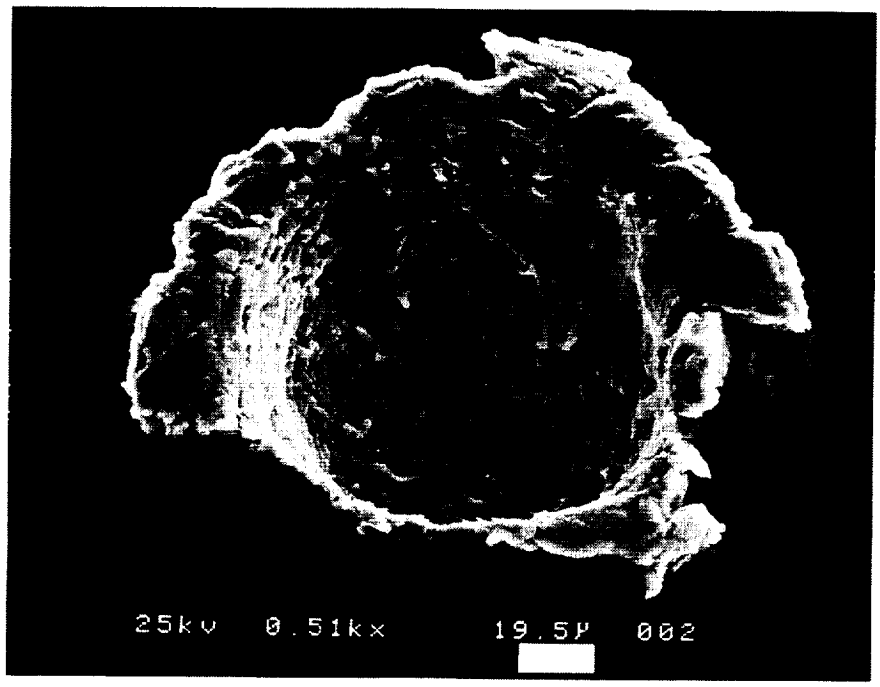
~~B08-C0~~ B07-C08


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B07-C08, 001

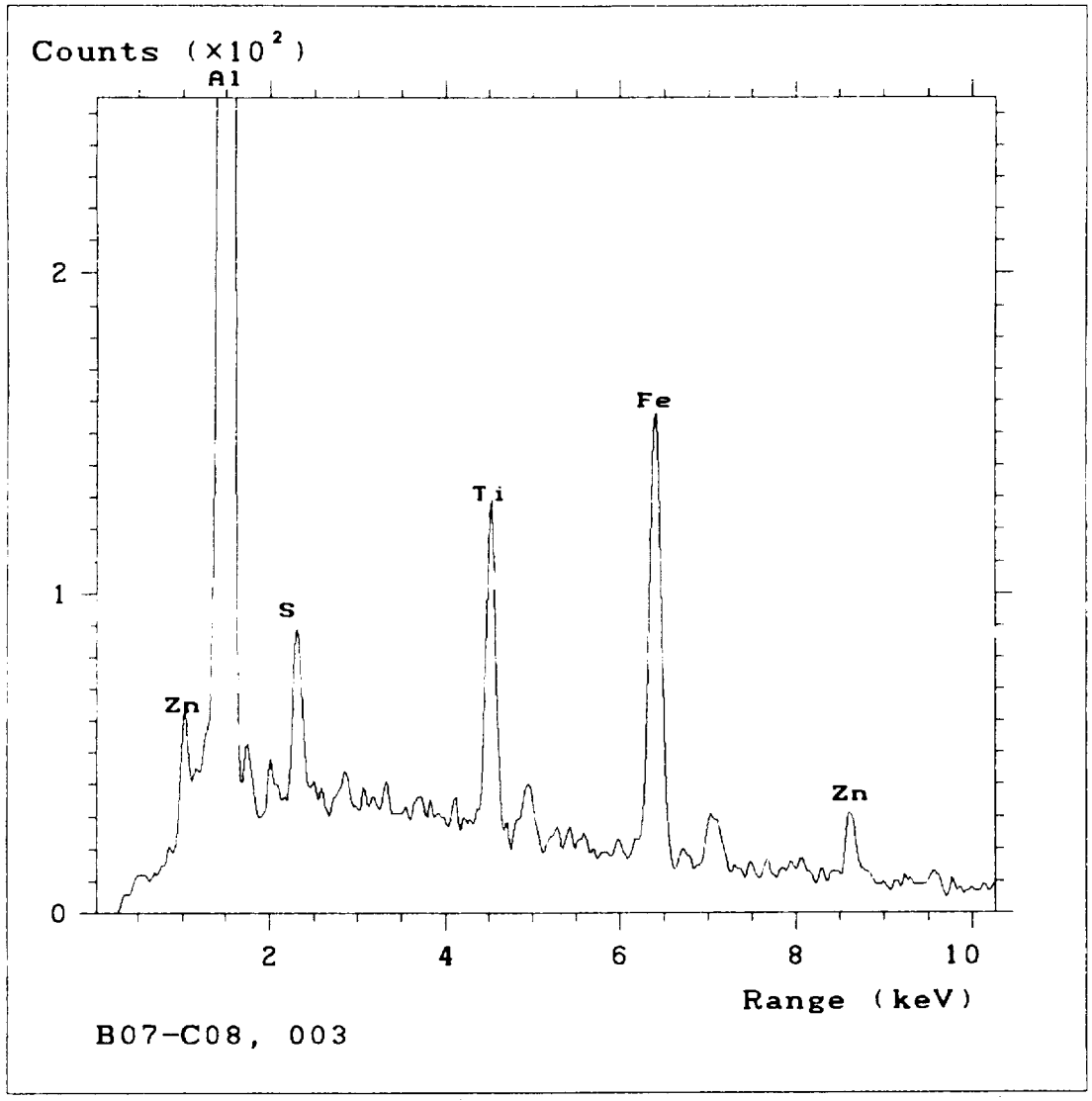

25kv 0.15kx 67.0µ 033

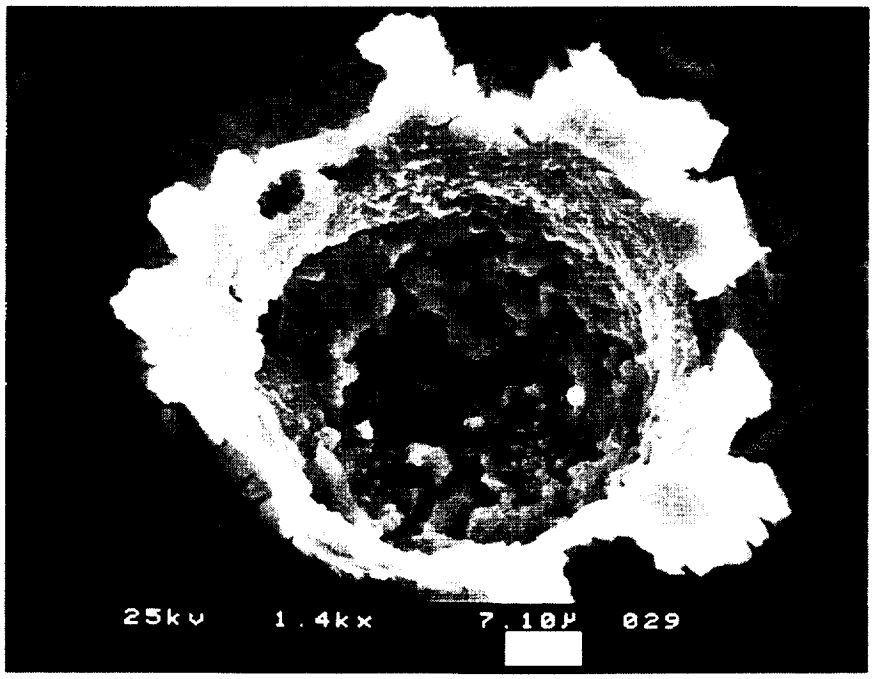
B07-C03 001


Counts (×10²)
Al
Si
Mg
Cl
Ca
Fe
S
K
Ti
0
1
2
0
2
4
6
8
10
Range (keV)
B07-C08, 002

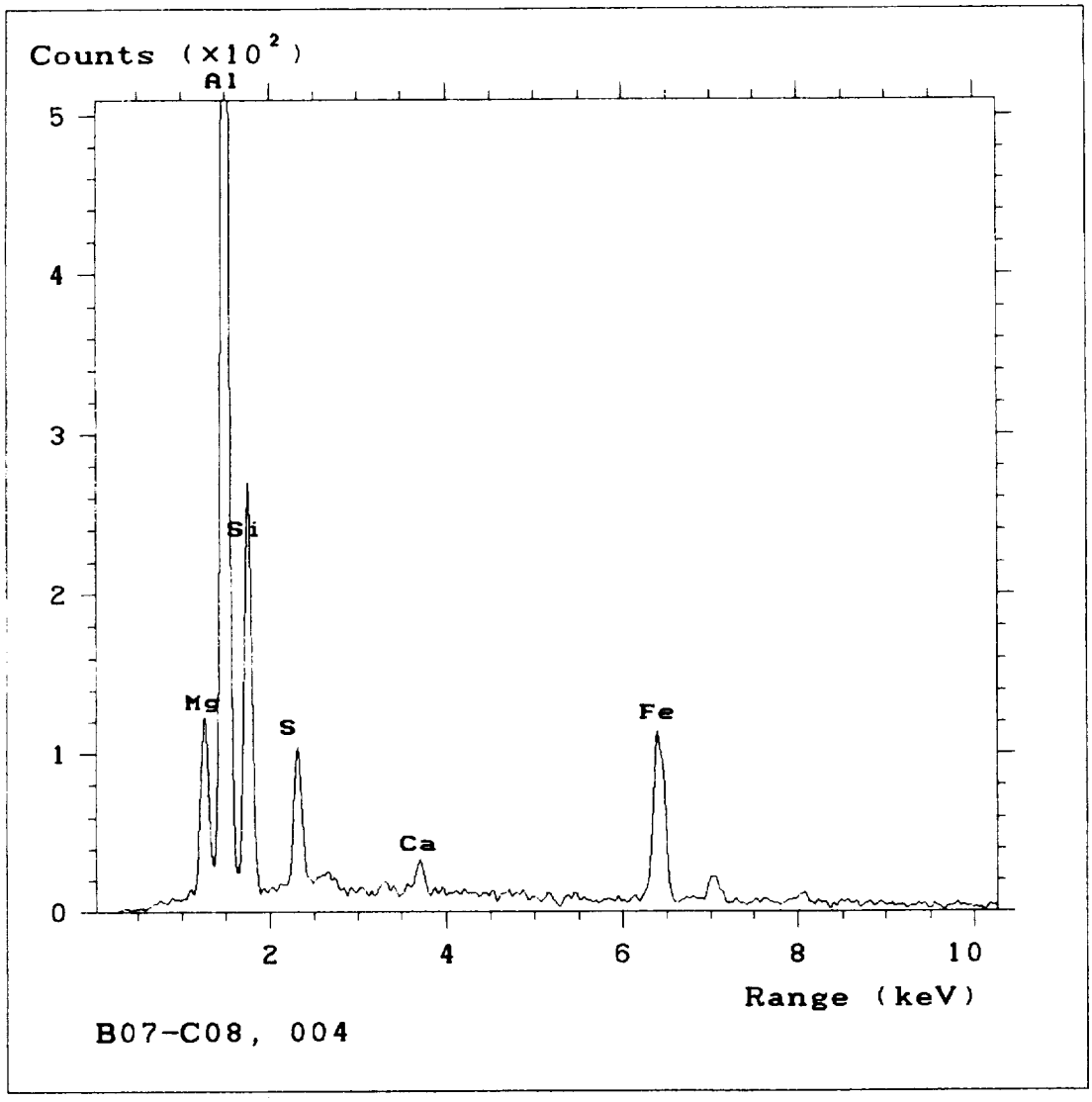

25kv 0.51kx 19.5μ 002

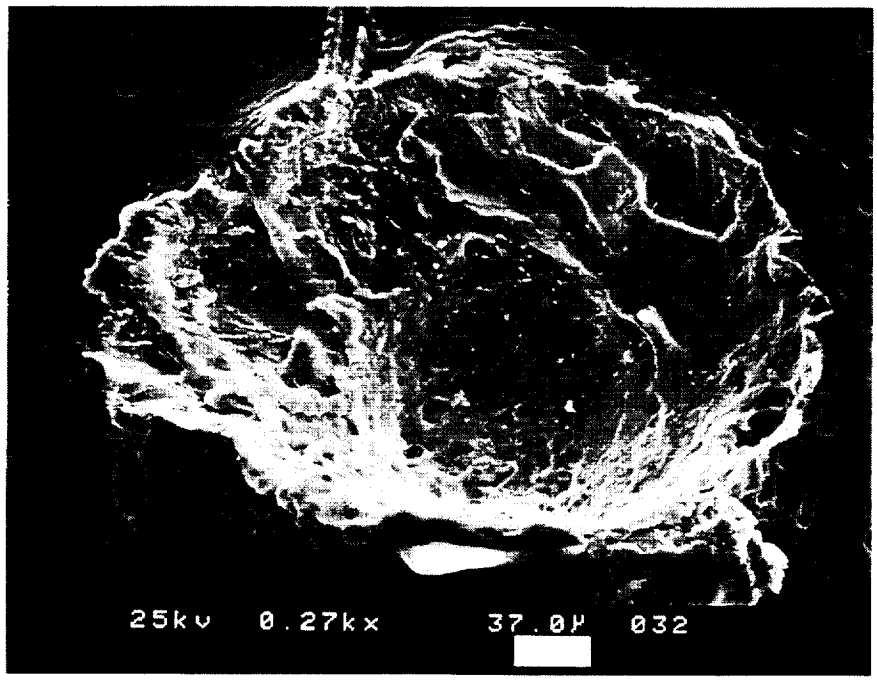
B07- C03 002


Counts (×10²)
Al
Zn
S
Ti
Fe
Zn
0
1
2
2
4
6
8
10
Range (keV)
B07-C08, 003

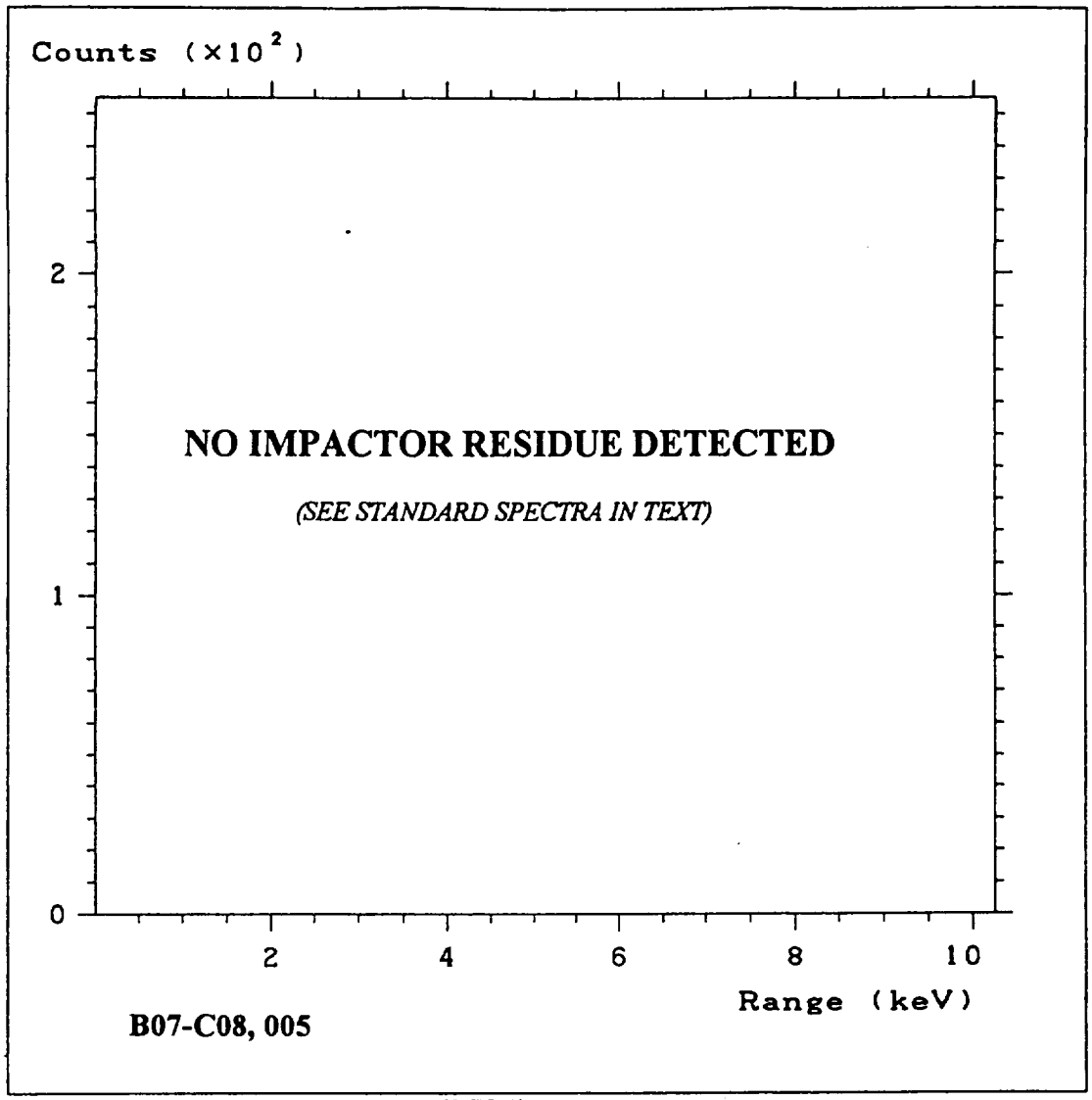

25kv 1.4kx 7.10μ 029

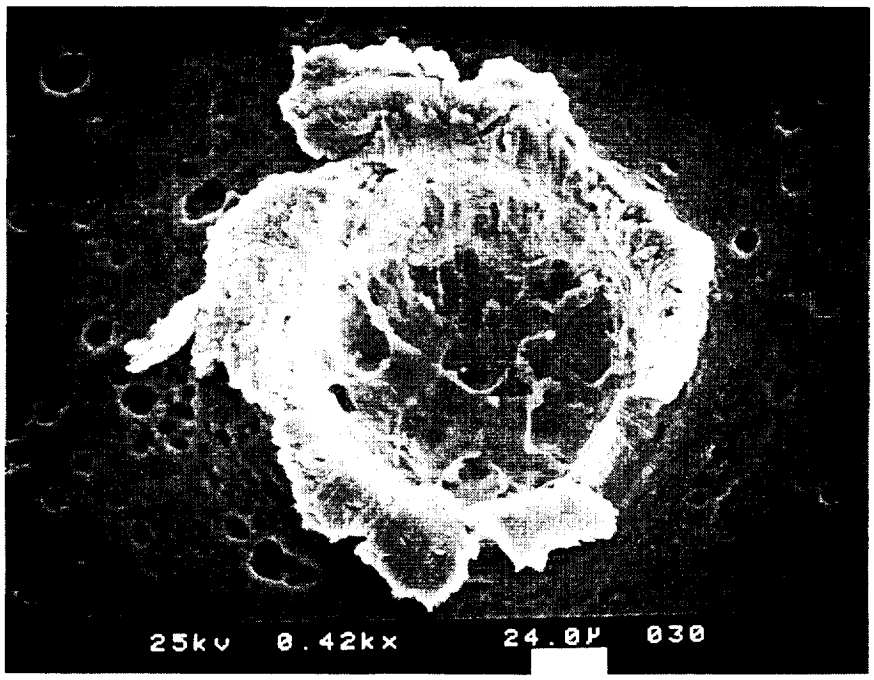
B07-C08 003



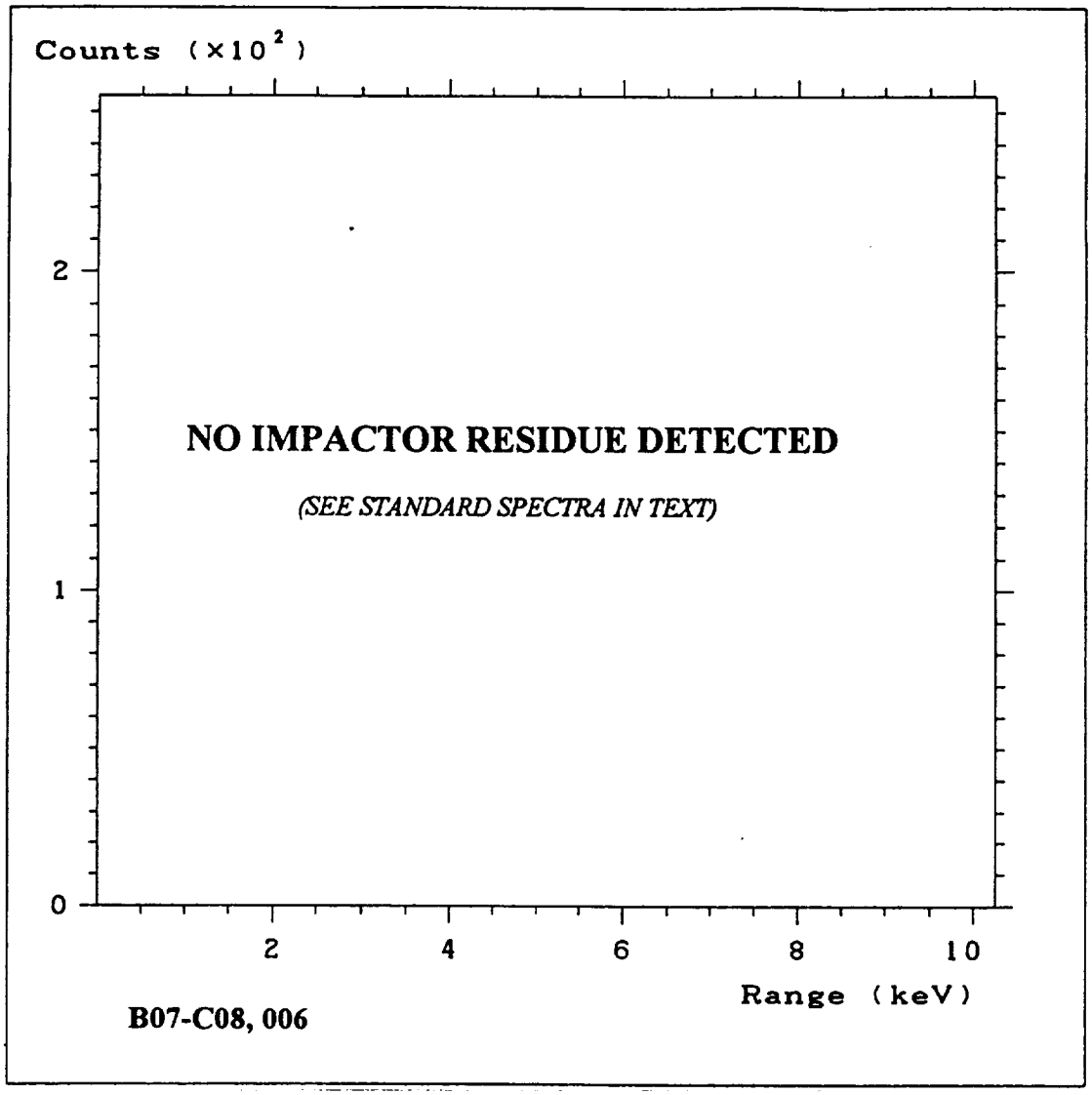


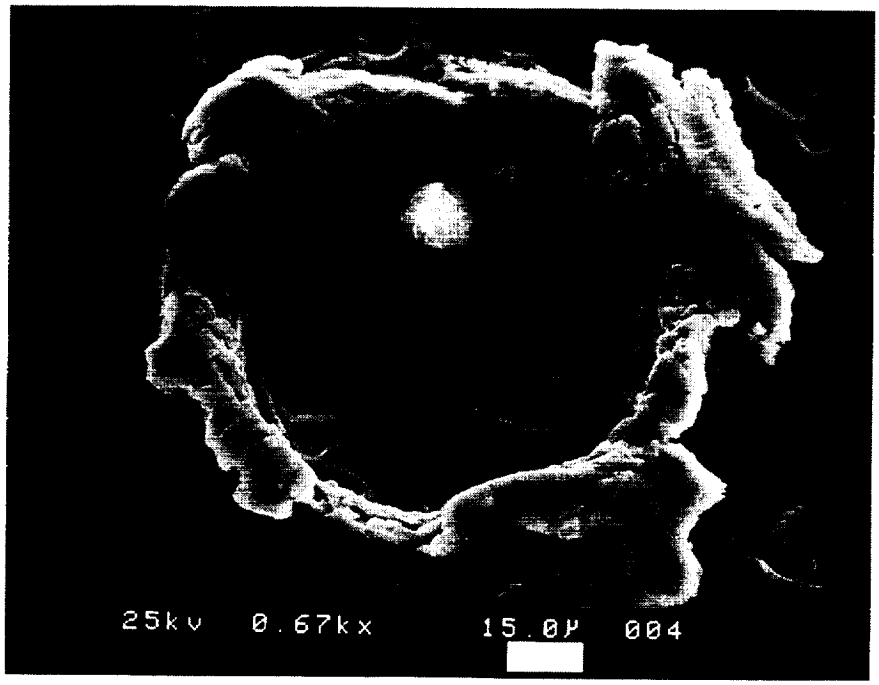
307-C08 004 MM


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B07-C08, 005

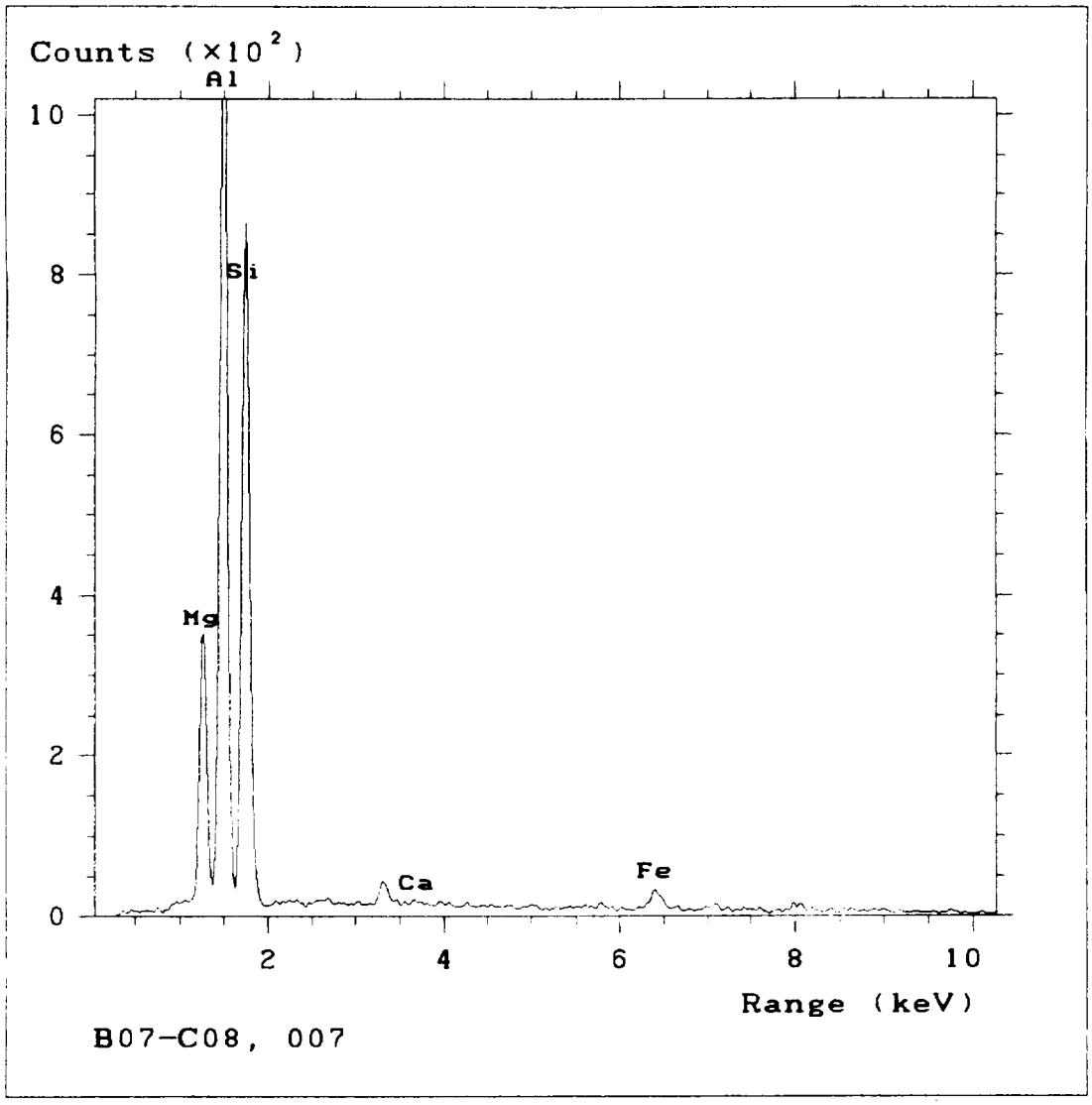

25kv 0.42kx 24.0µ 030

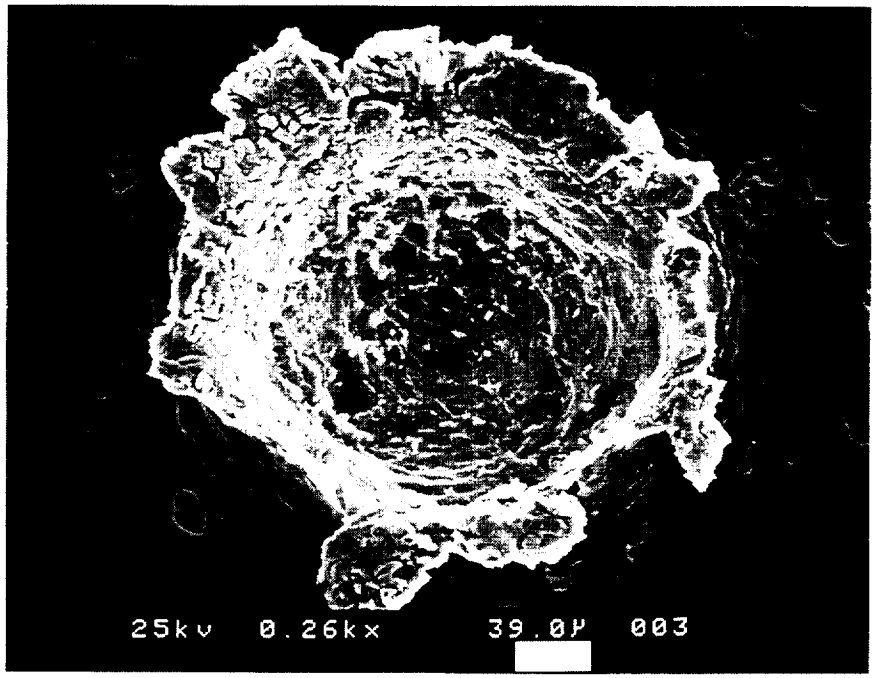
B07-C08 005


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B07-C08, 006

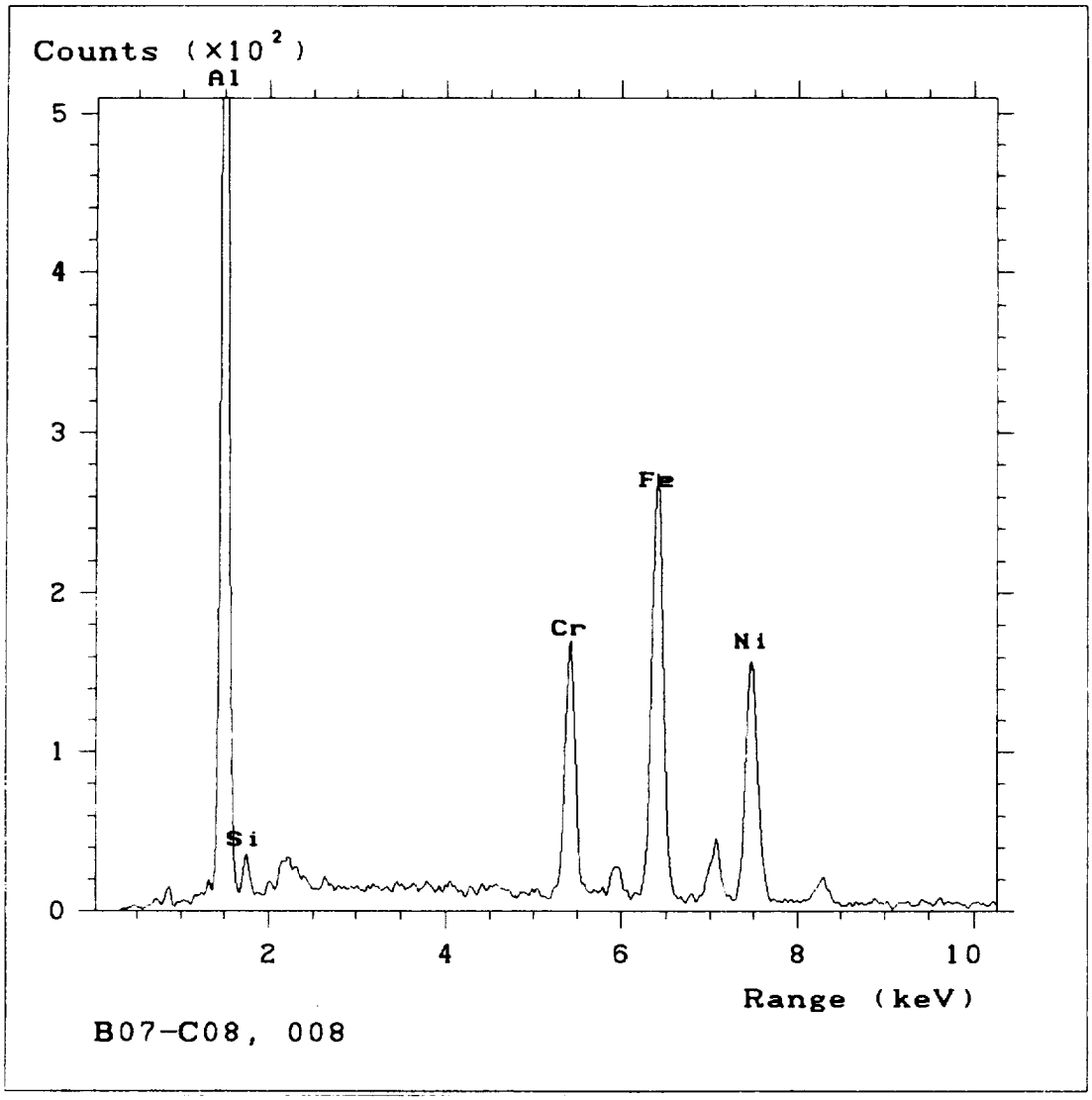

25kv 0.67kx 15.0μ 004

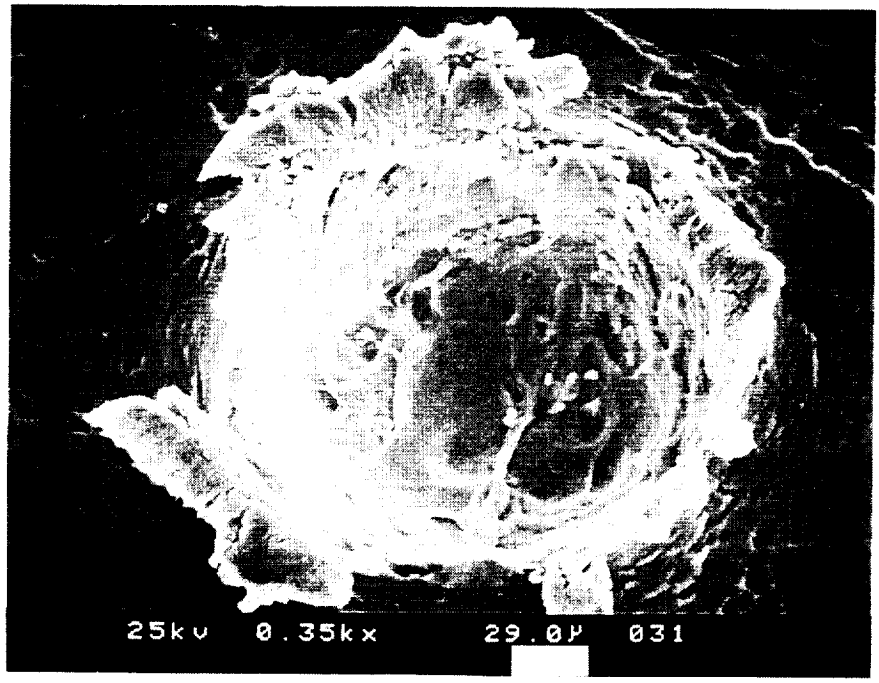
B07-C08 006





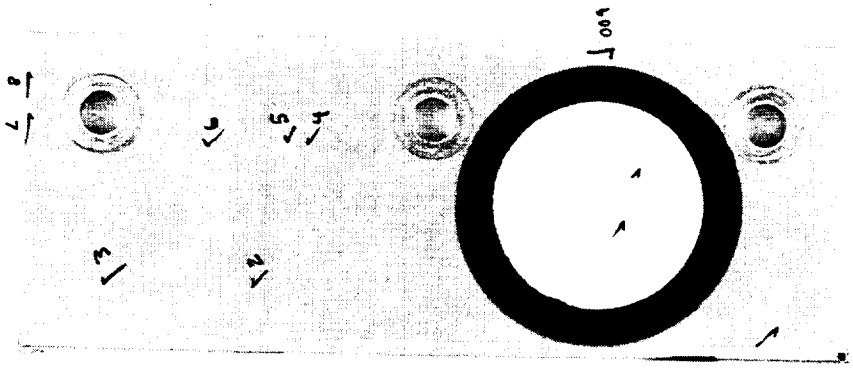
B07-C08 C07 mm



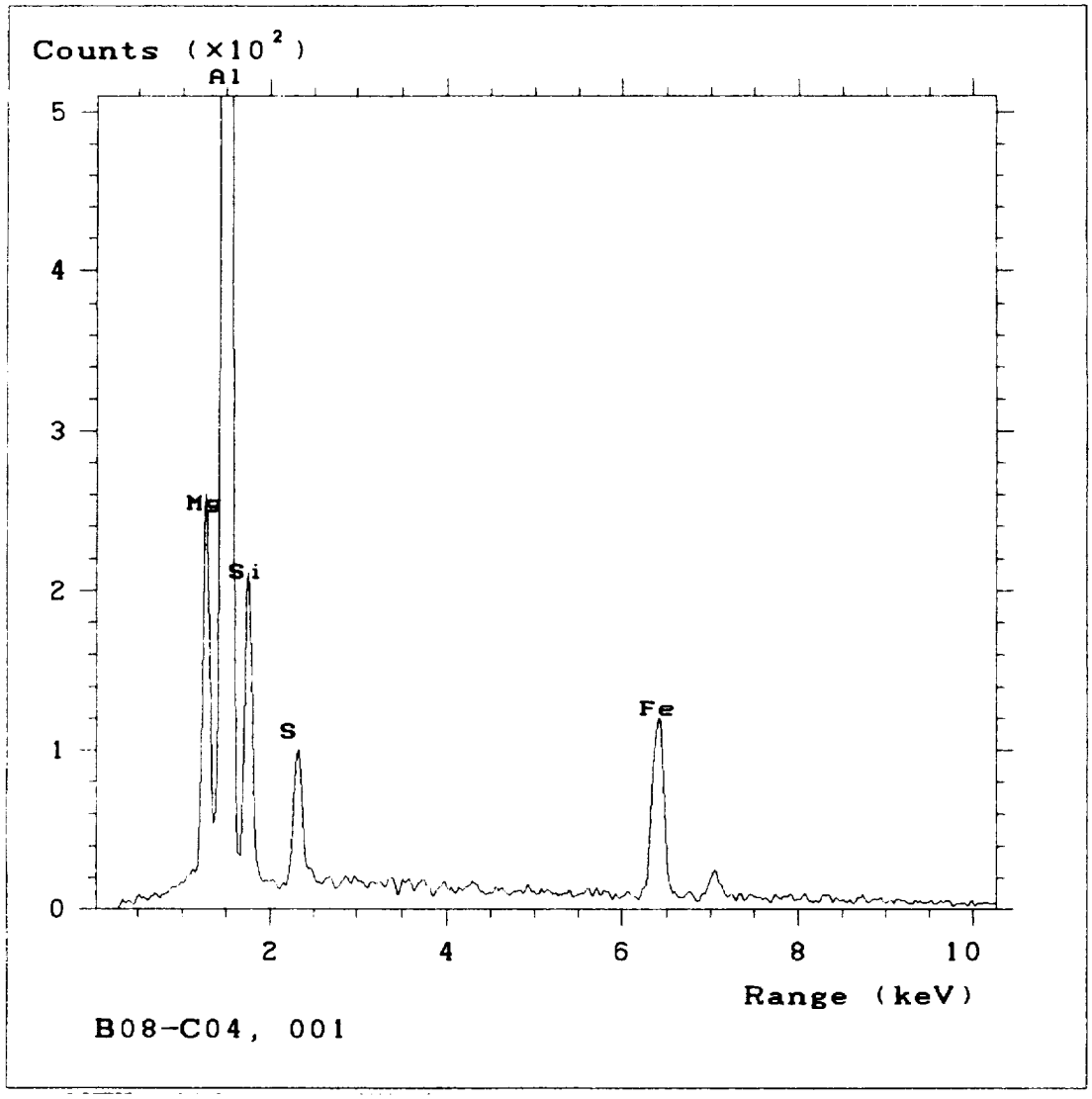


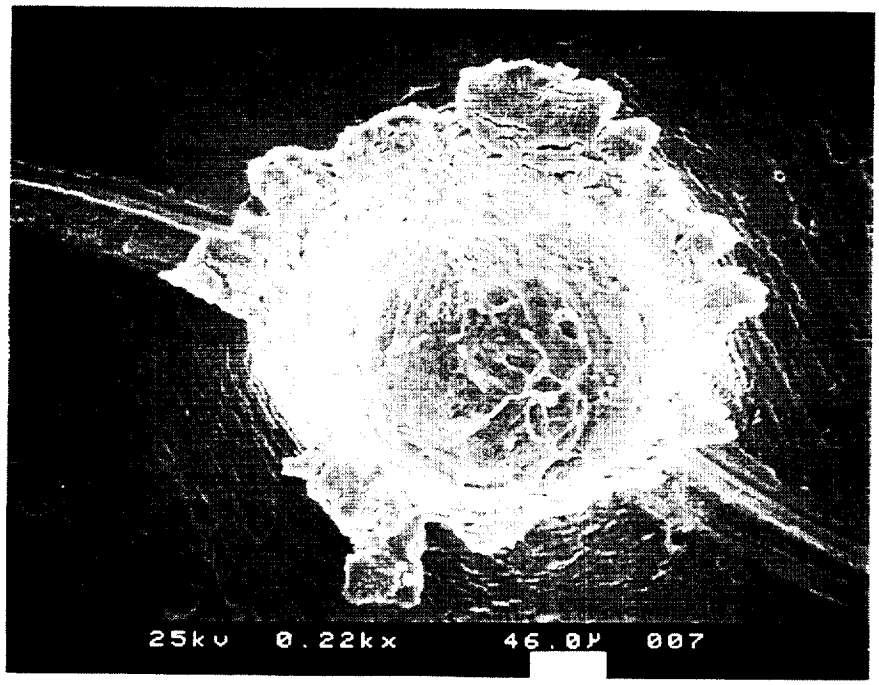
B07-C08 008 5s

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B08-C04	001	5	10	300	MICROMETEORITIC
	002	8	90	30	UNKNOWN
	003	8	115	50	MICROMETEORITIC
	004	31	84	50	UNKNOWN
	005	31	88	40	UNKNOWN
	006	31	100	240	UNKNOWN
	007	36	128	230	UNKNOWN
	008	43	129	40	MICROMETEORITIC
	009	48	39	50	MICROMETEORITIC

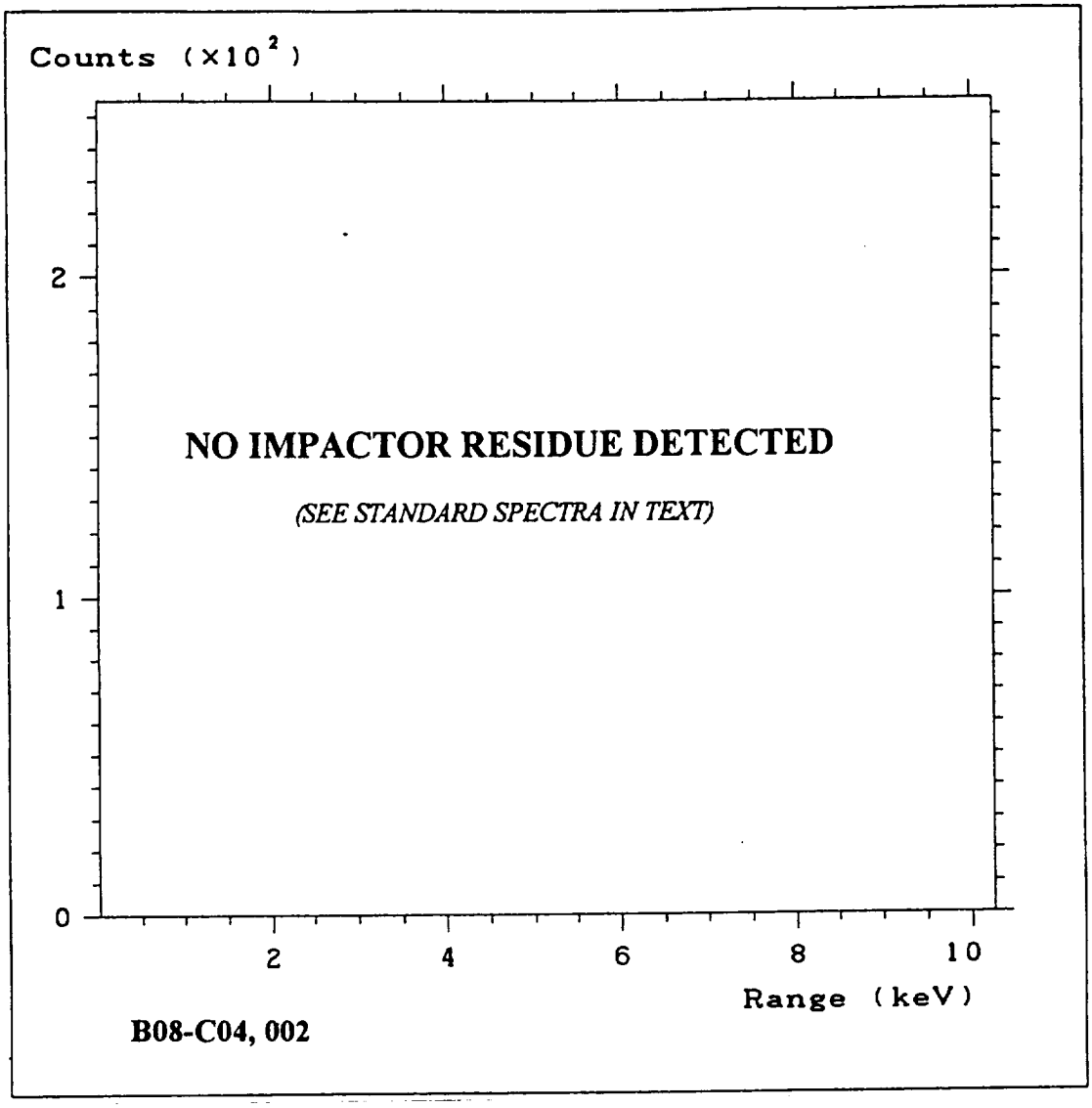


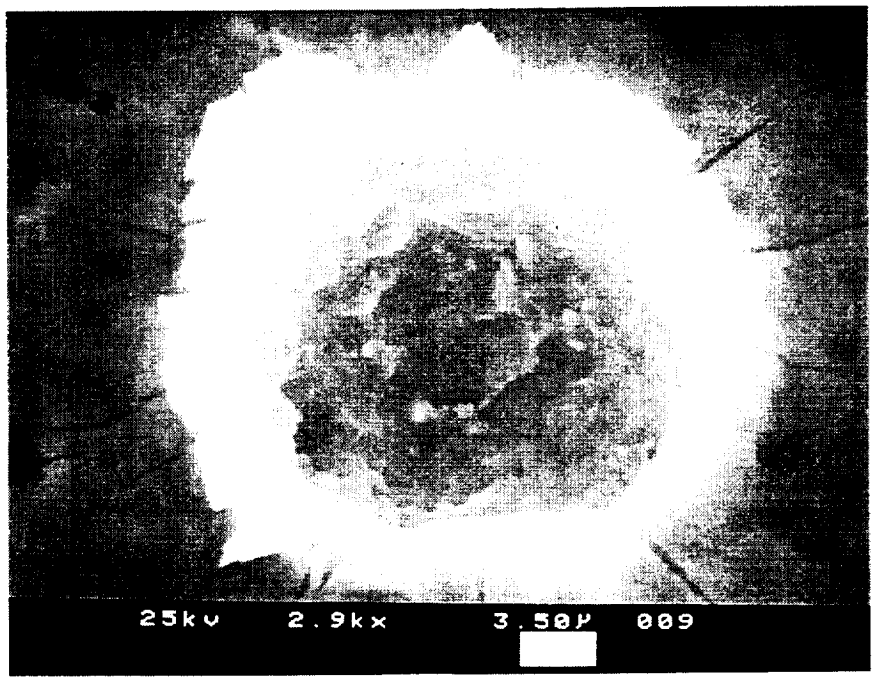
B08-C04


Counts (×10²)
Al
Mg
Si
S
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B08-C04, 001

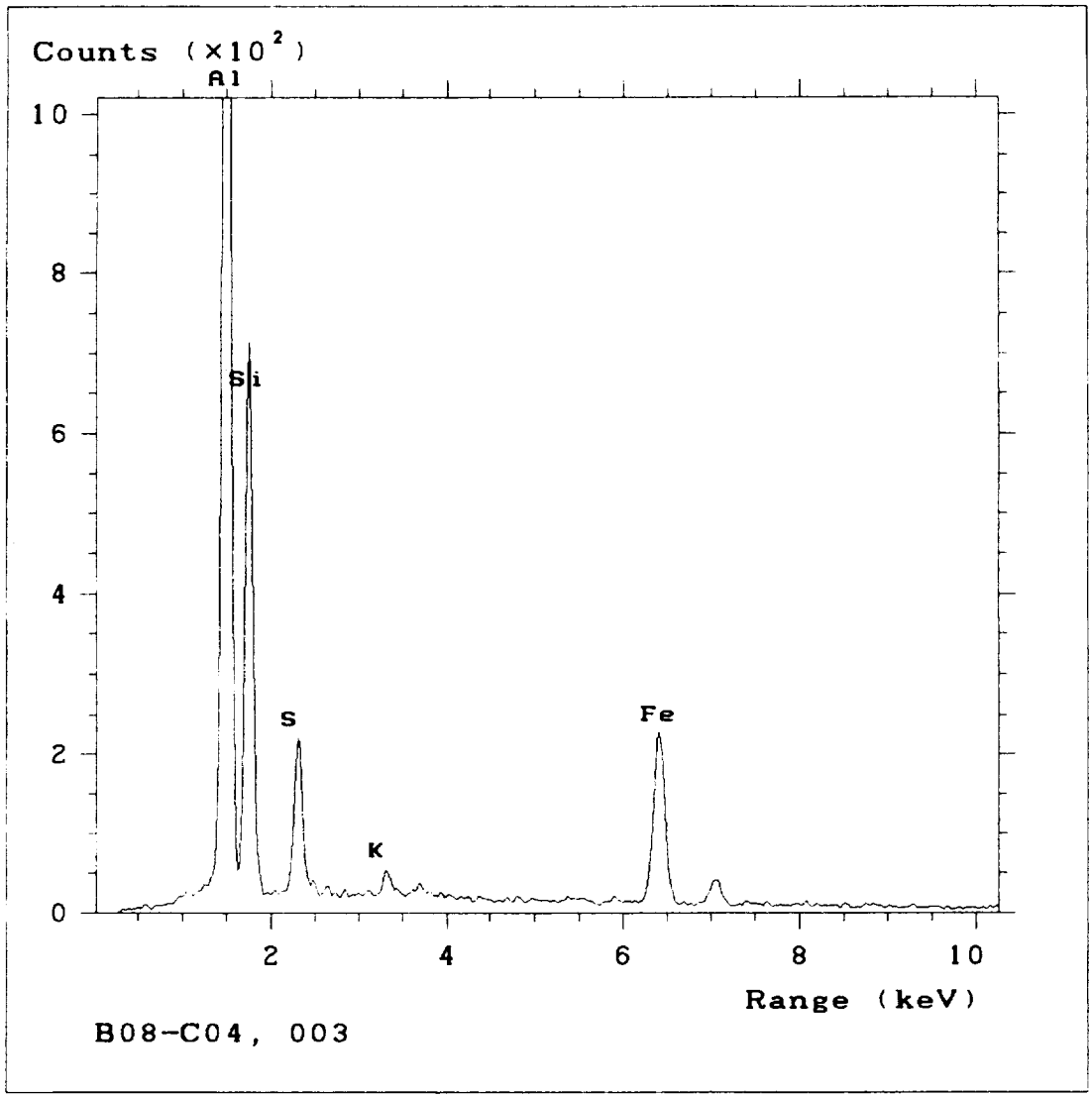

25kv 0.22kx 46.0µ 007

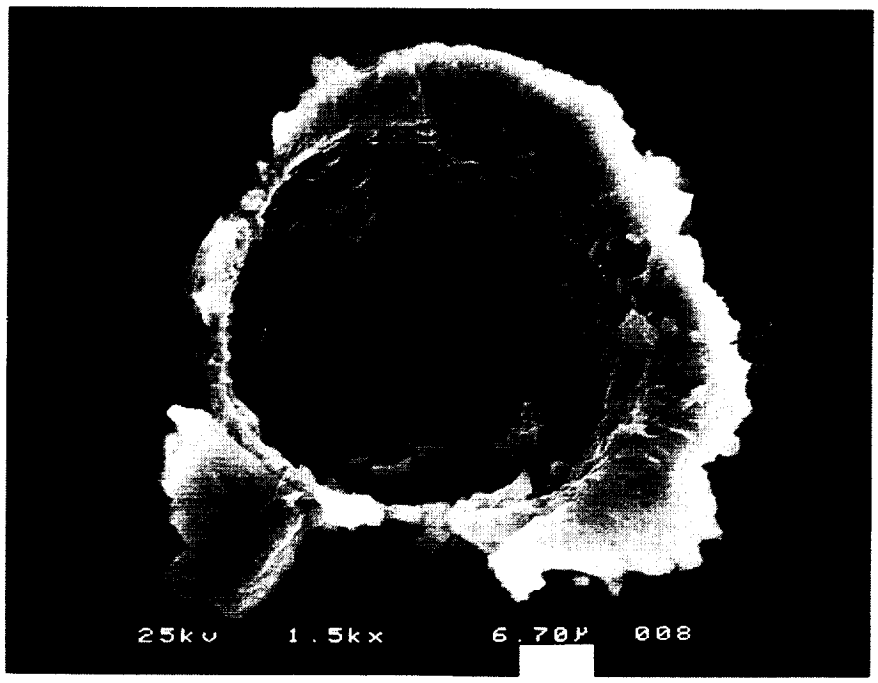
B08- C04 ^01


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C04, 002

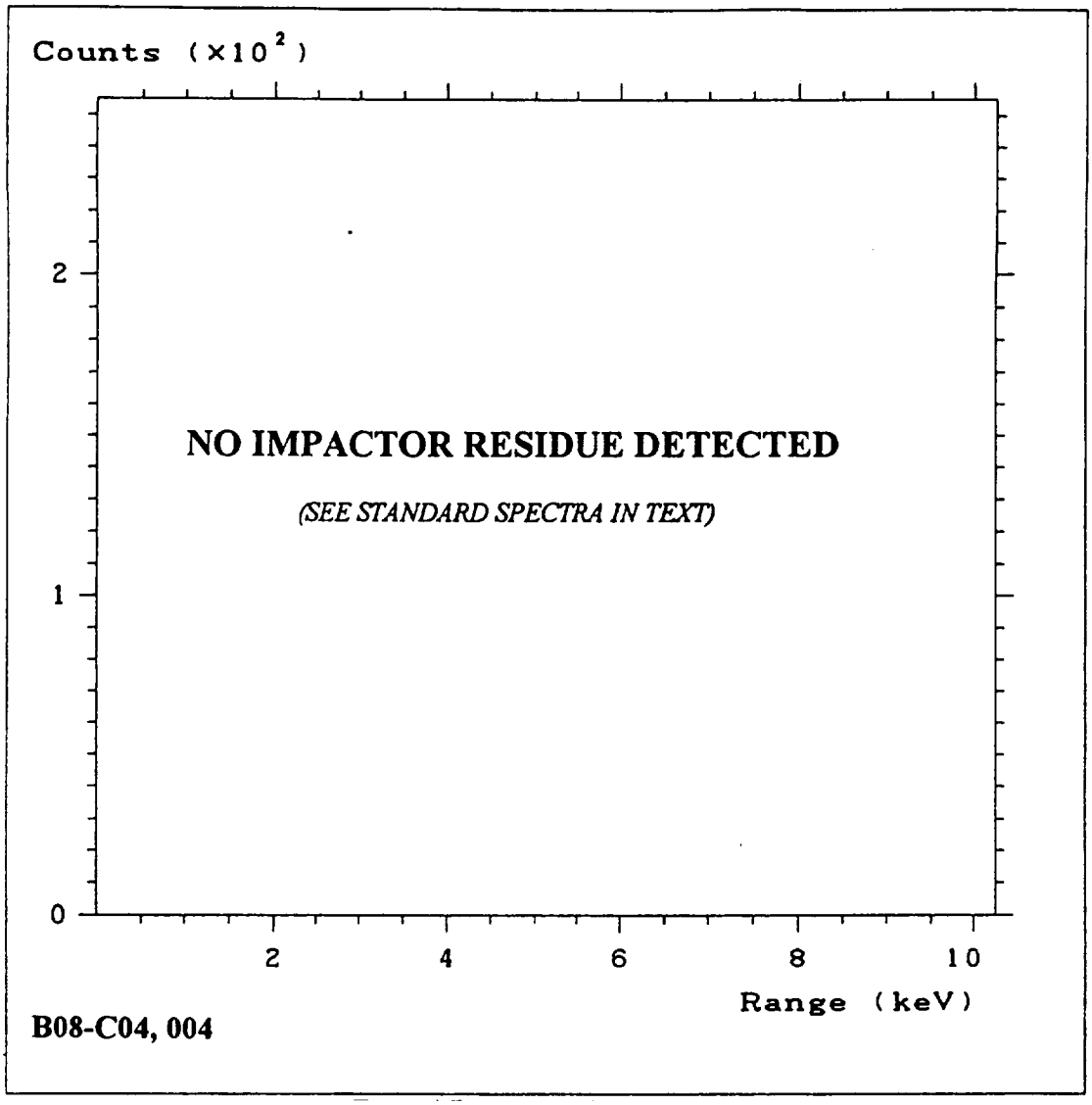

25kv 2.9kx 3.50μ 009

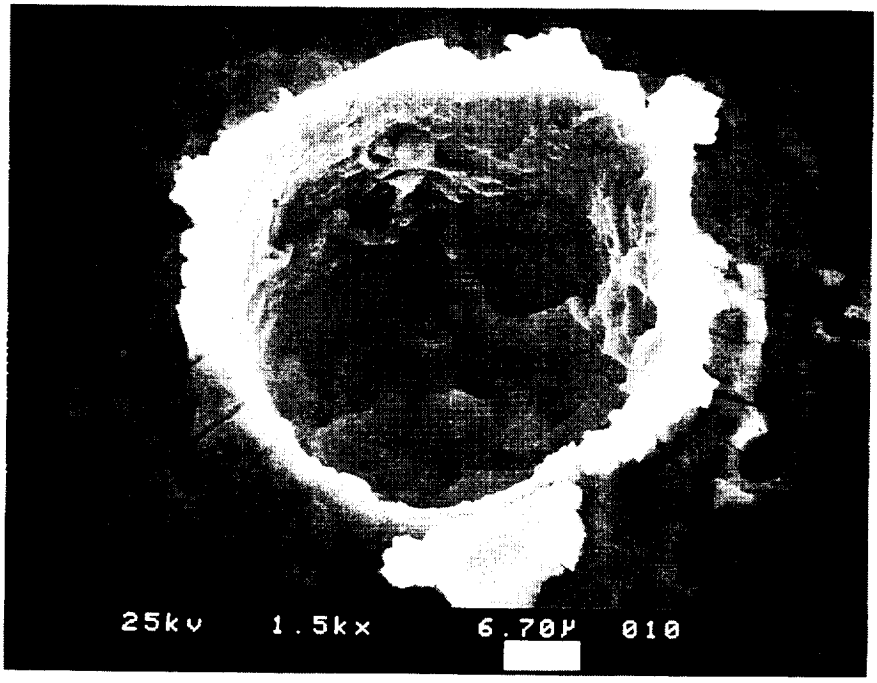
B08-C04 002



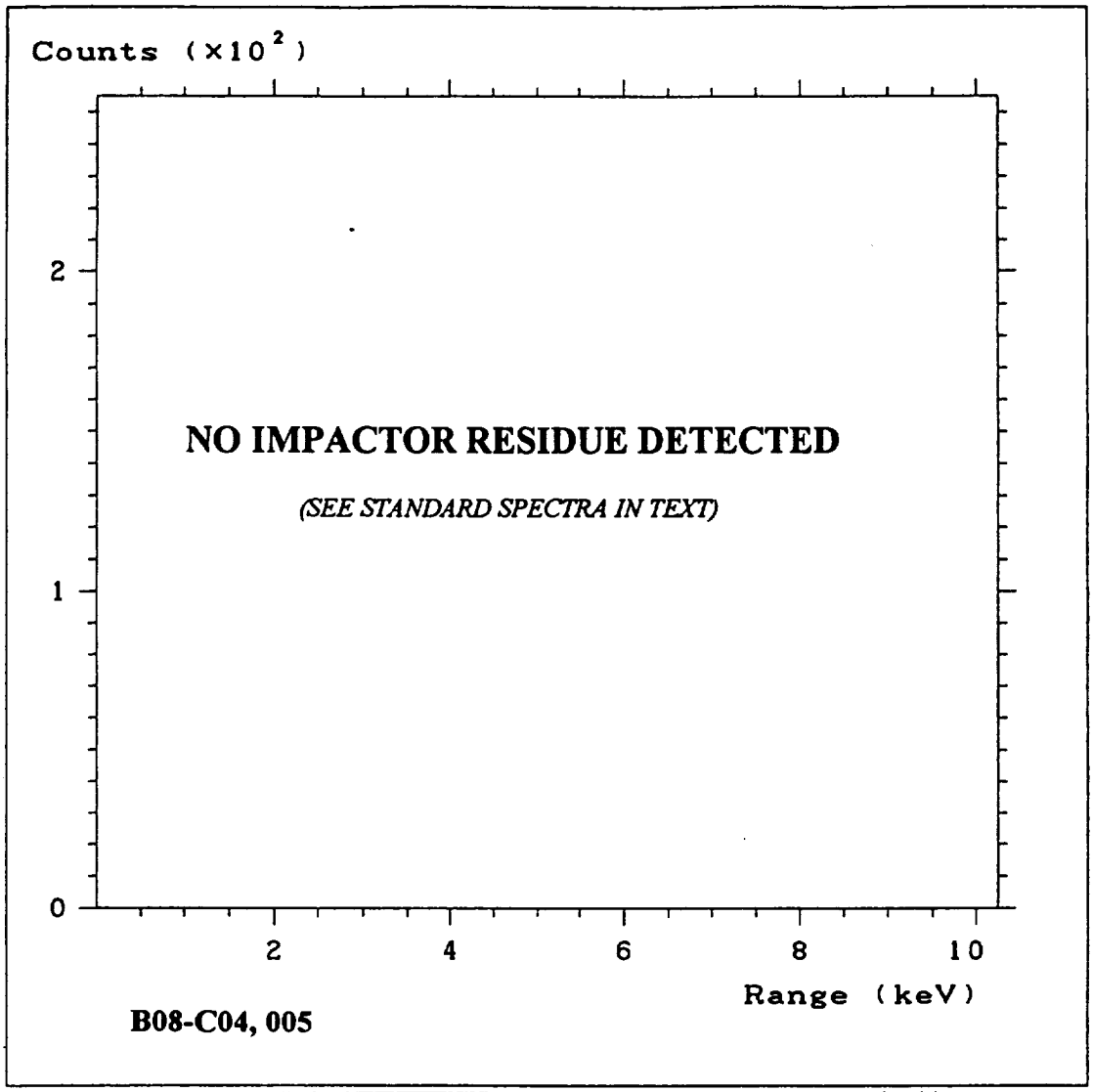


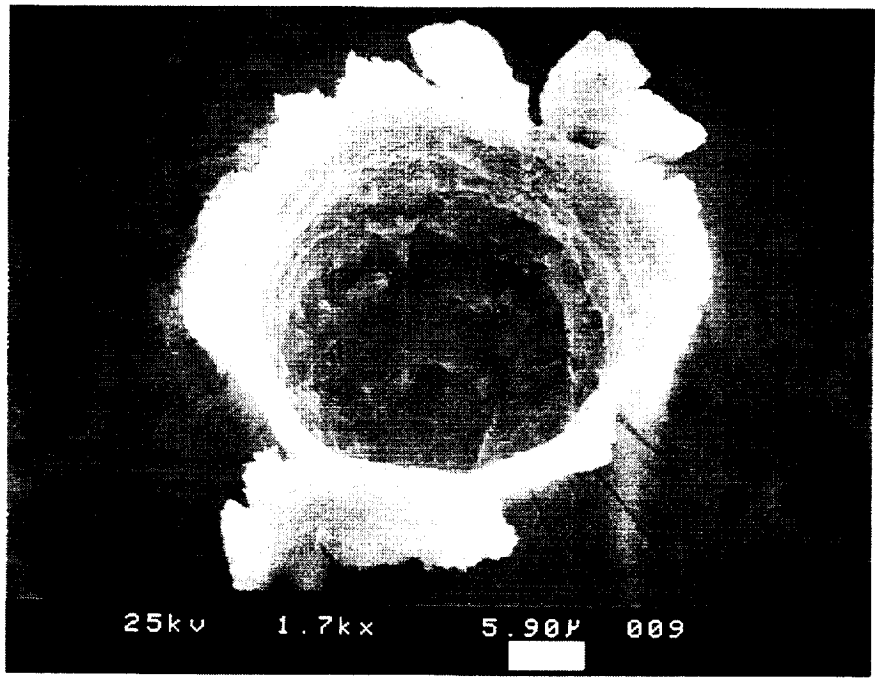
B08-C04 ~~002~~ 003


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C04, 004

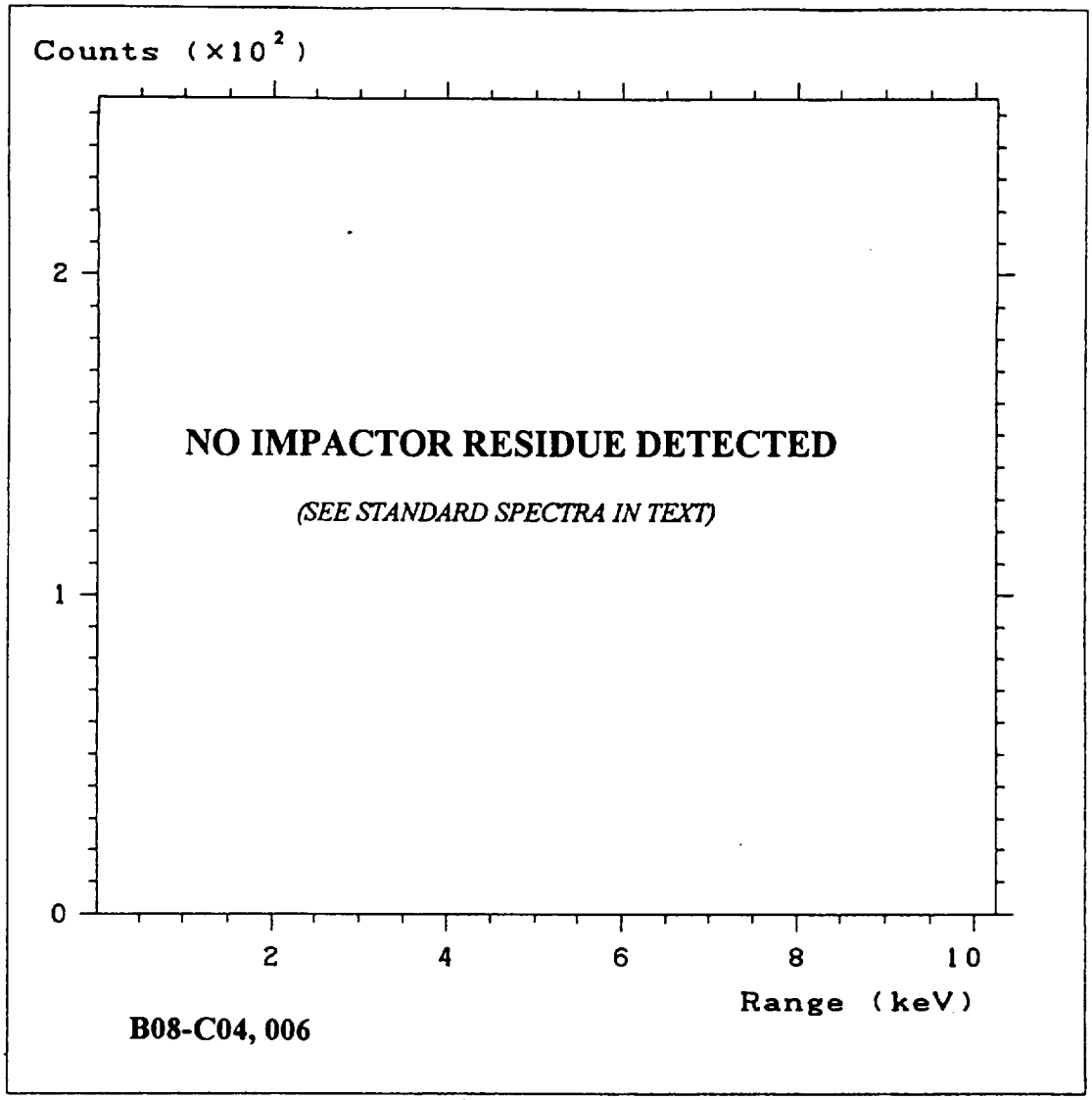

25kv 1.5kx 6.70μ 010

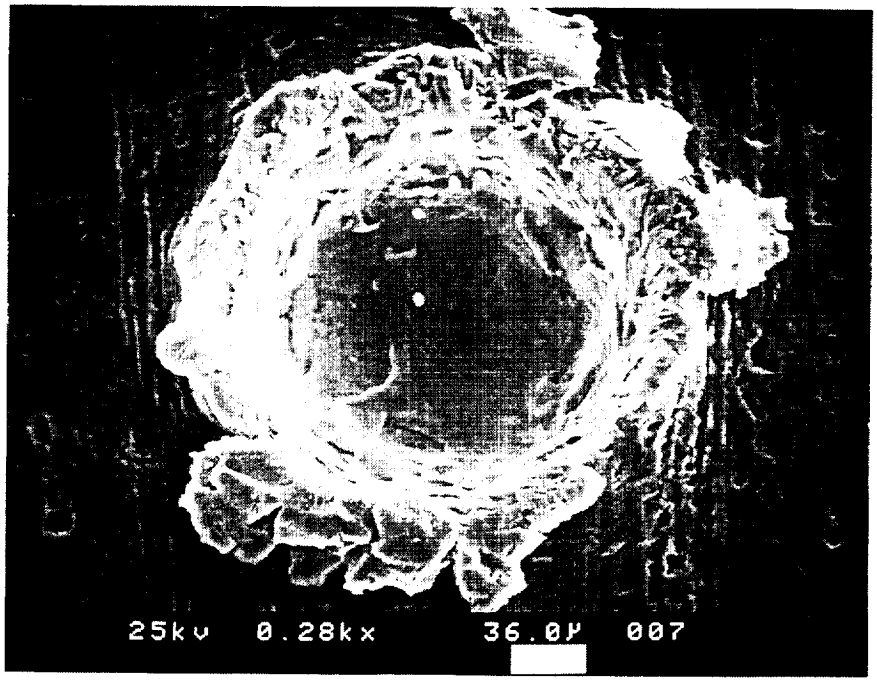
B08-C04 C04


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C04, 005

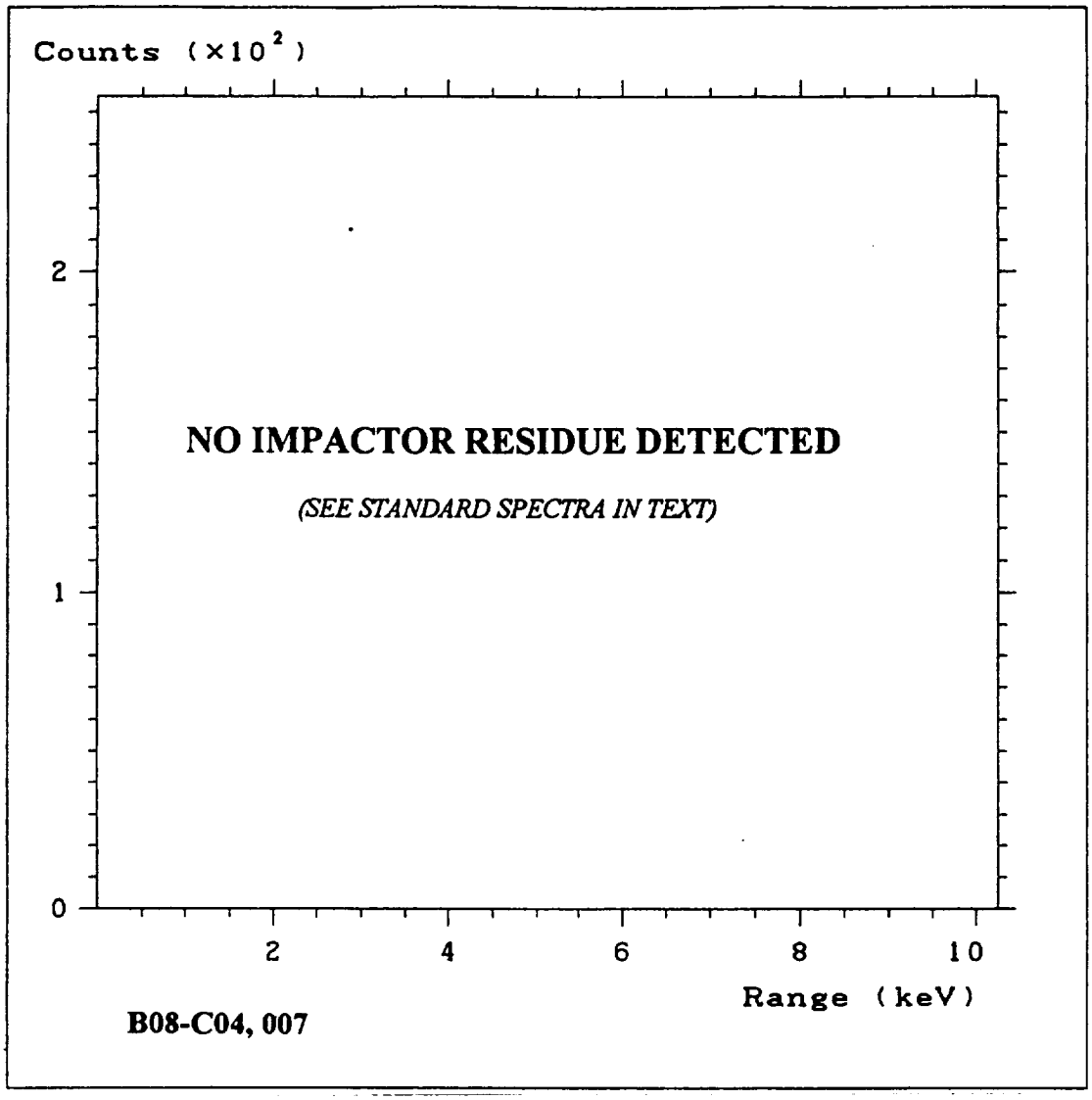

25kv 1.7kx 5.90µ 009

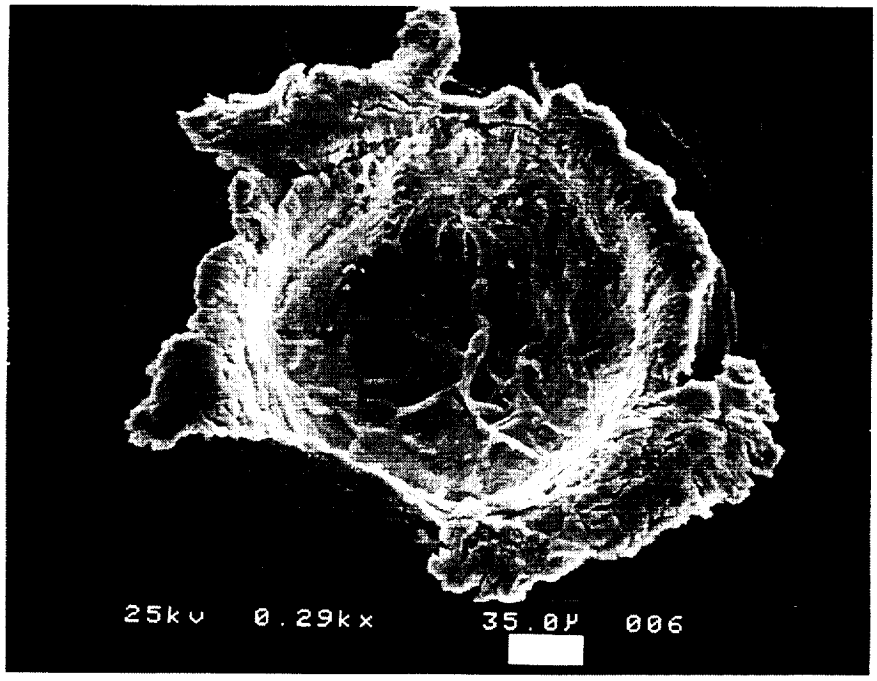
B08-C04 C05


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C04, 006

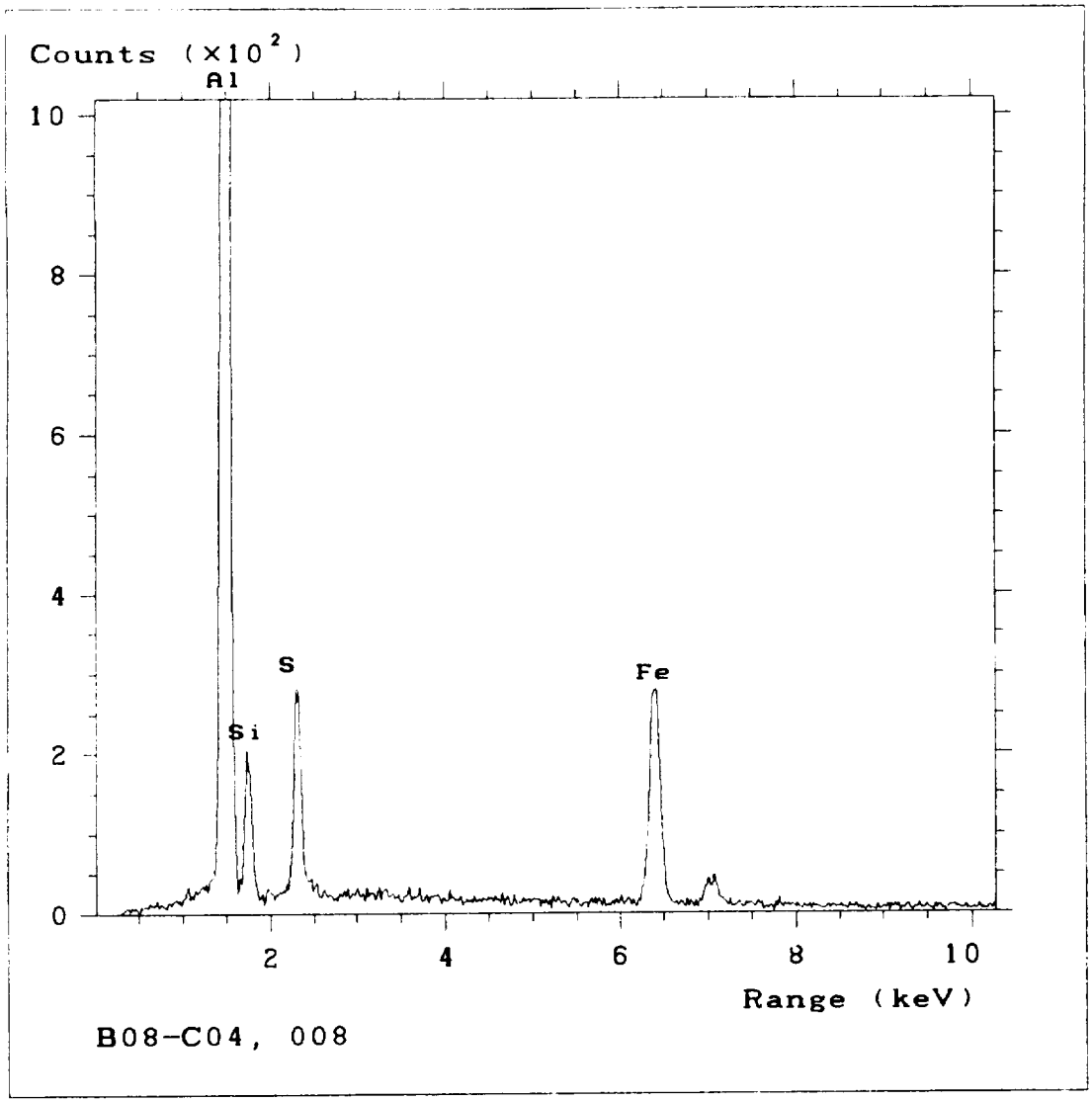

25kv 0.28kx 36.0µ 007

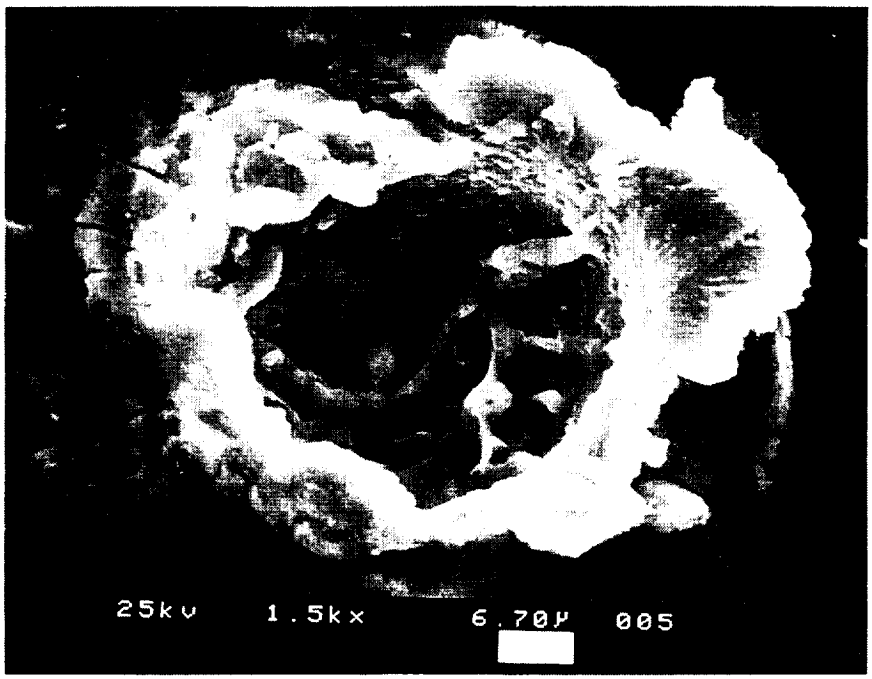
B08 - C04 006


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C04, 007

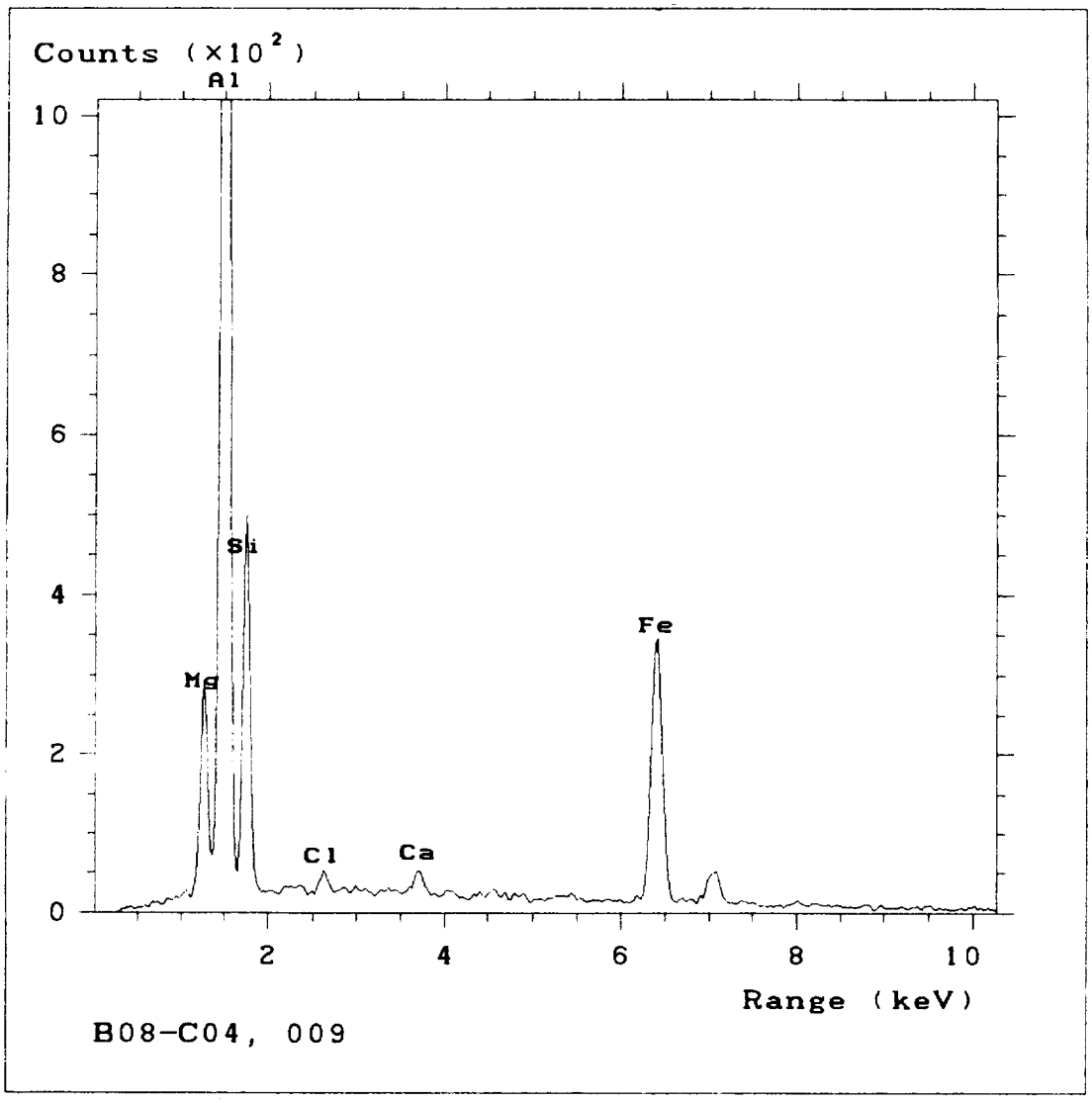

25kv 0.29kx 35.0μ 006

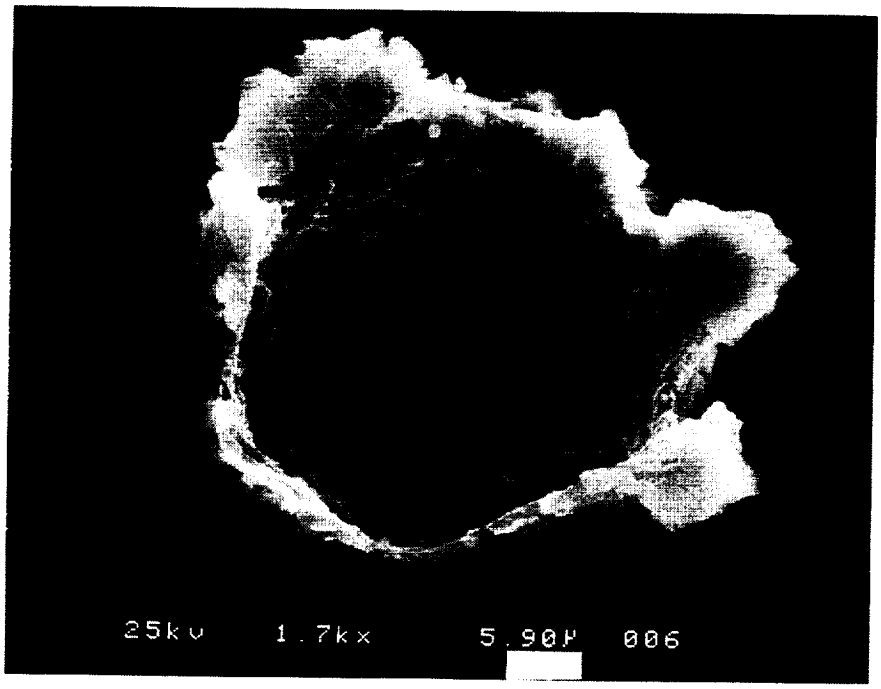
B08-C04 007





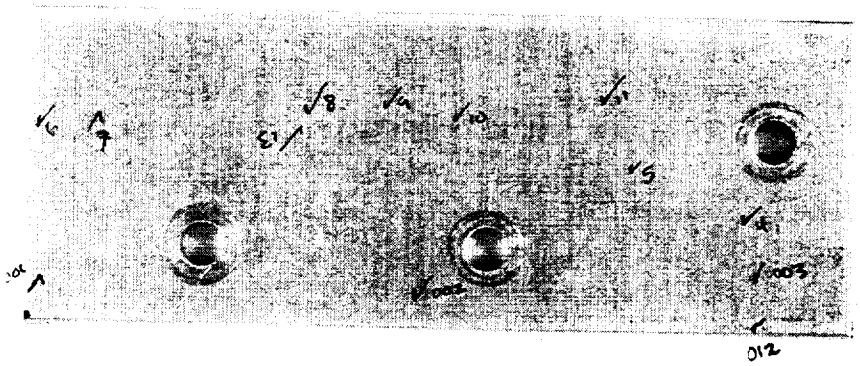
B08-C04 008 mm



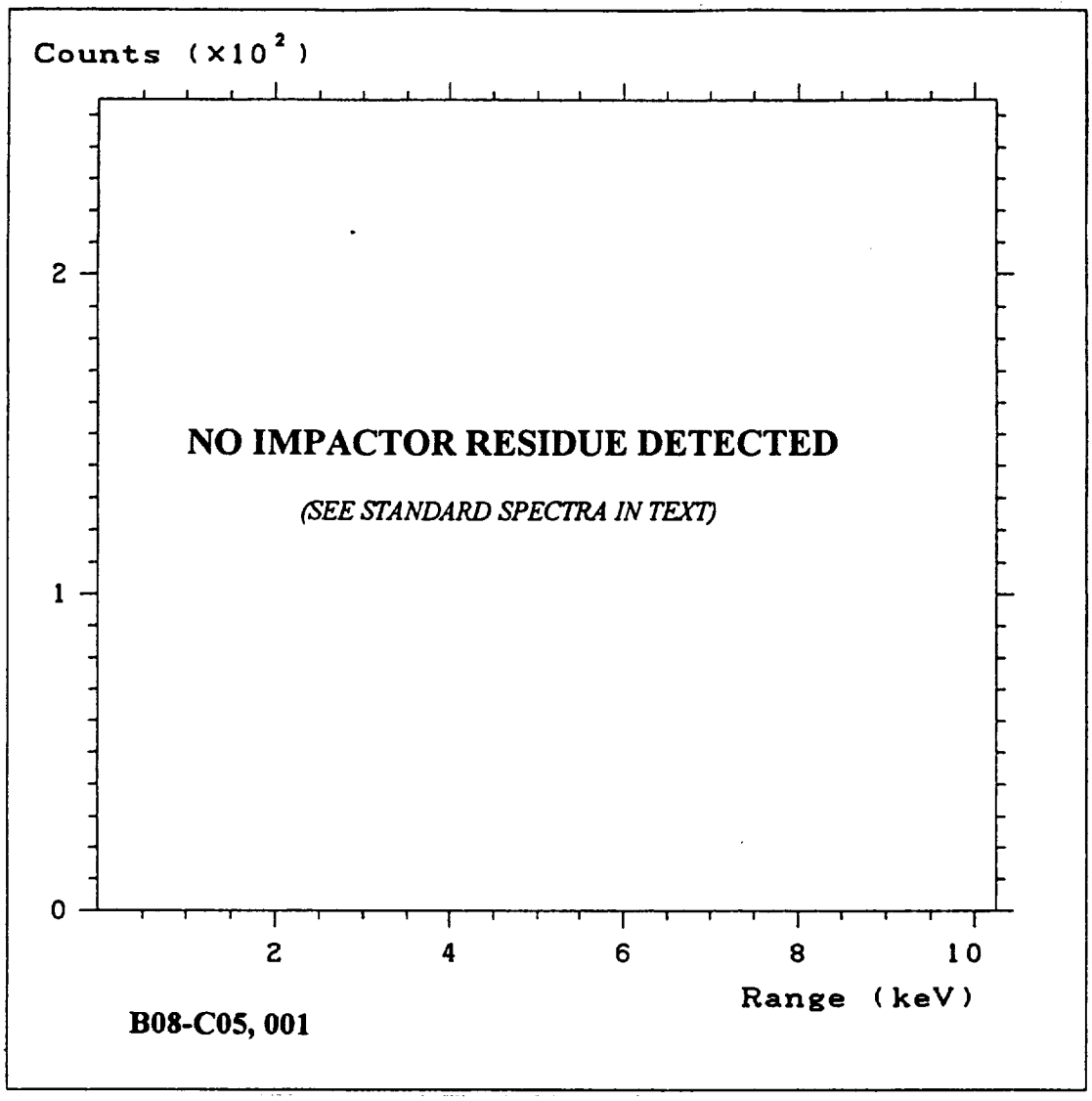


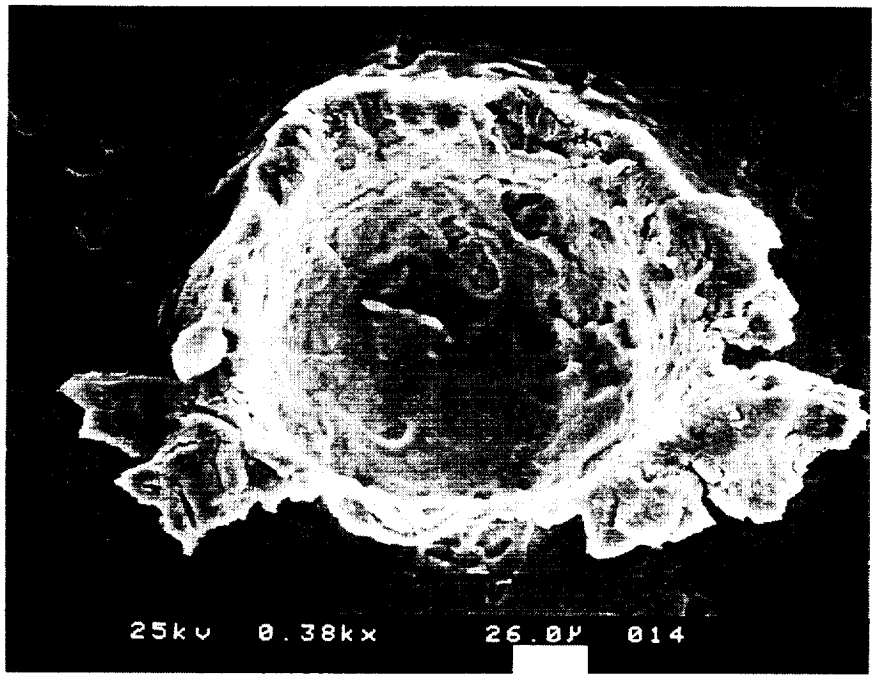
B08-C04 009 MM

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B08-C05	001	2	6	200	UNKNOWN
	002	60	2	380	UNKNOWN
	003	112	6	140	UNKNOWN
	004	109	15	50	MICROMETEORITIC
	005	93	22	170	UNKNOWN
	006	1	27	70	STAINLESS STEEL
	007	14	30	90	UNKNOWN
	008	47	29	200	UNKNOWN
	009	58	30	110	MICROMETEORITIC
	010	70	29	90	PAINT
	011	93	31	260	MICROMETEORITIC
	012	112	0	420	UNKNOWN
	013	46	30	90	UNKNOWN

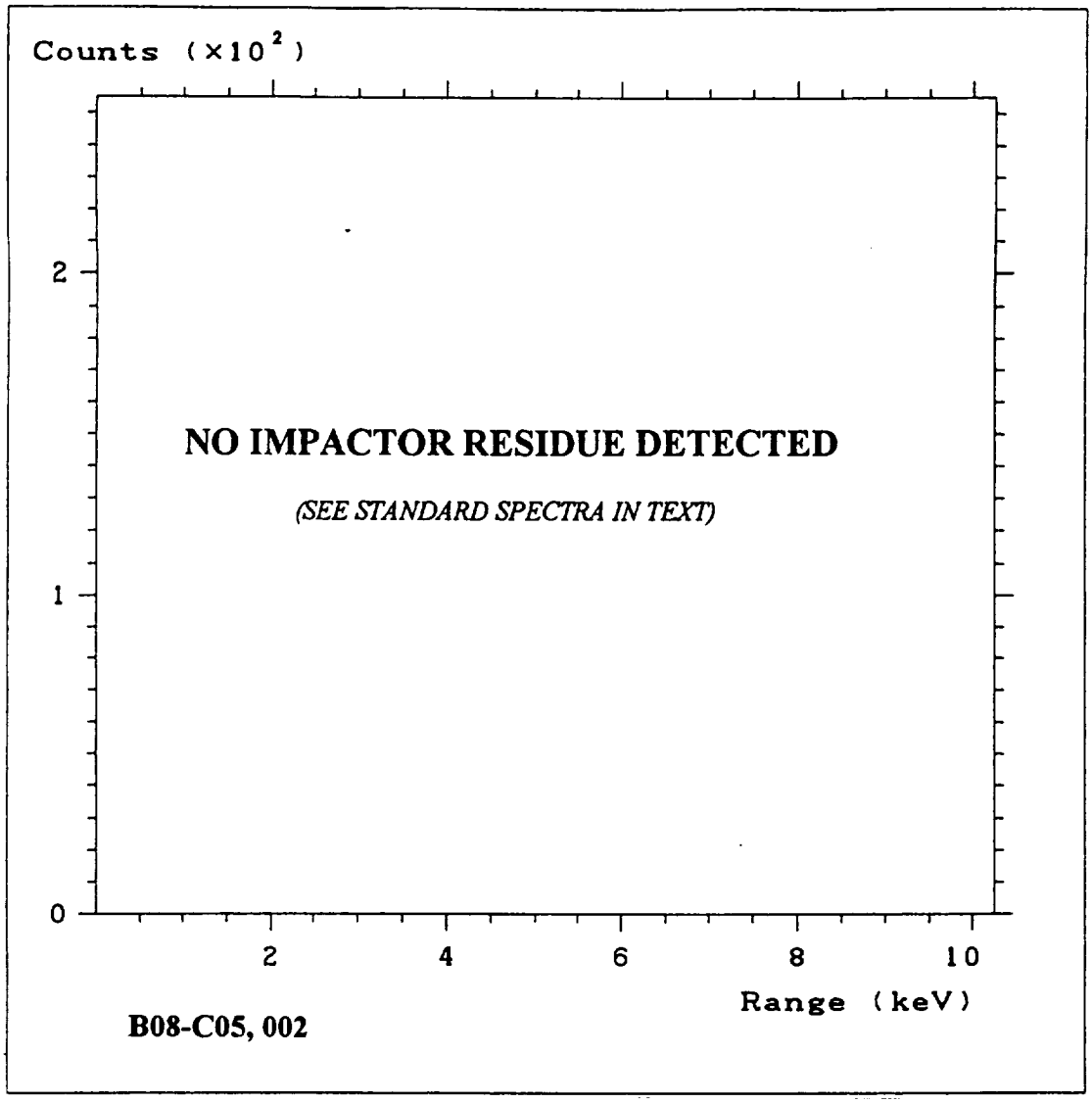


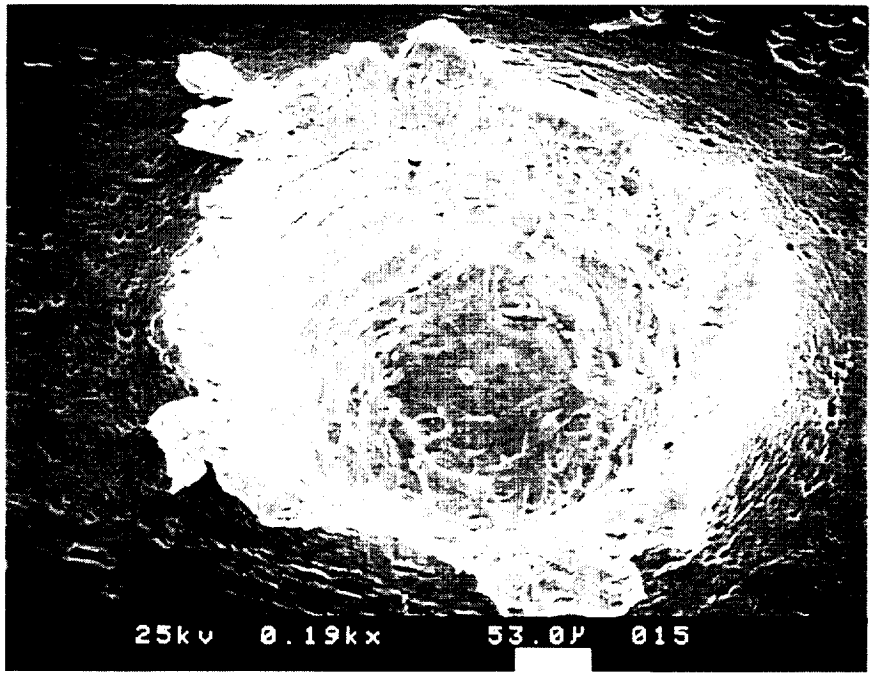
B08-C05


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 001

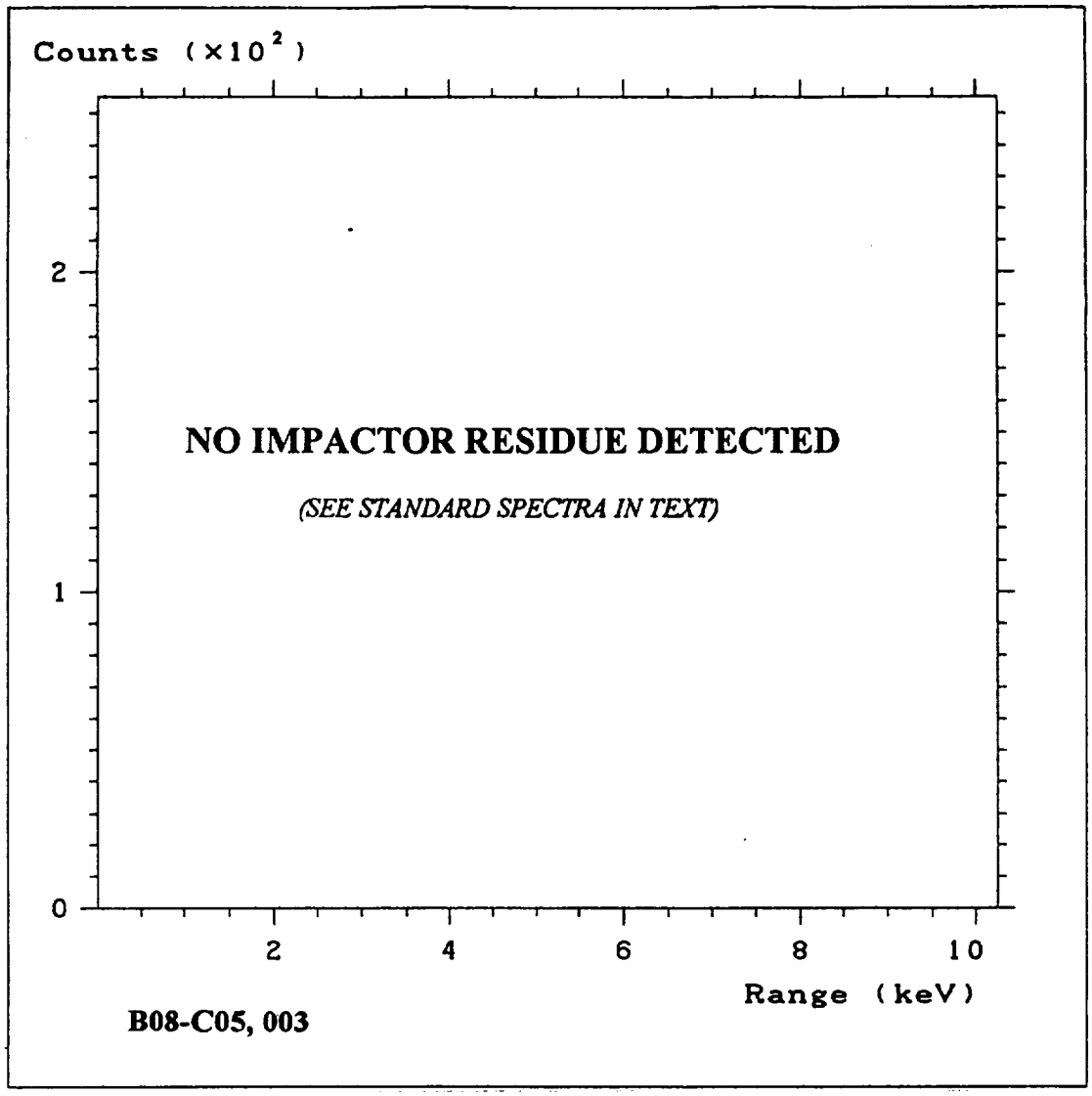

25kv 0.38kx 26.0µ 014

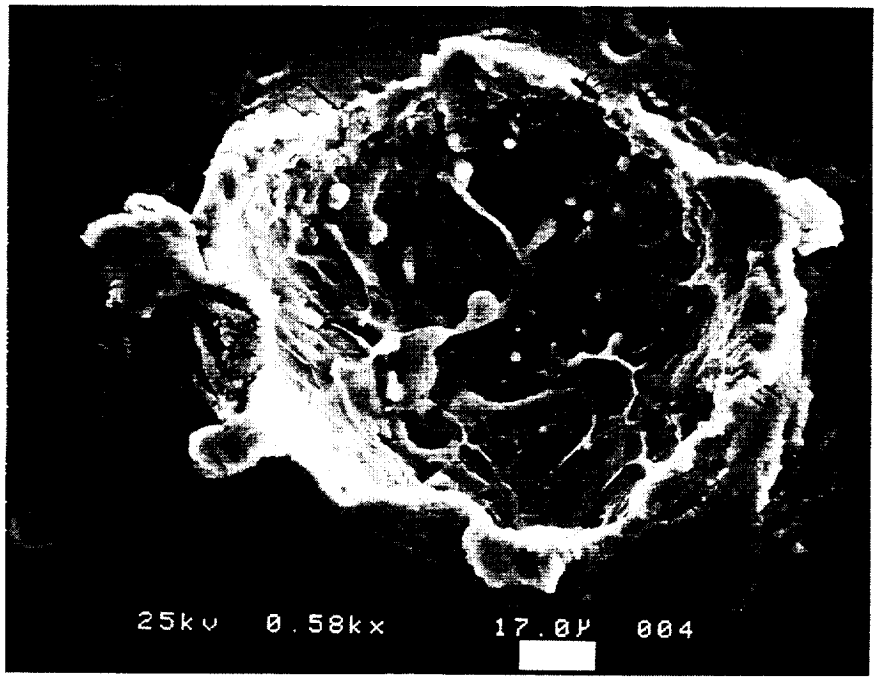
B08-C05 001


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 002

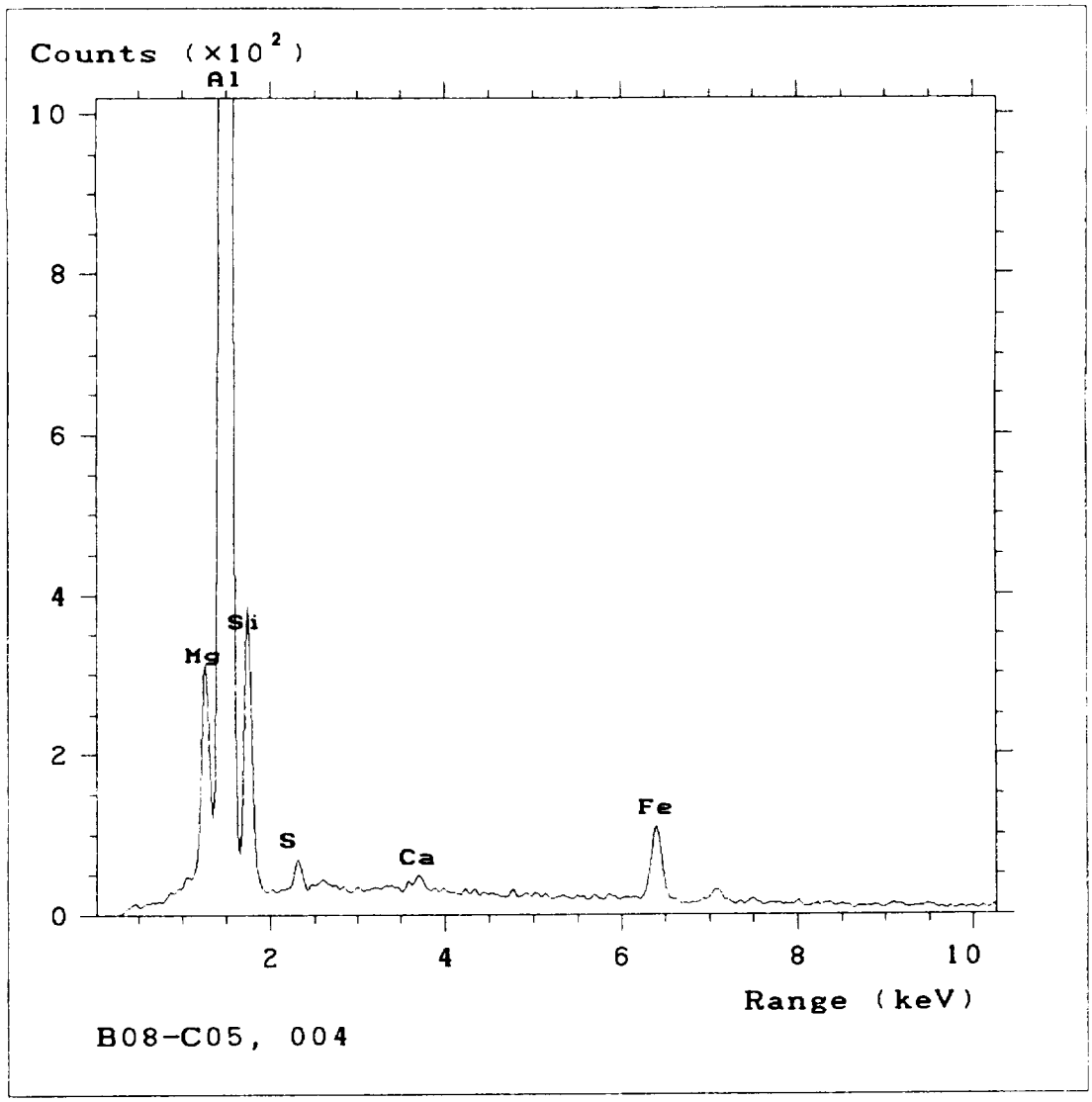

25kv 0.19kx 53.0µ 015

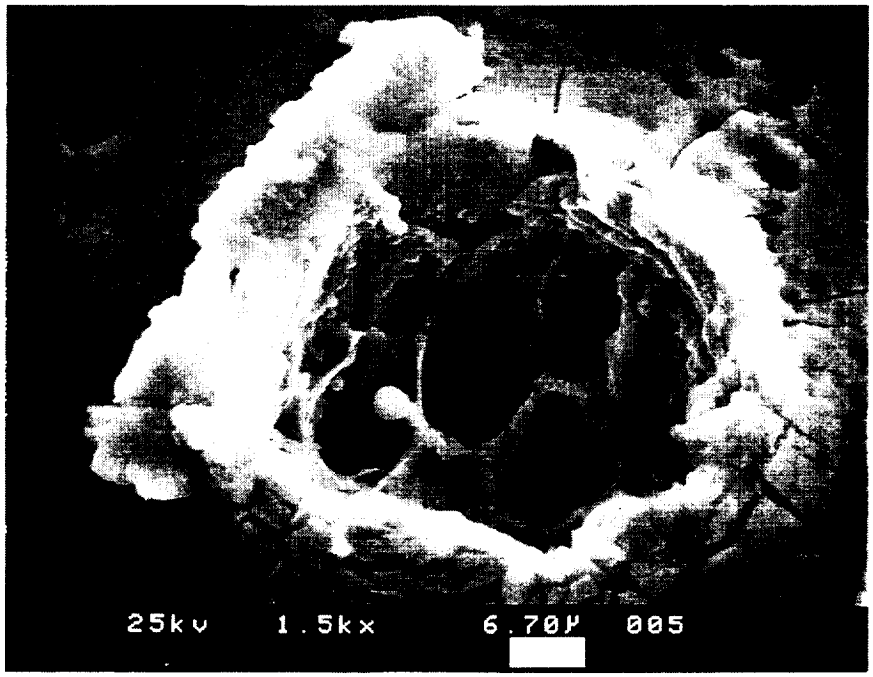
B08-C05 002


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 003

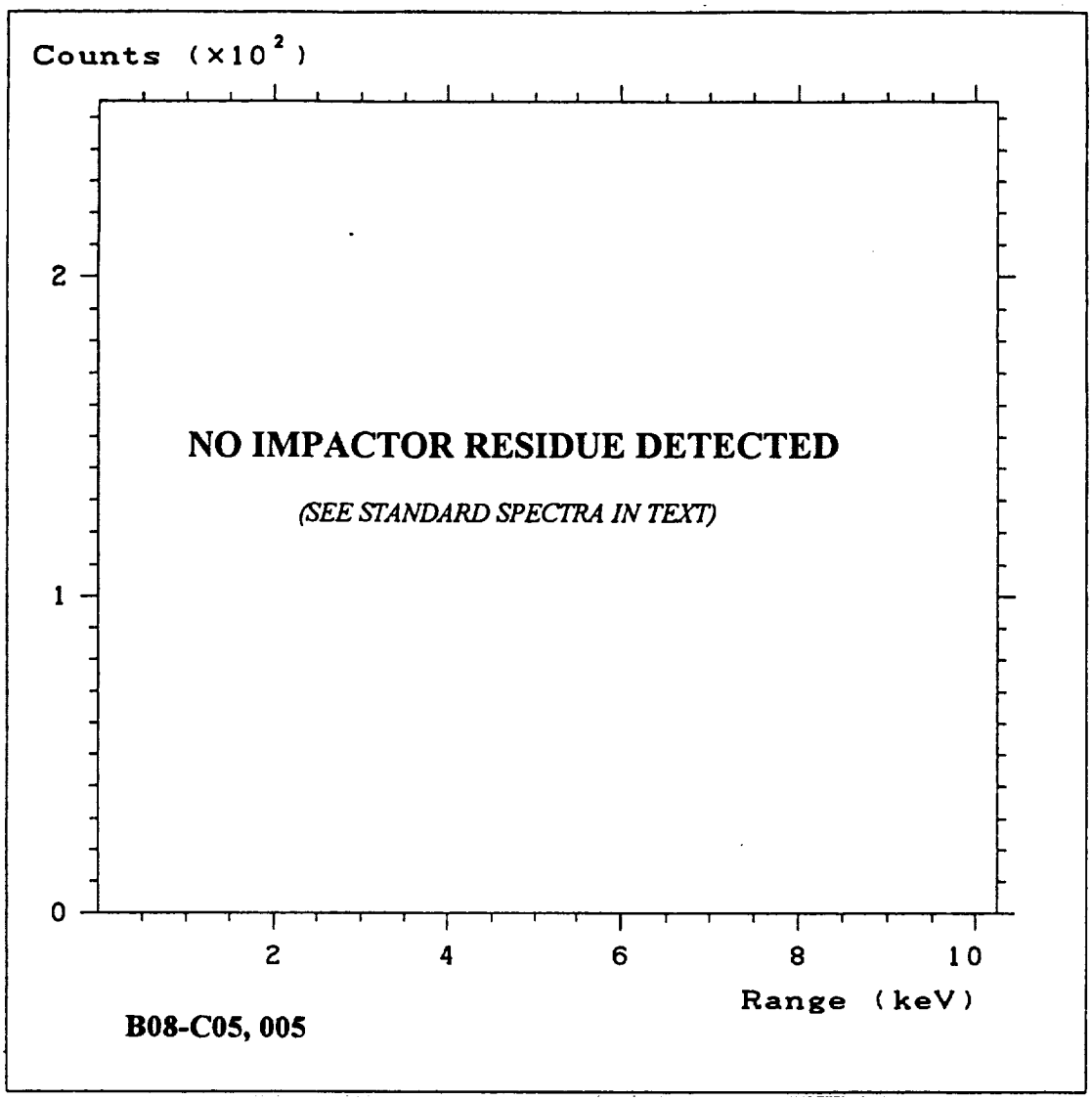

25kv 0.58kx 17.0μ 004

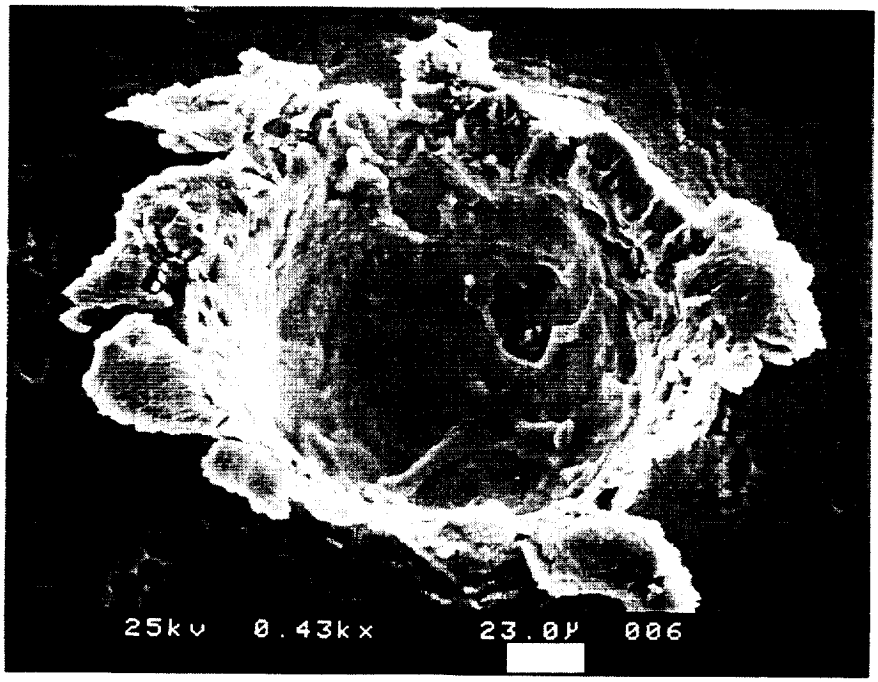
B08·C05 003



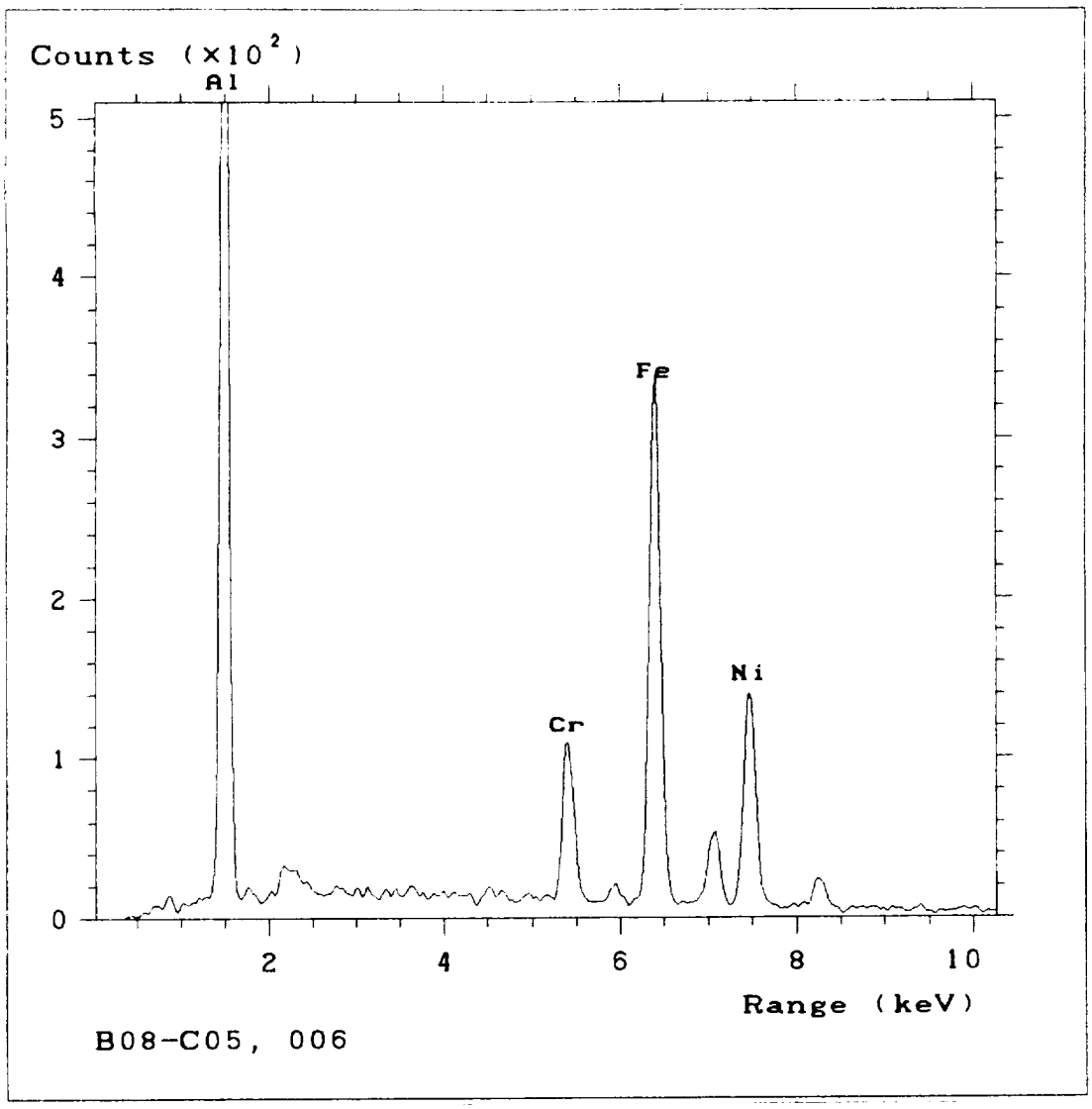


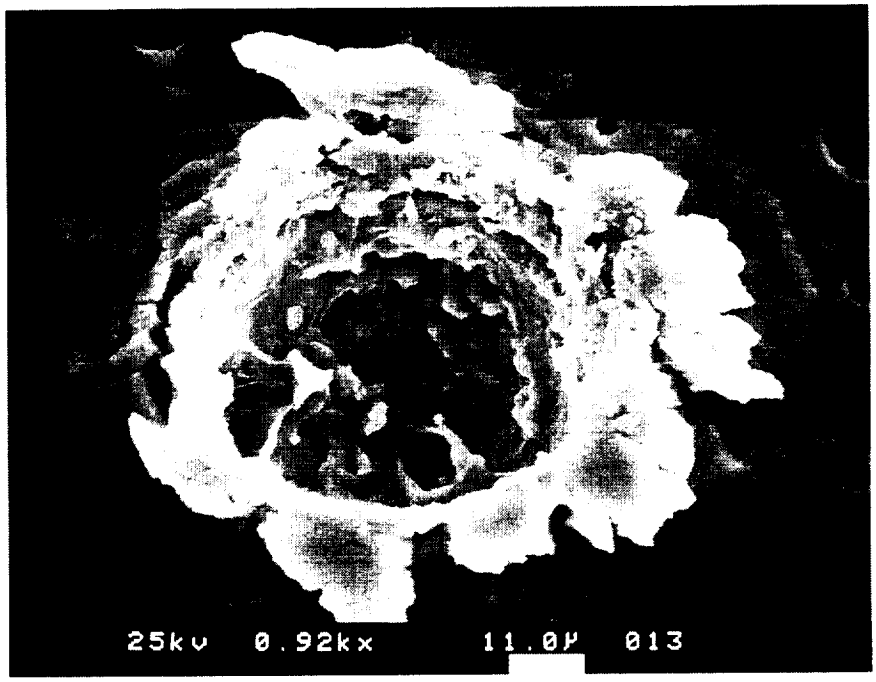
B08-C05 004 mm


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 005

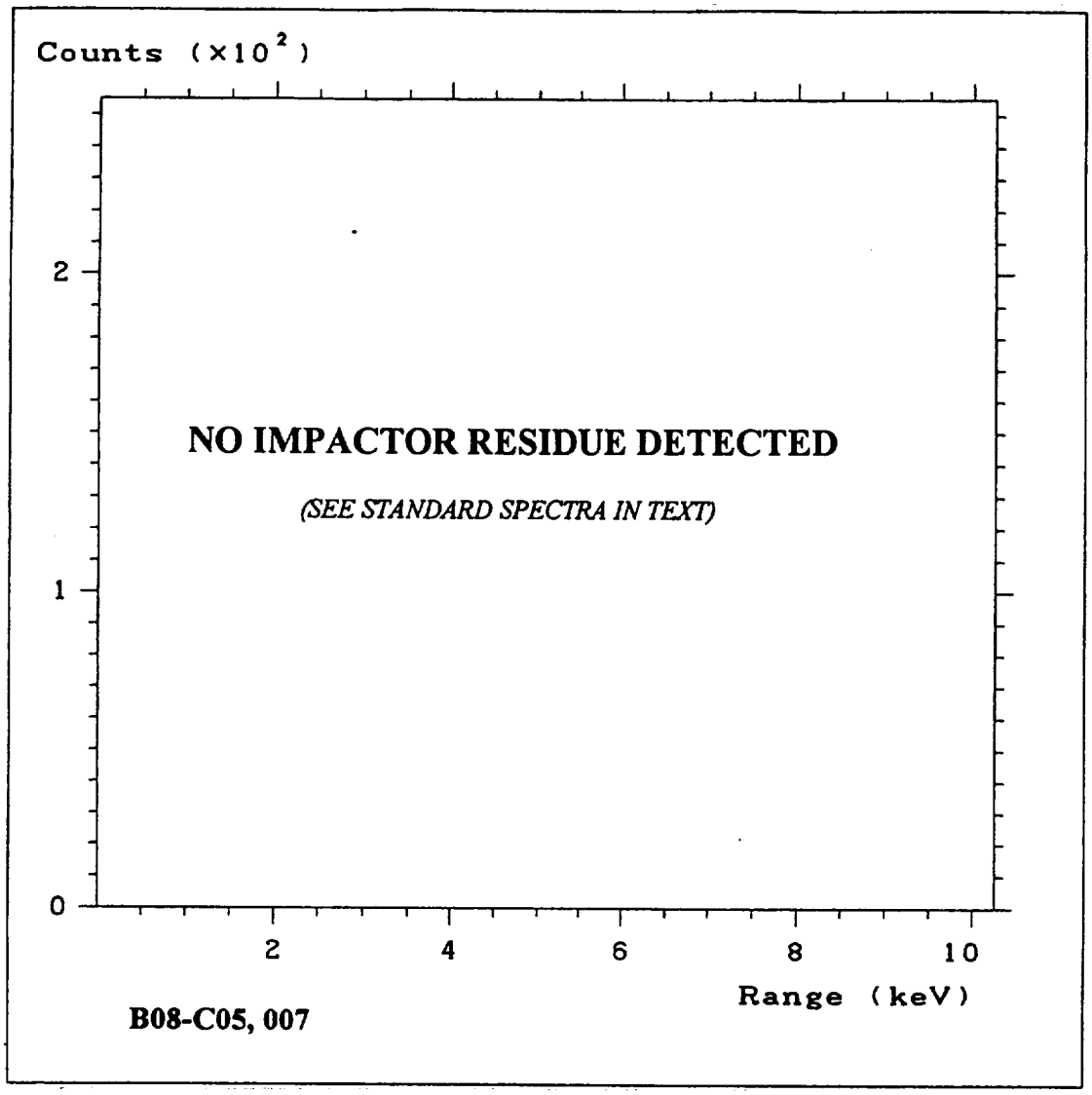

25kv 0.43kx 23.0µ 006

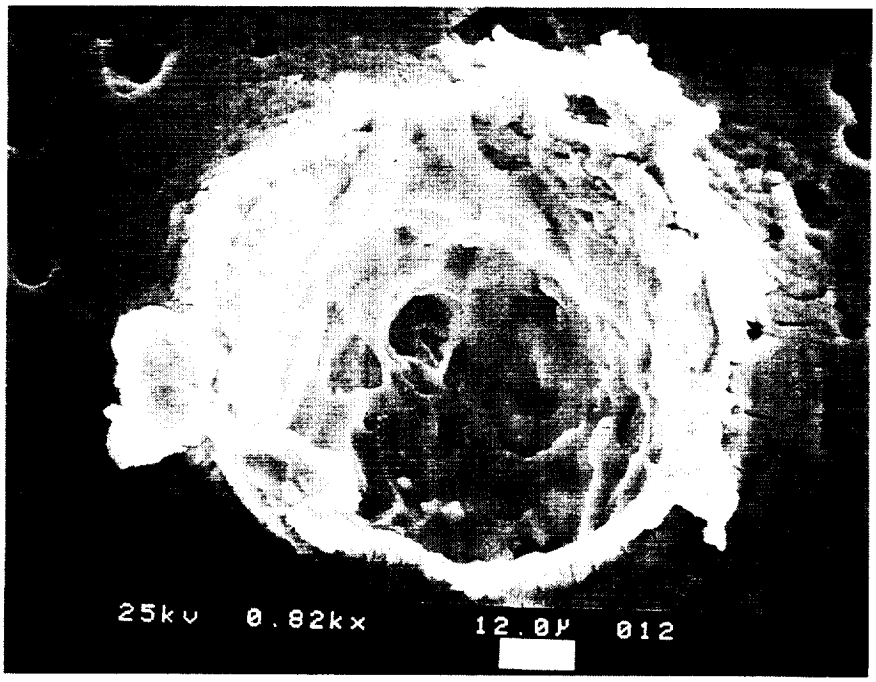
B08-C05 -05





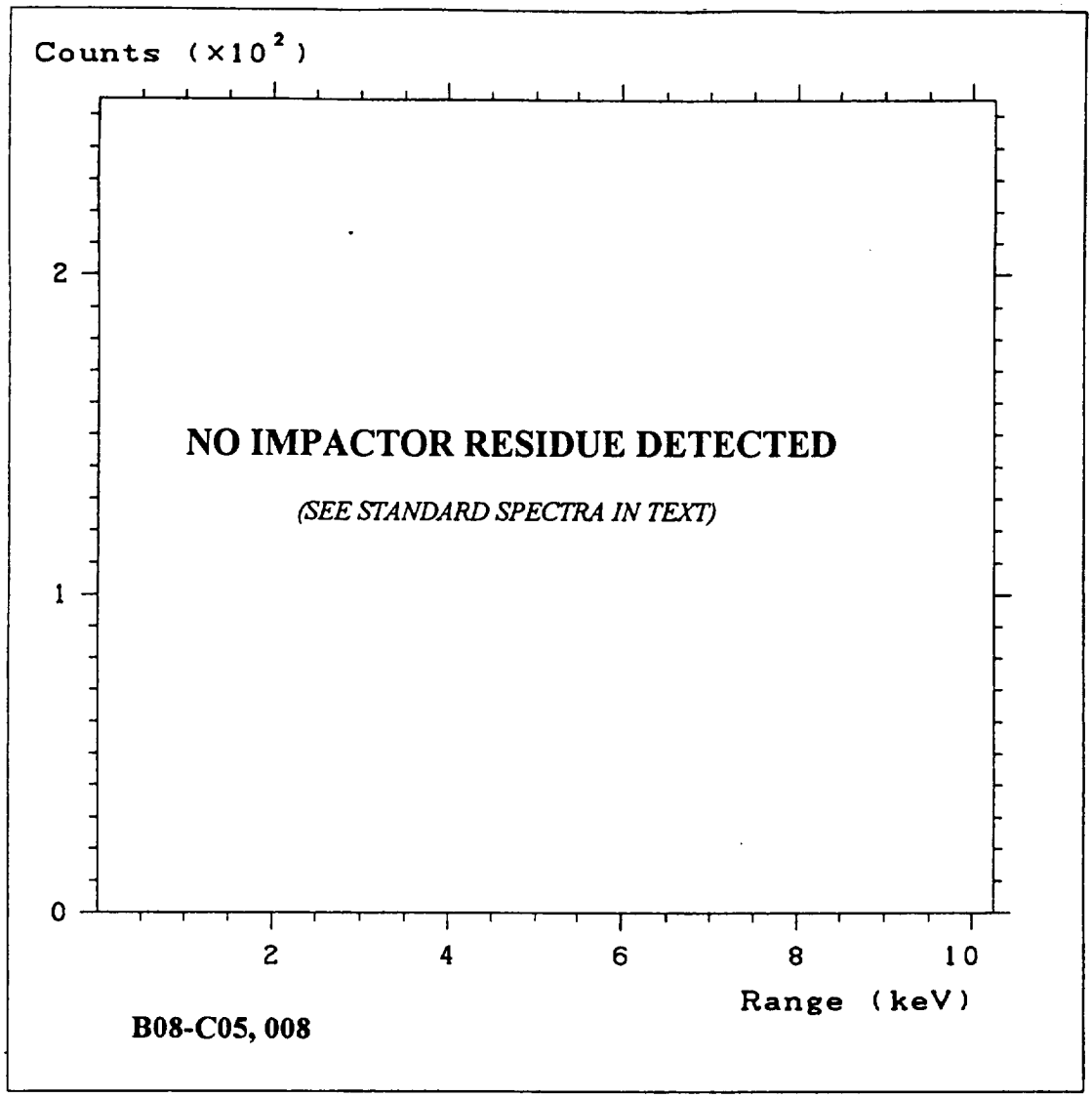
B08-C05 006 SS

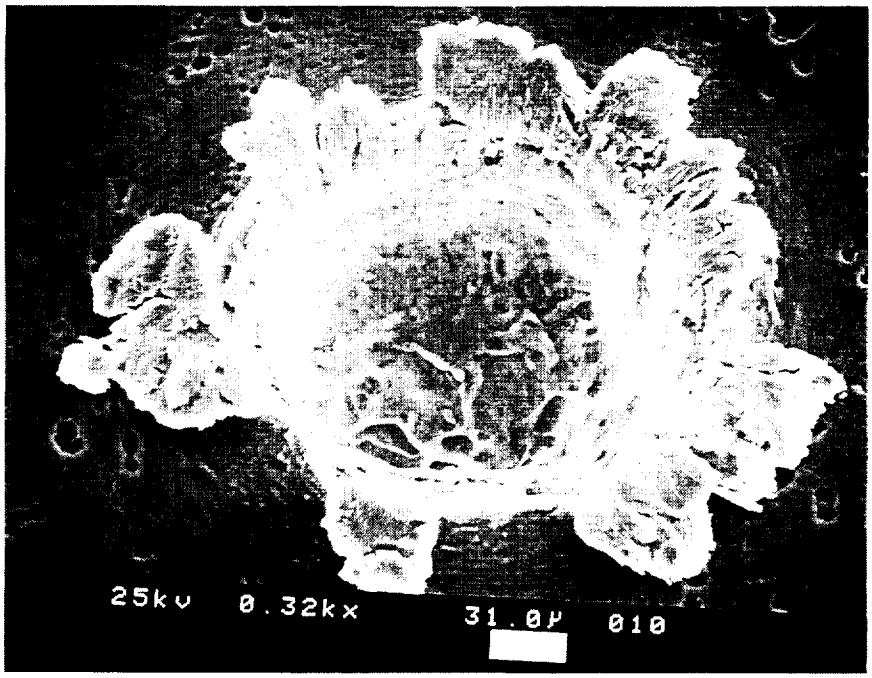

Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 007


25kv 0.82kx 12.0µ 012

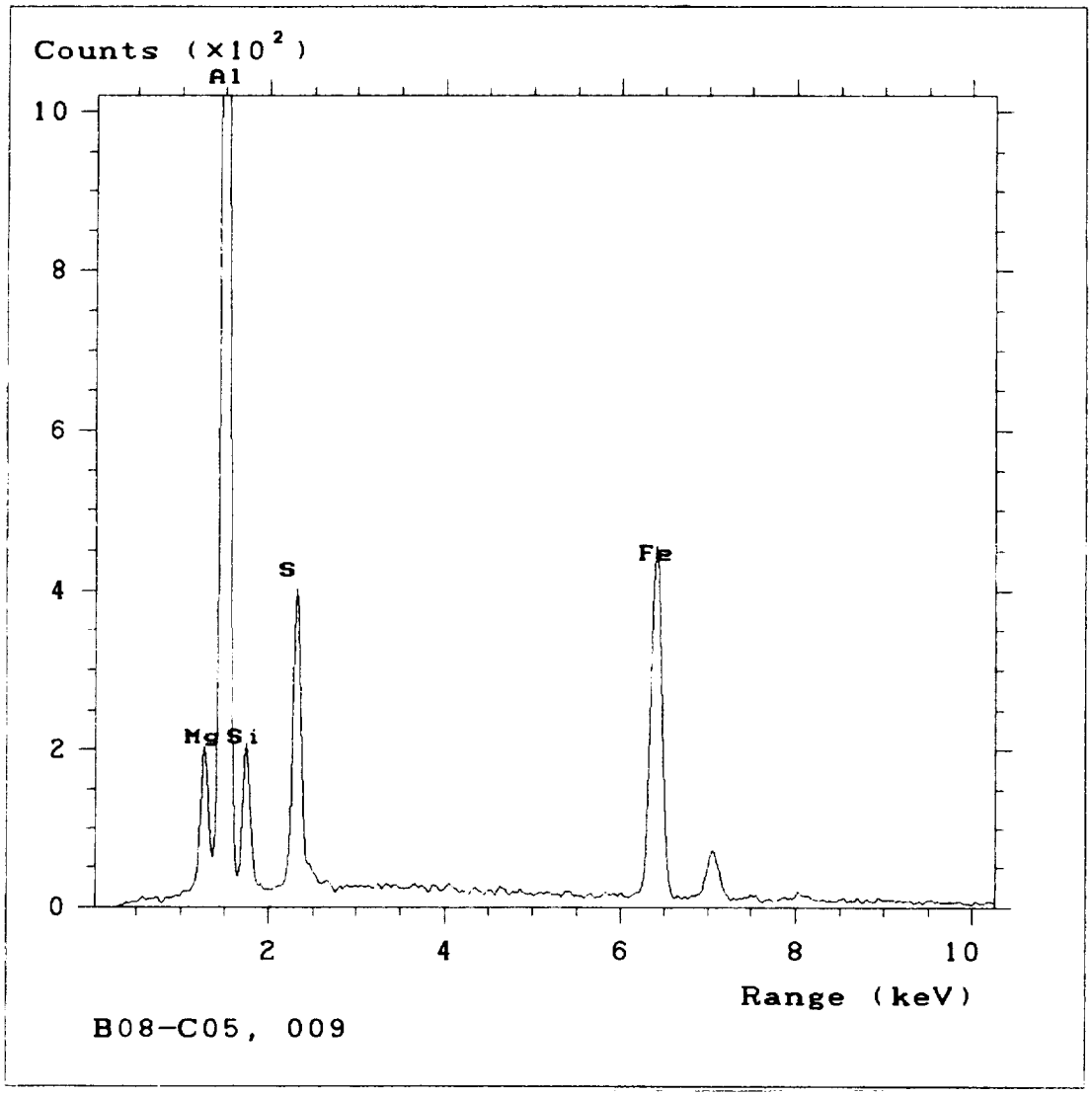
B08-C05

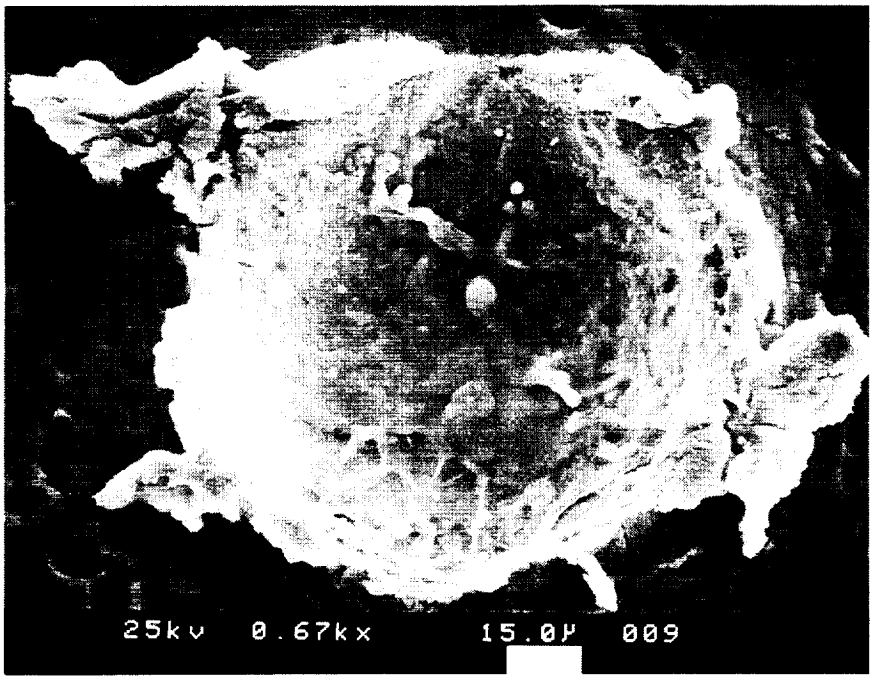
007


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B08-C05, 008

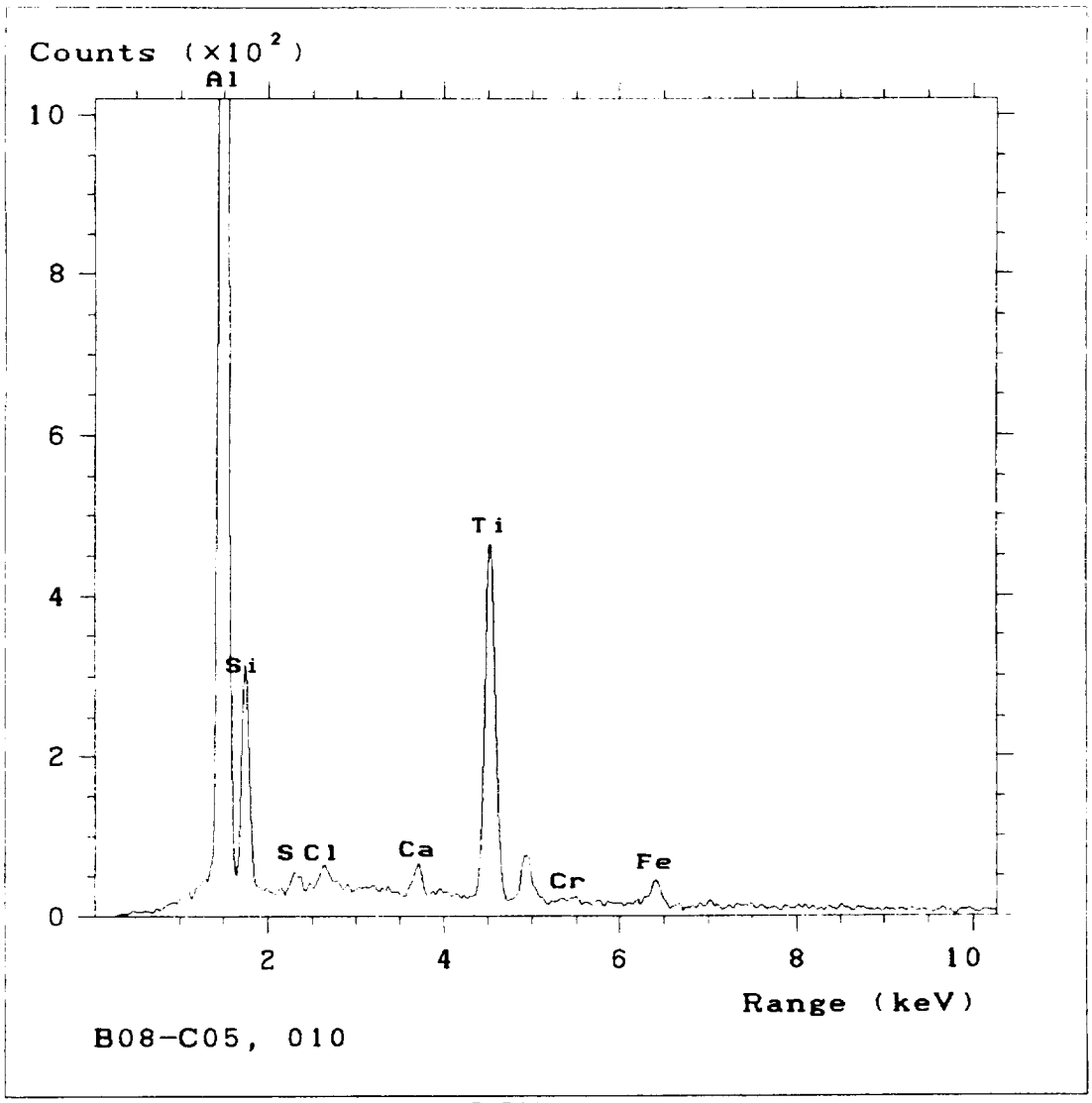

25kv 0.32kx 31.0μ 010

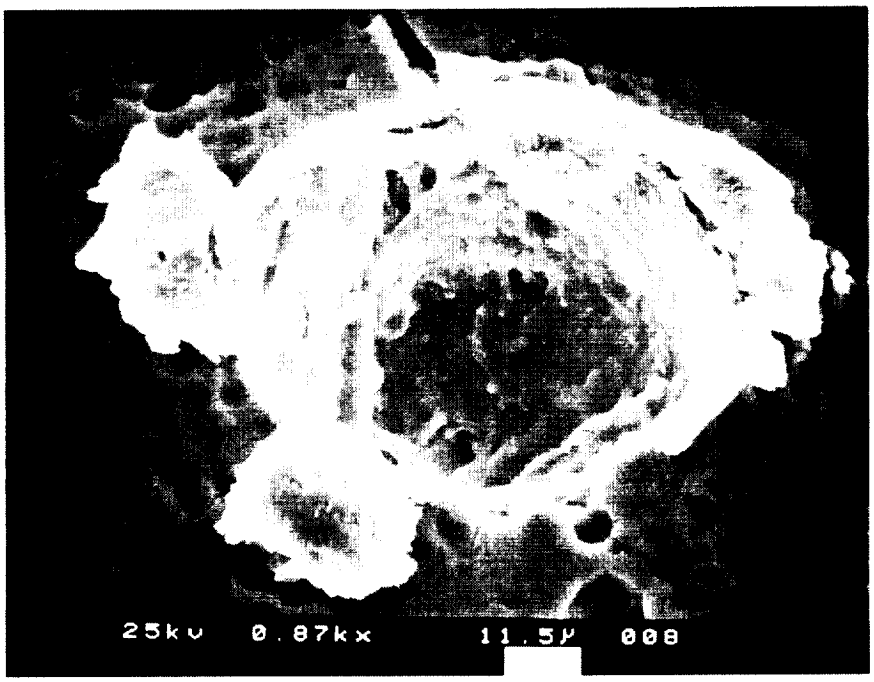
B08-C05 ^08



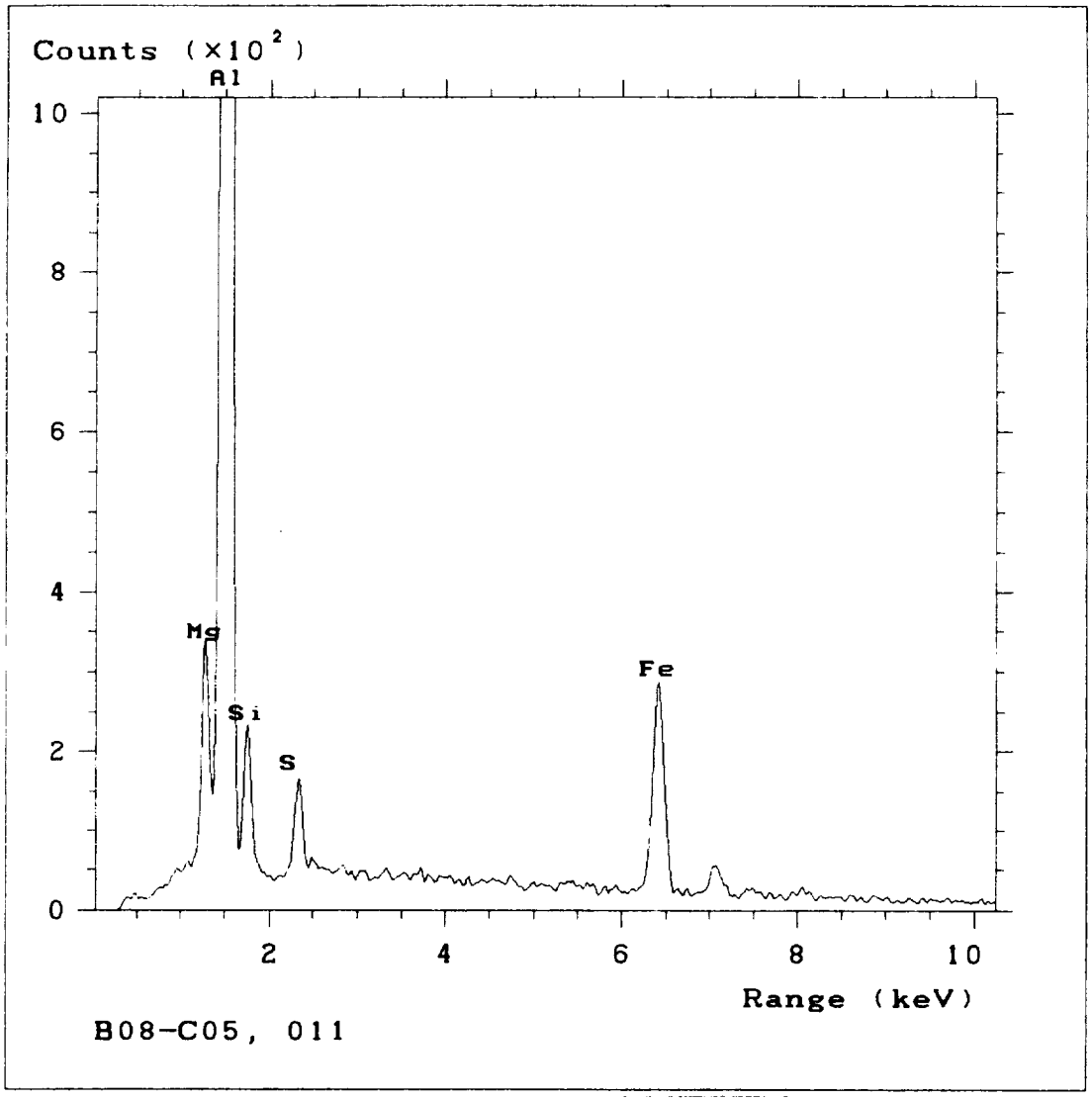


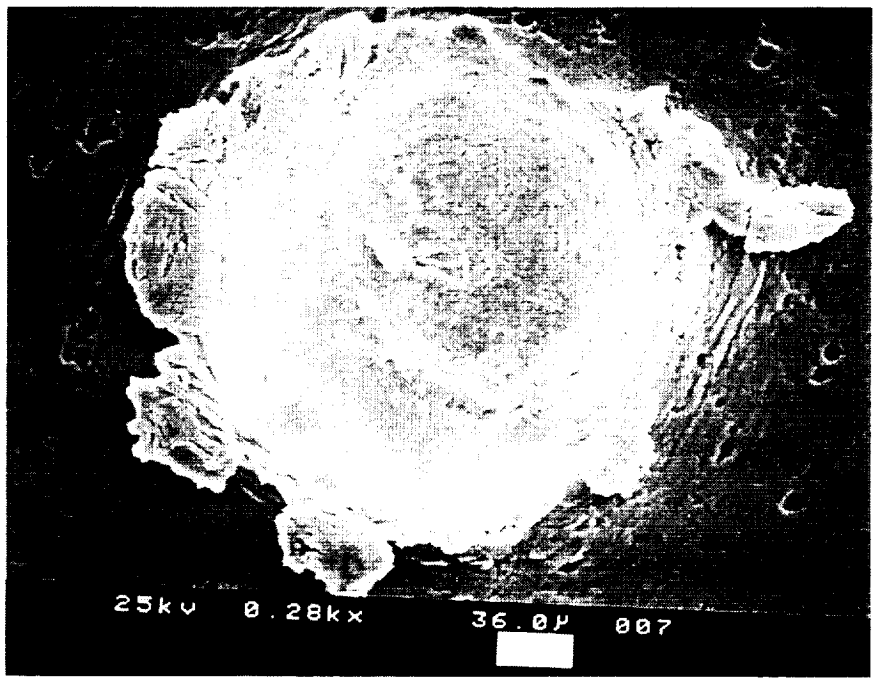
B08-C05 009 mM



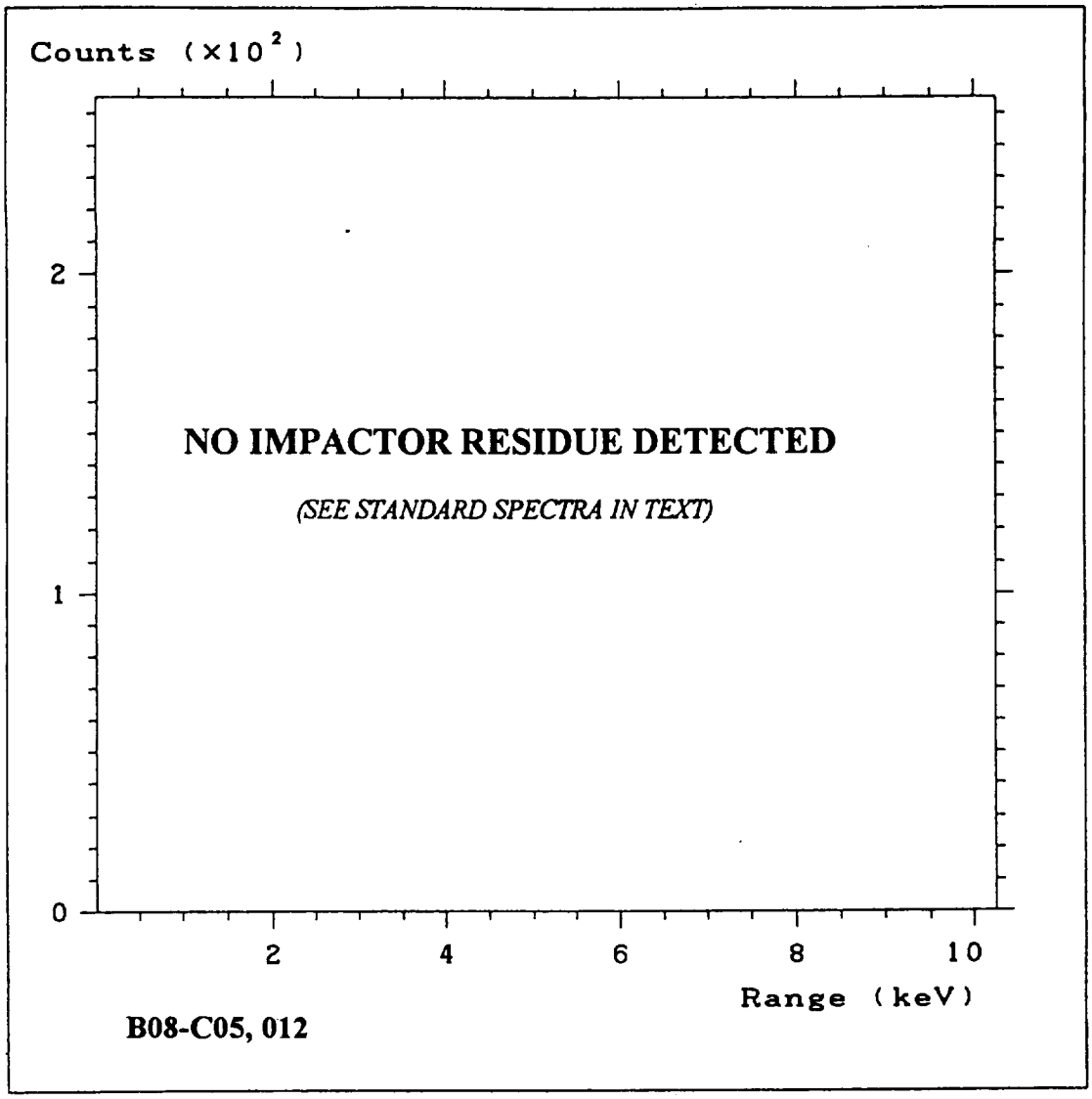


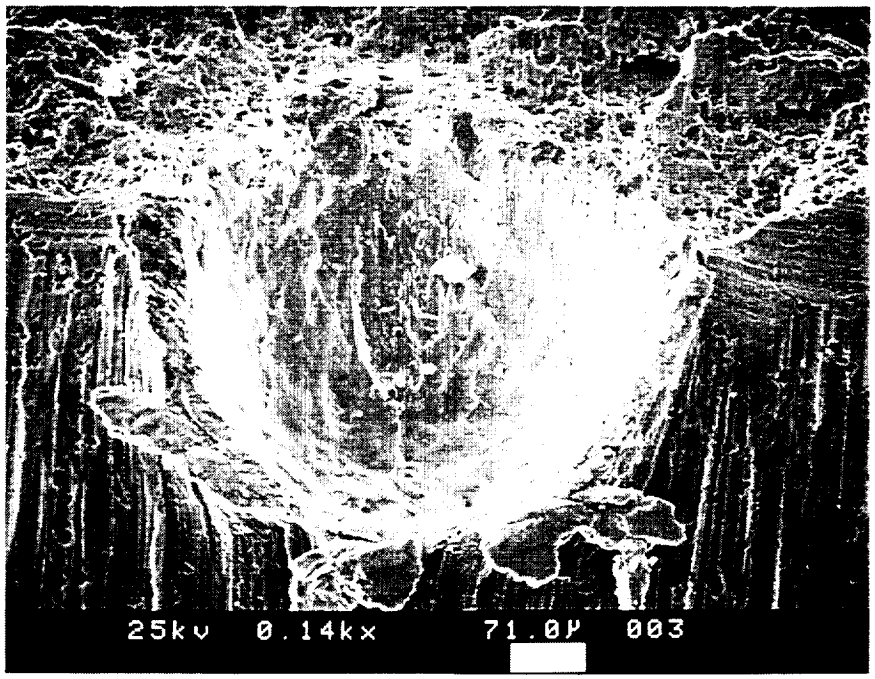
B08-C05 010 PRINT



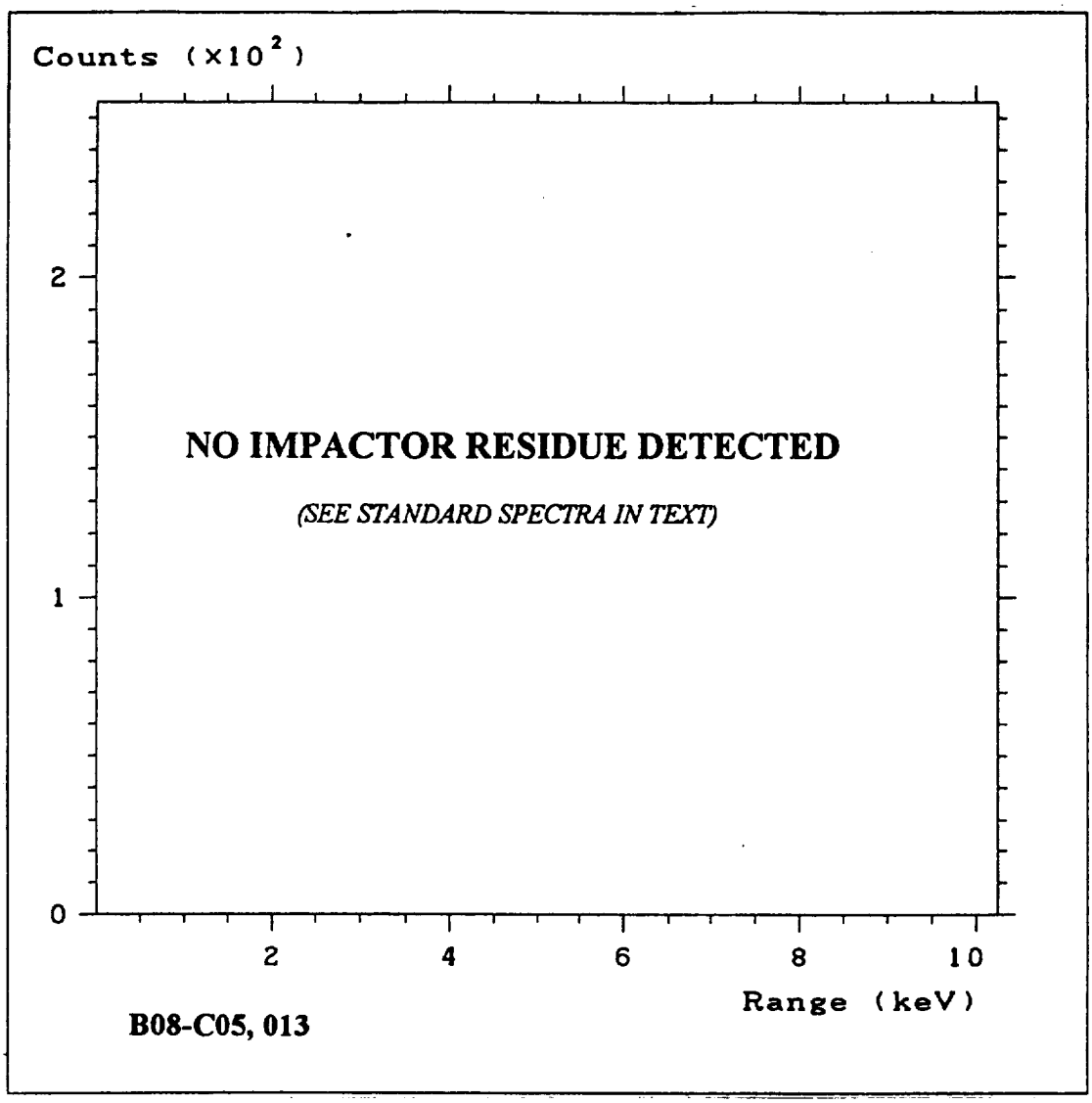


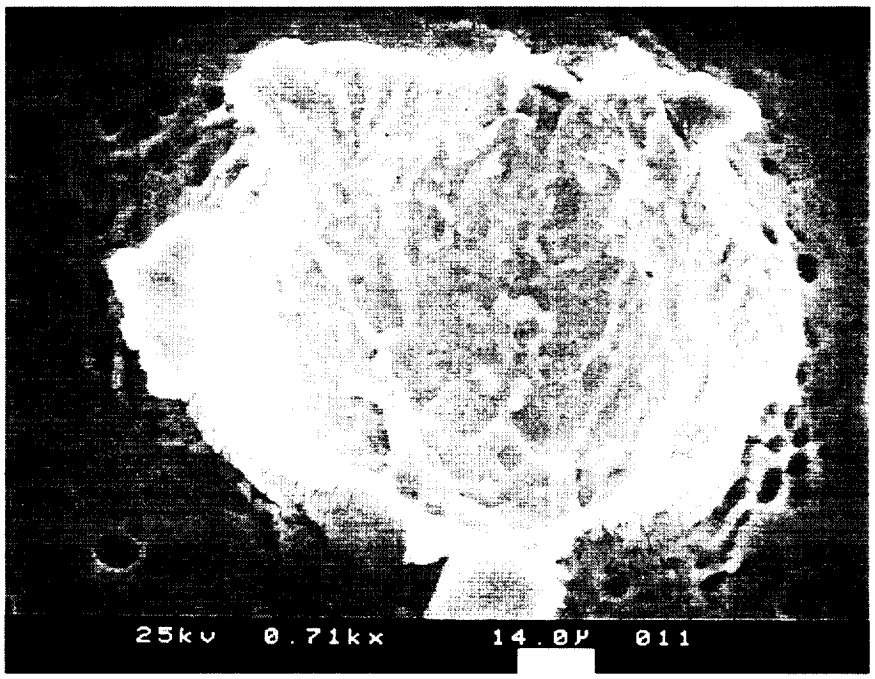
B08-C05 011 mm


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 012


25kv 0.14kx 71.0µ 003

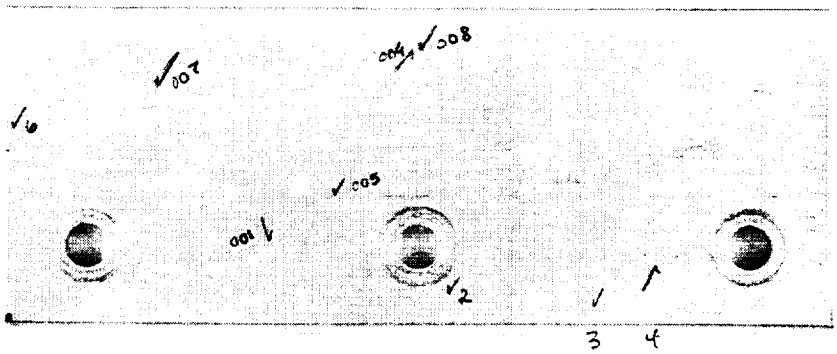
B08-C05 012


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C05, 013

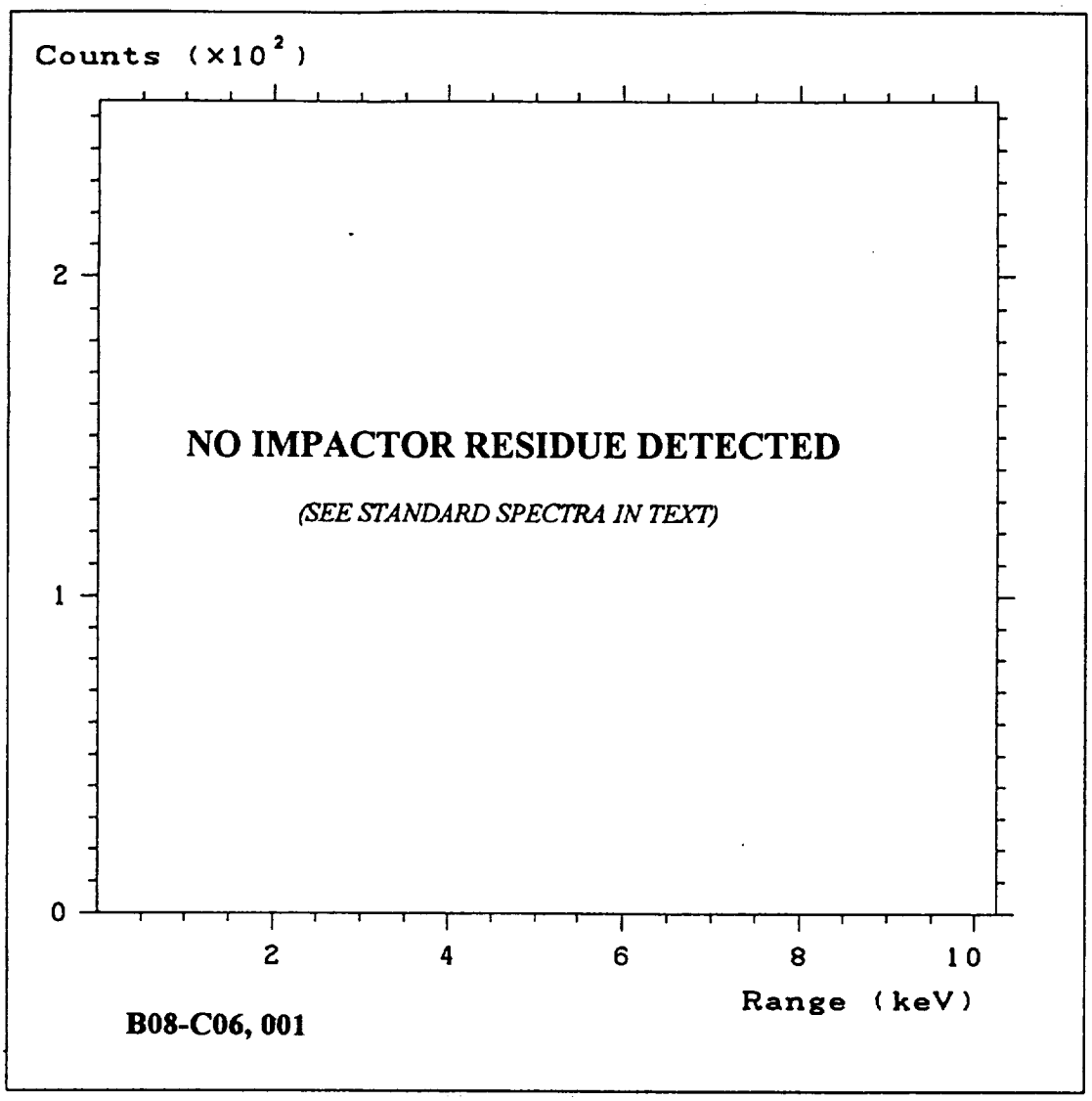

25kv 0.71kx 14.0µ 011

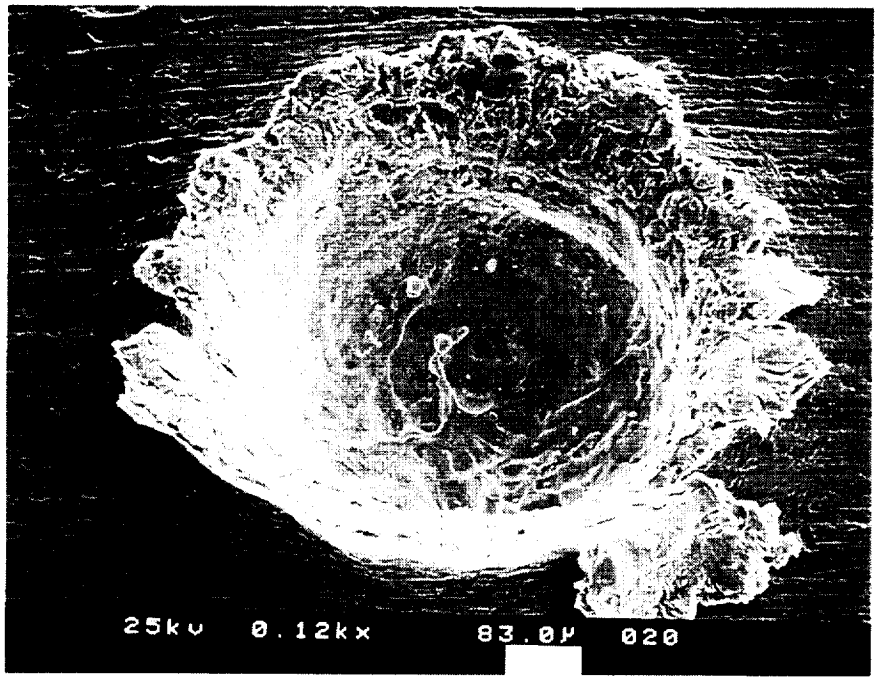
B08-C05 013

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B08-C06	001	40	12	600	UNKNOWN
	002	67	4	70	PAINT
	003	89	2	100	UNKNOWN
	004	99	9	460	UNKNOWN
	005	50	18	140	MICROMETEORITIC
	006	2	28	130	UNKNOWN
	007	24	34	130	MICROMETEORITIC
	008	64	40	200	MICROMETEORITIC
	009	63	39	40	UNKNOWN

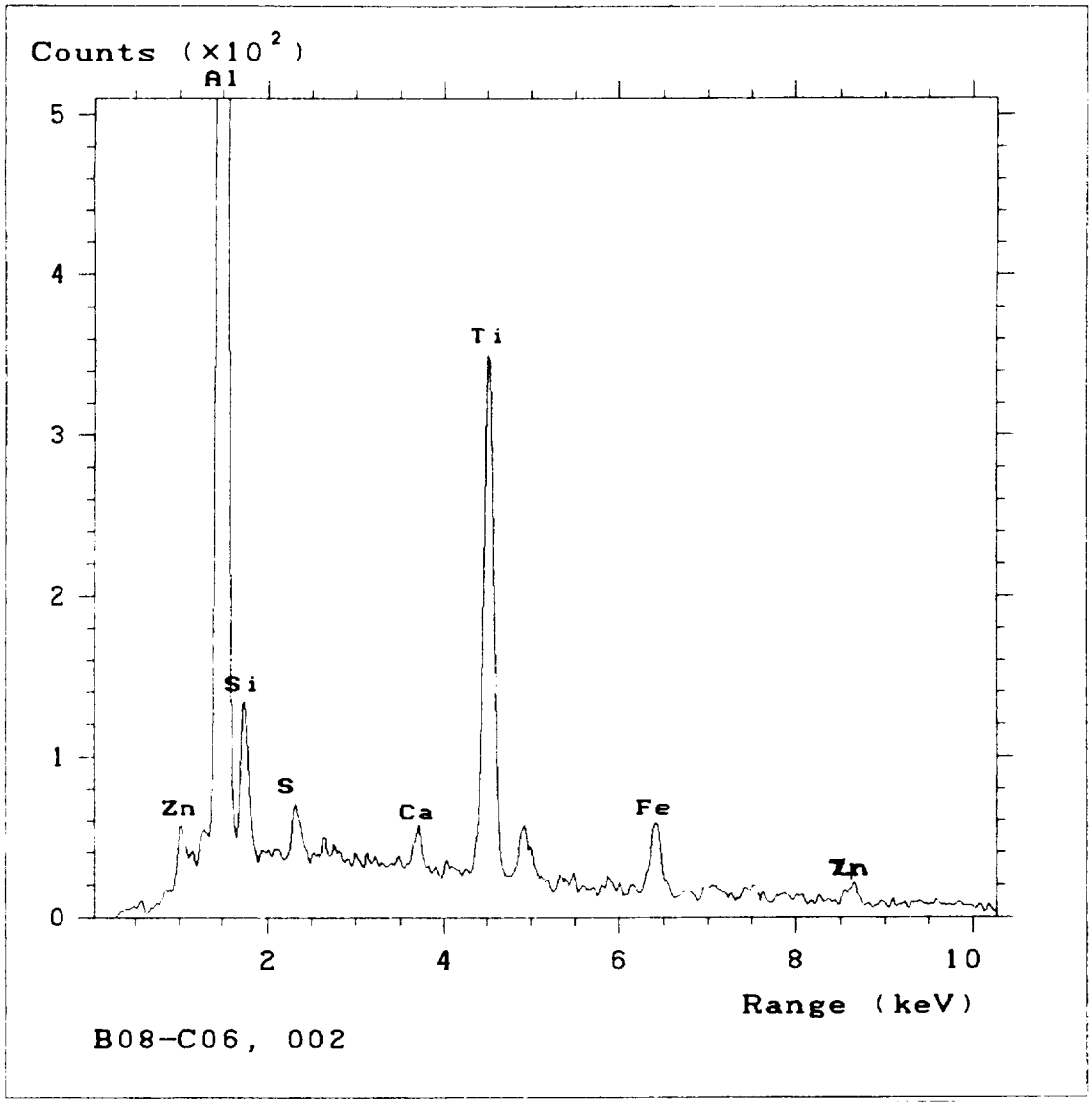


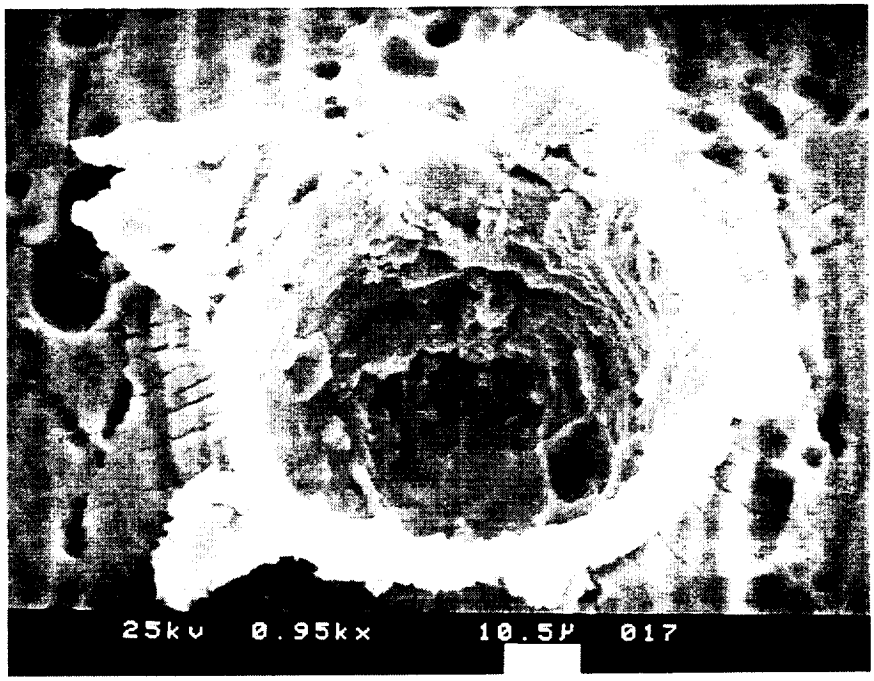
B08 - C06


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C06, 001

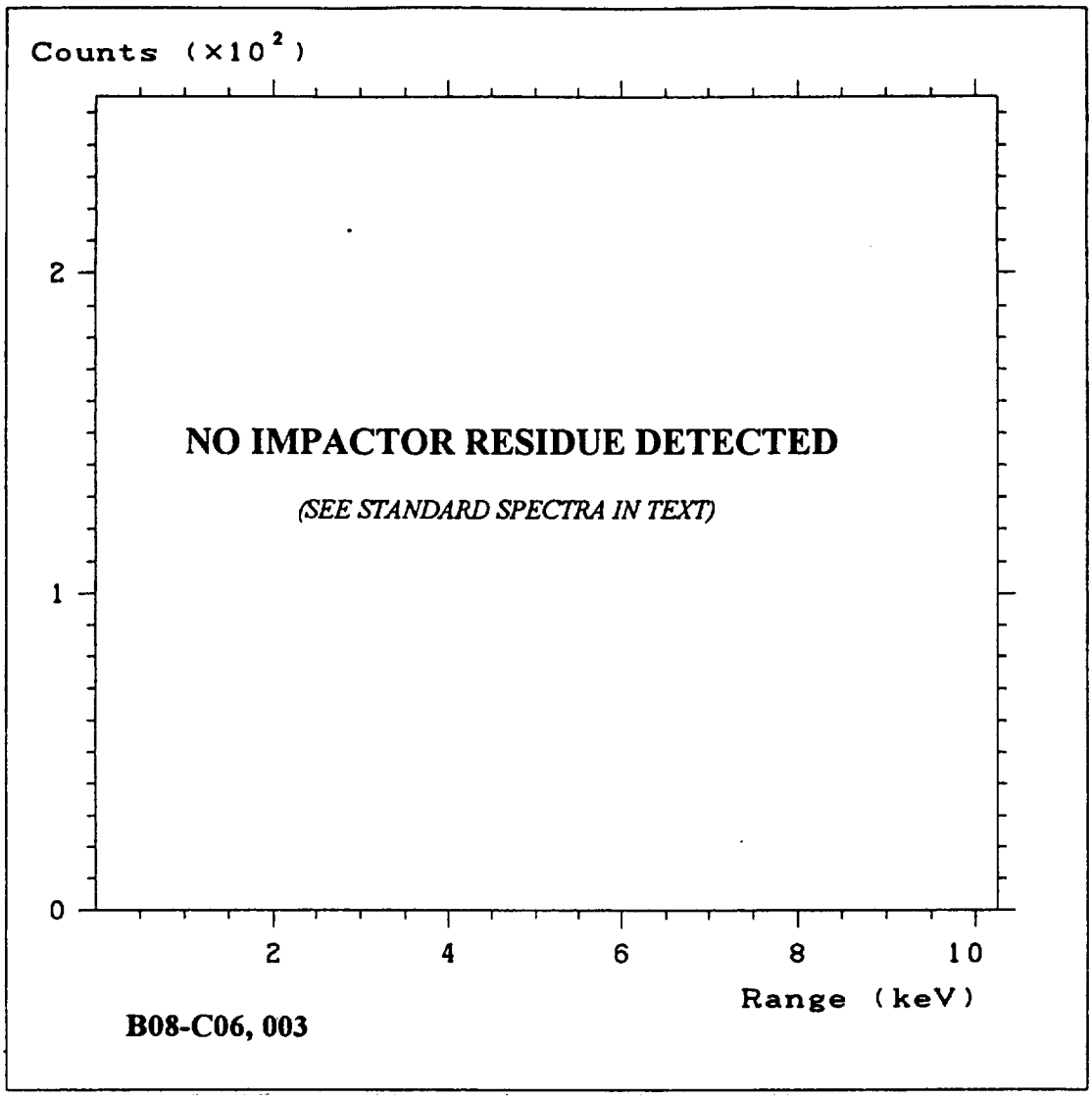

25kv 0.12kx 83.0μ 020

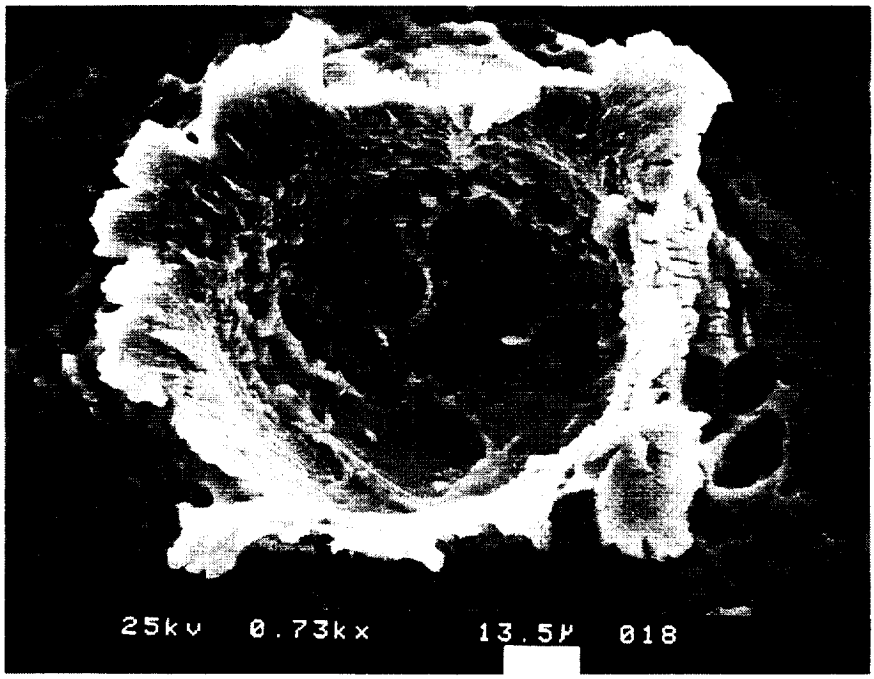
B08-C06 001



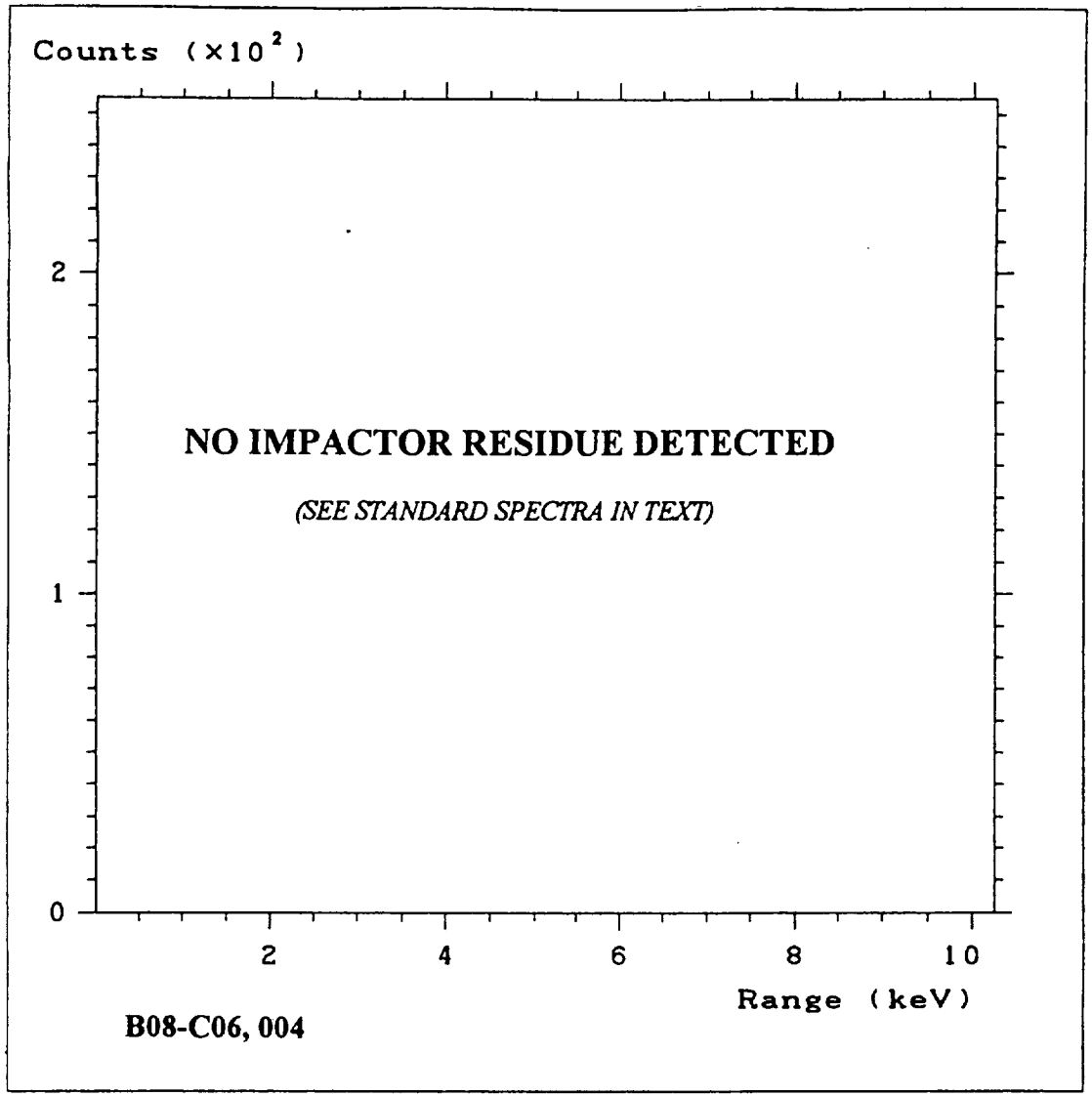


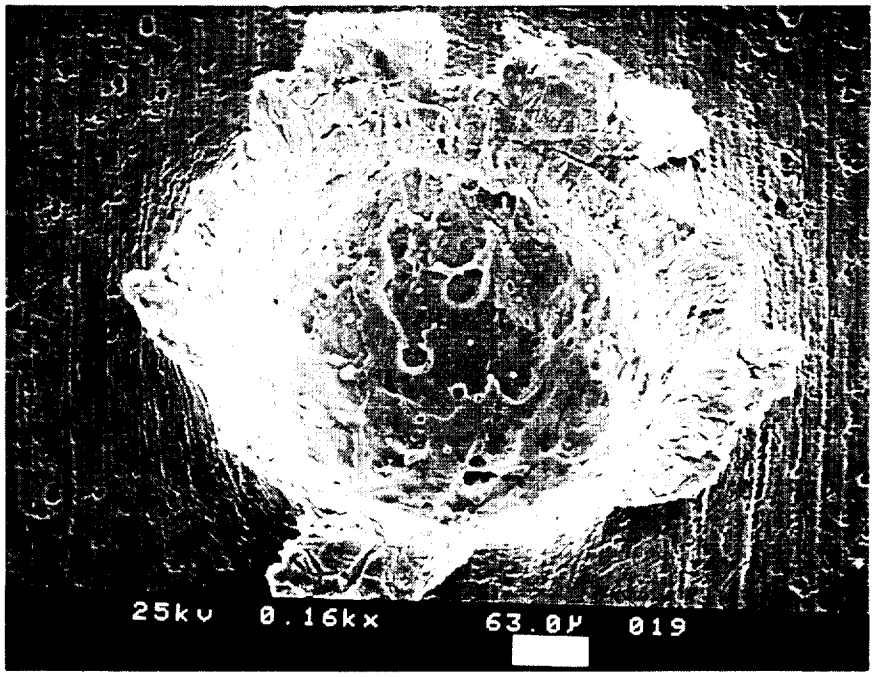
B08-C06 002 PAINT


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C06, 003

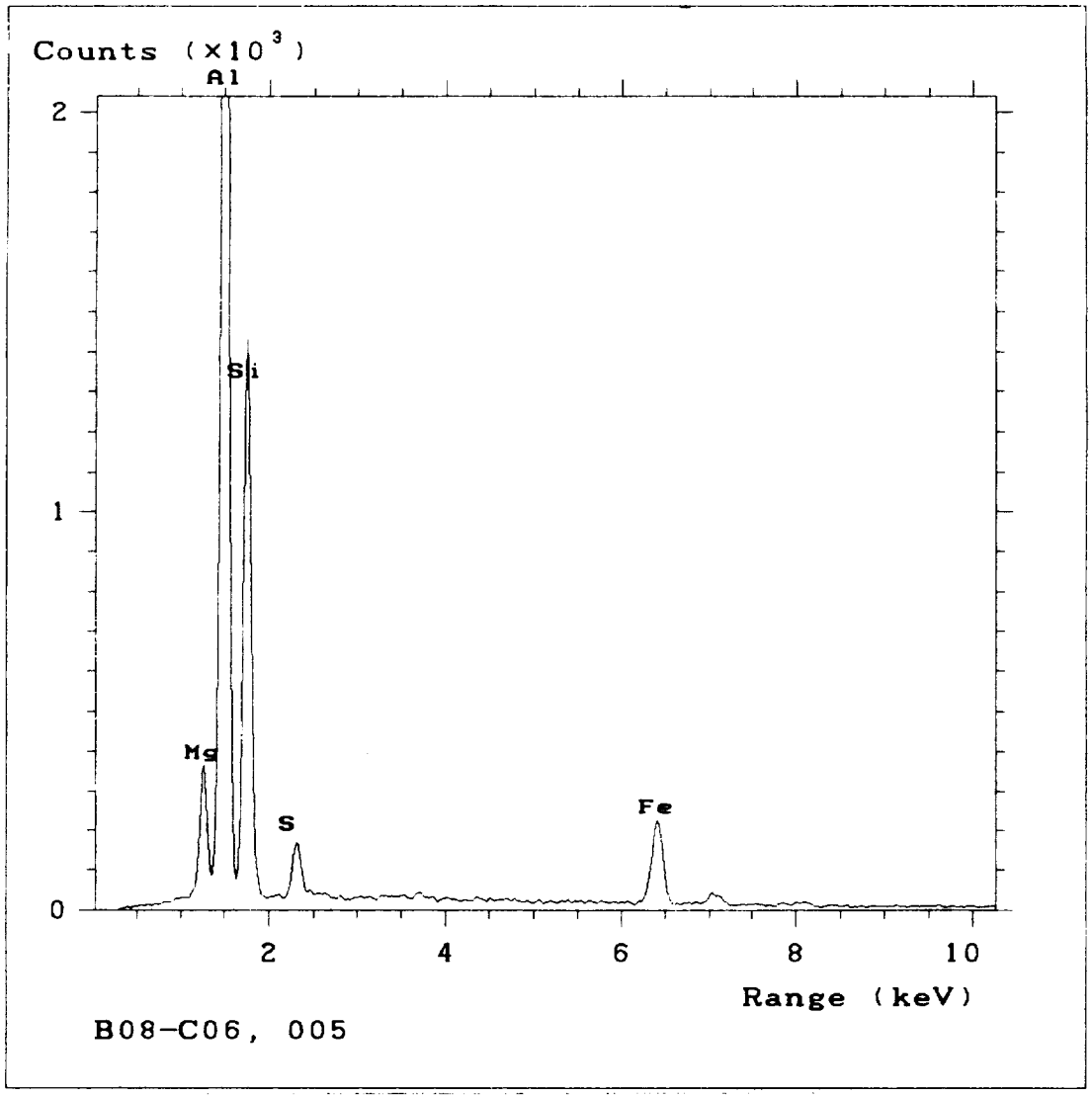

25kv 0.73kx 13.5µ 018

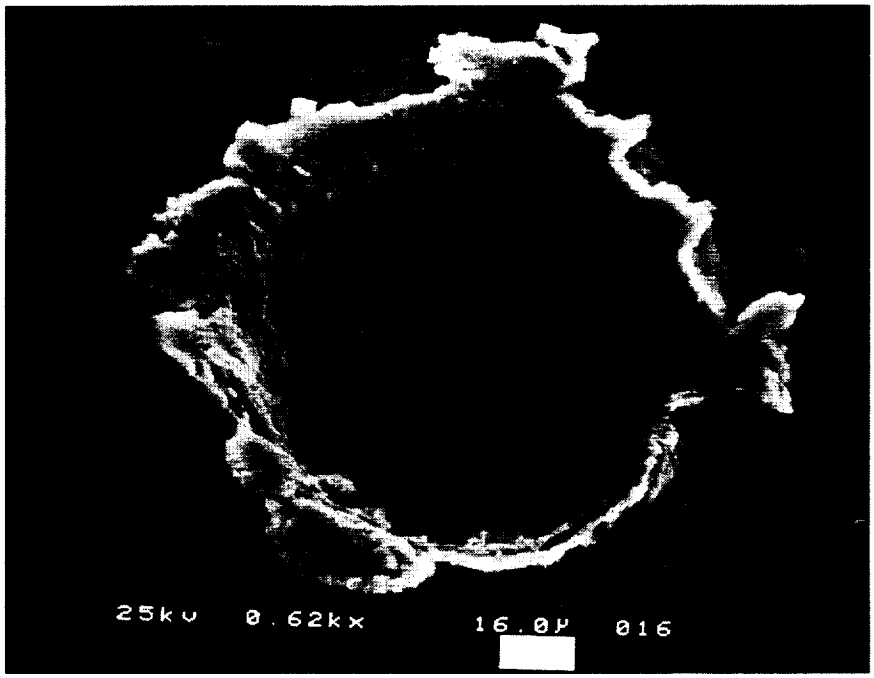
B08-C06 003


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C06, 004

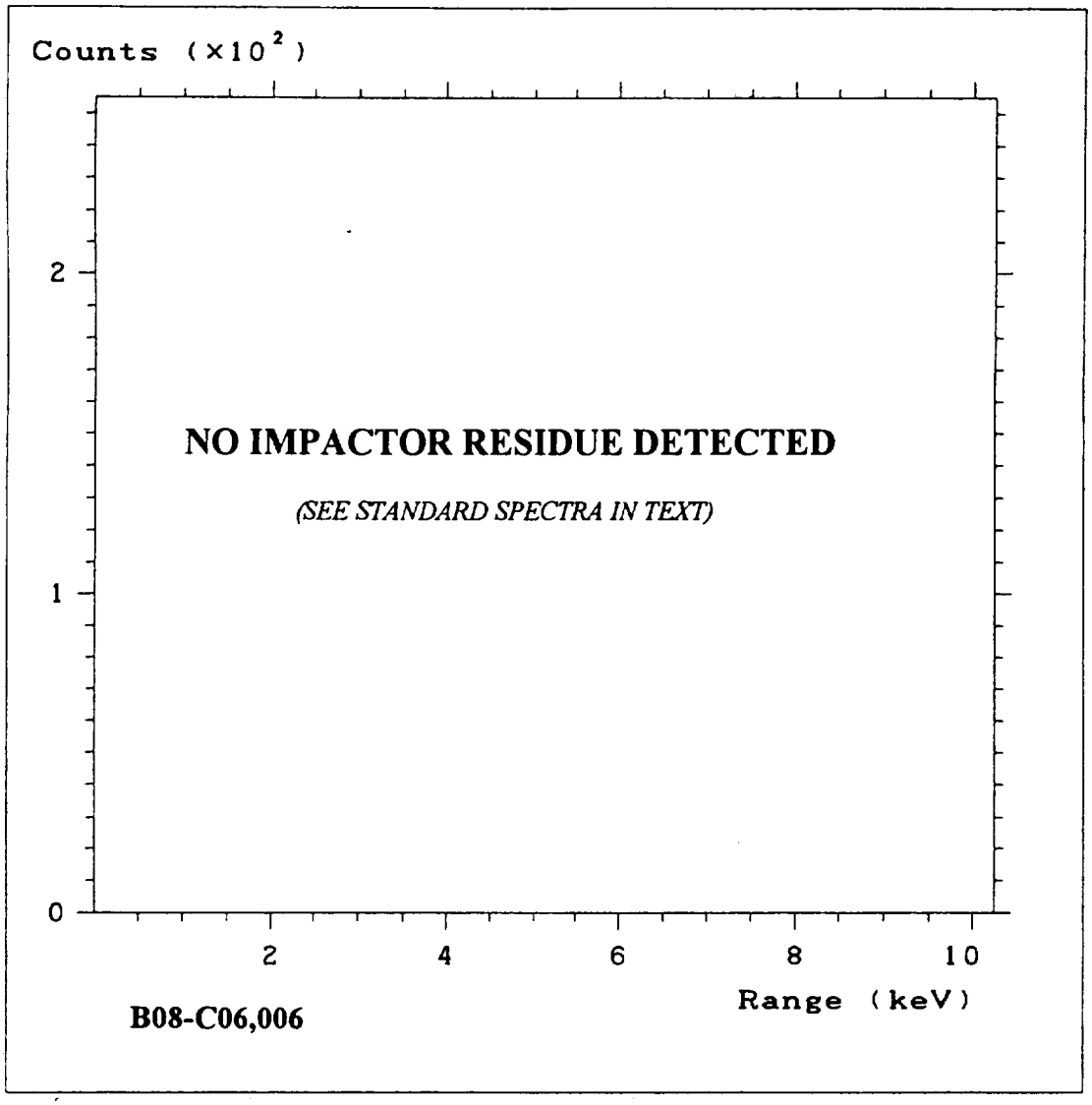

25kv 0.16kx 63.0µ 019

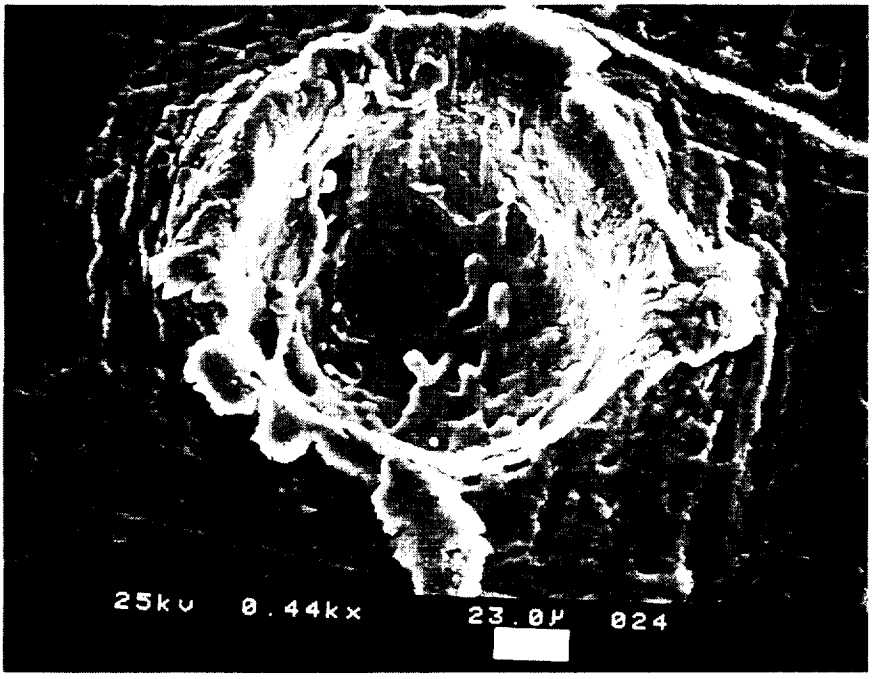
B08-C06 04



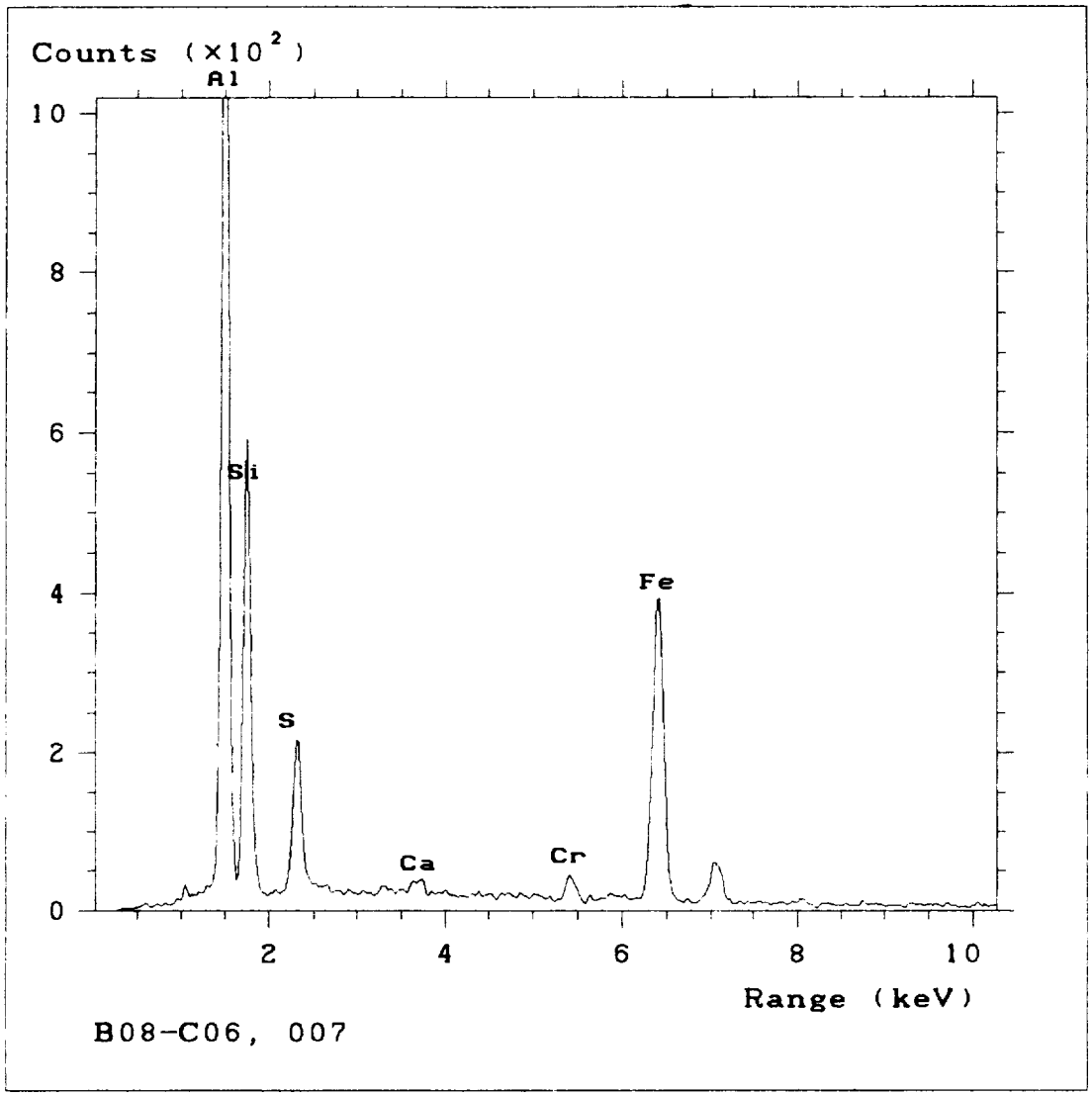


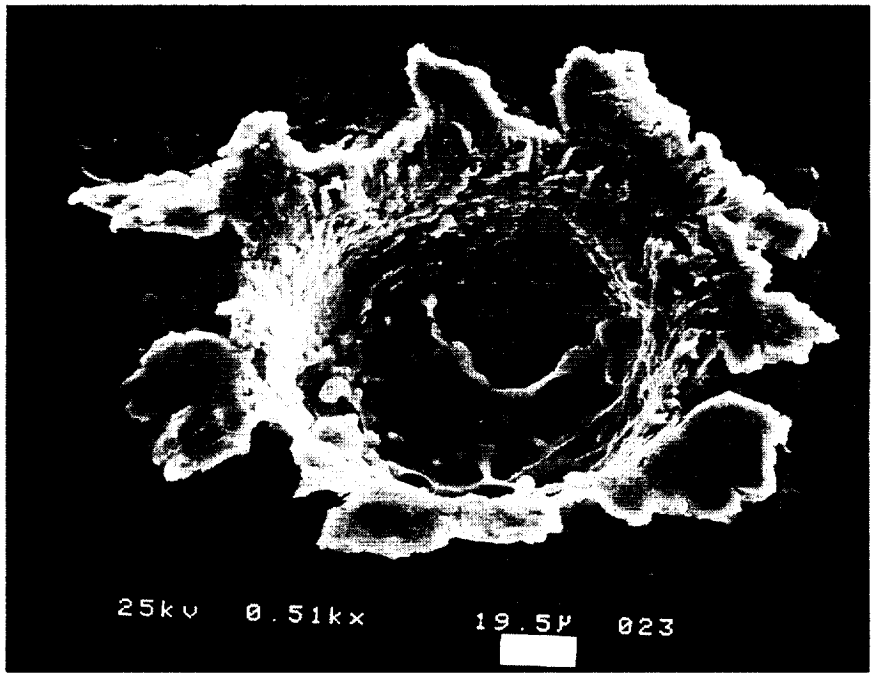
B08-C06 005 Fe, Mg, Si


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C06,006

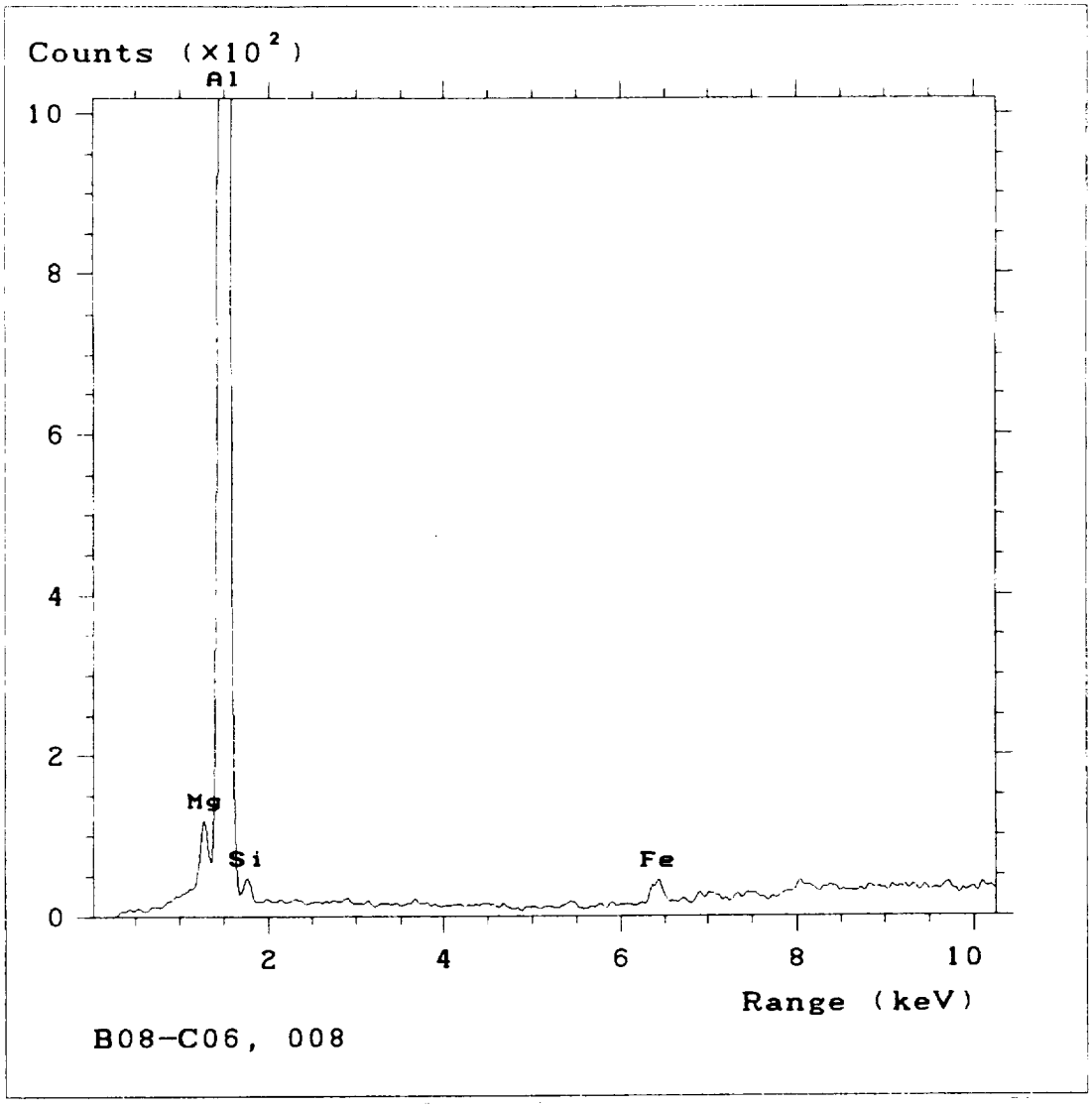

25kv 0.44kx 23.0μ 024

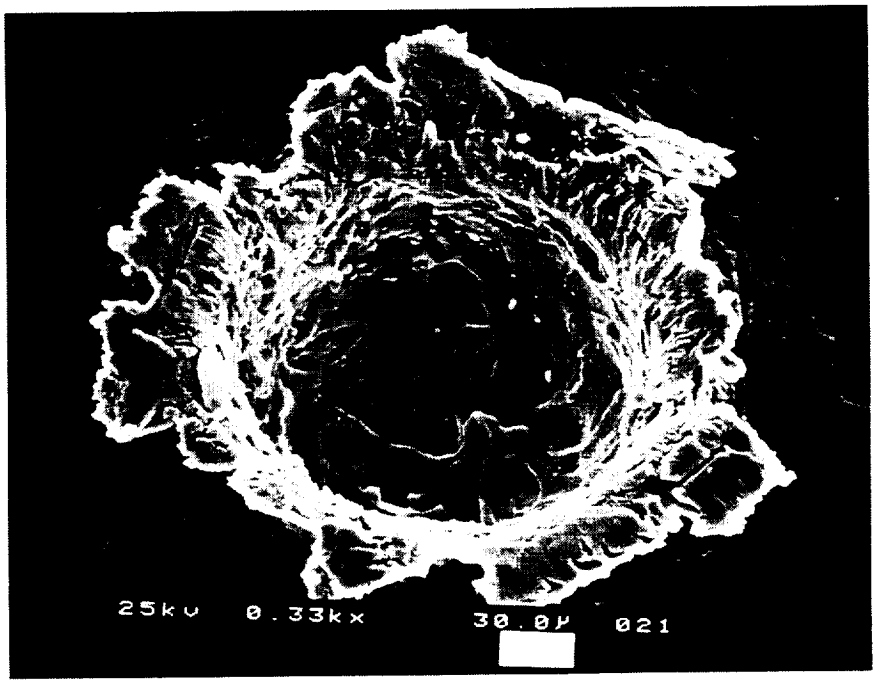
B08-C06 006



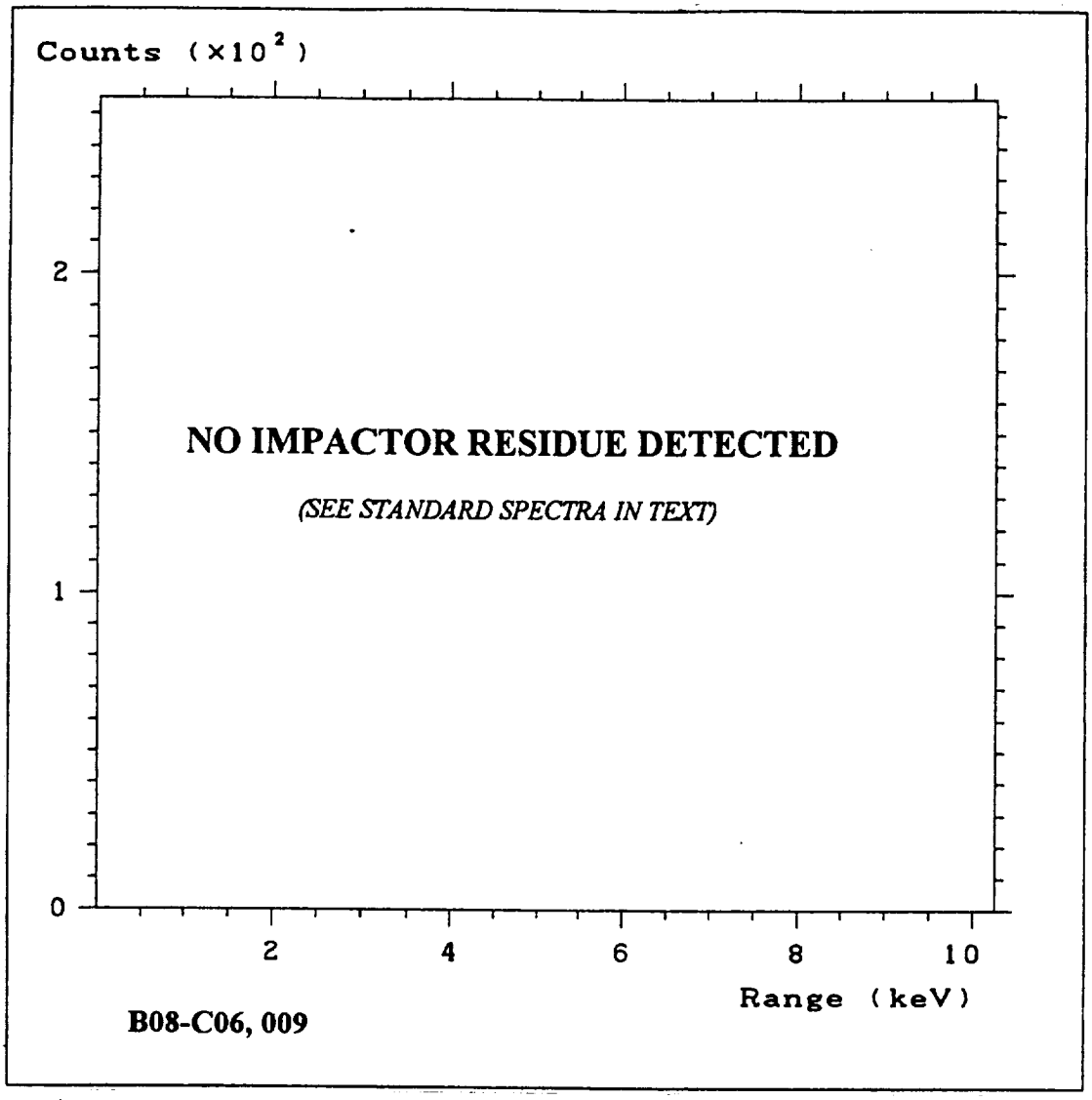


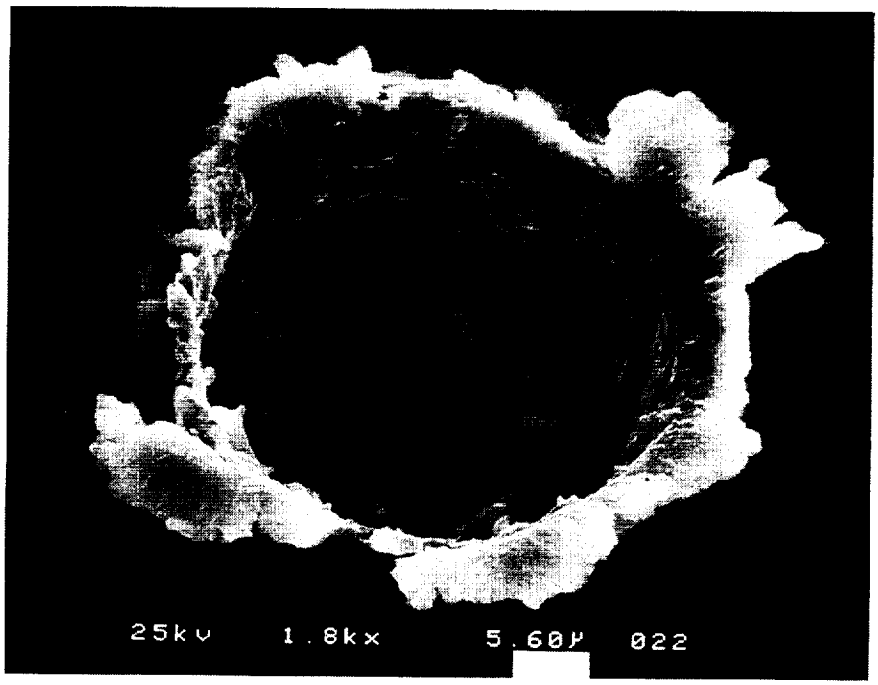
B08-C06 007 MM


Counts (×10²)
Al
Mg
Si
Fe
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B08-C06, 008


25kv 0.33kx 30.0µ 021

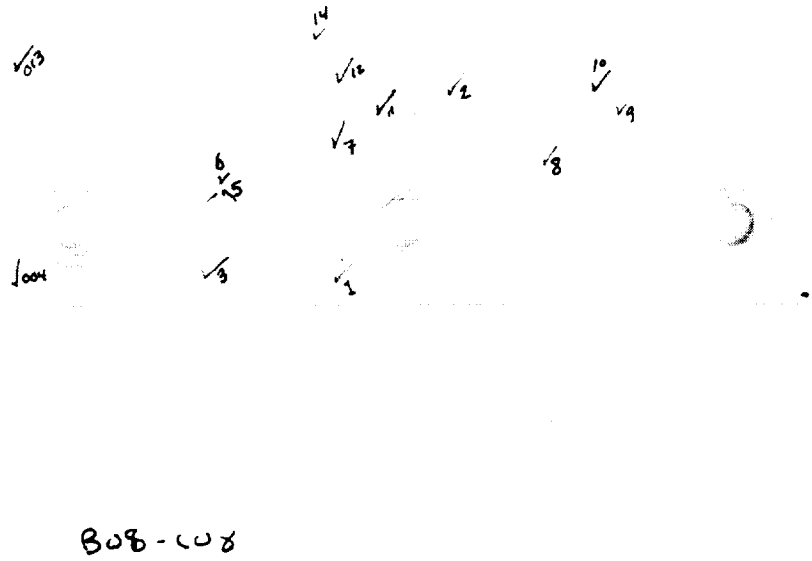
B08-C06 008

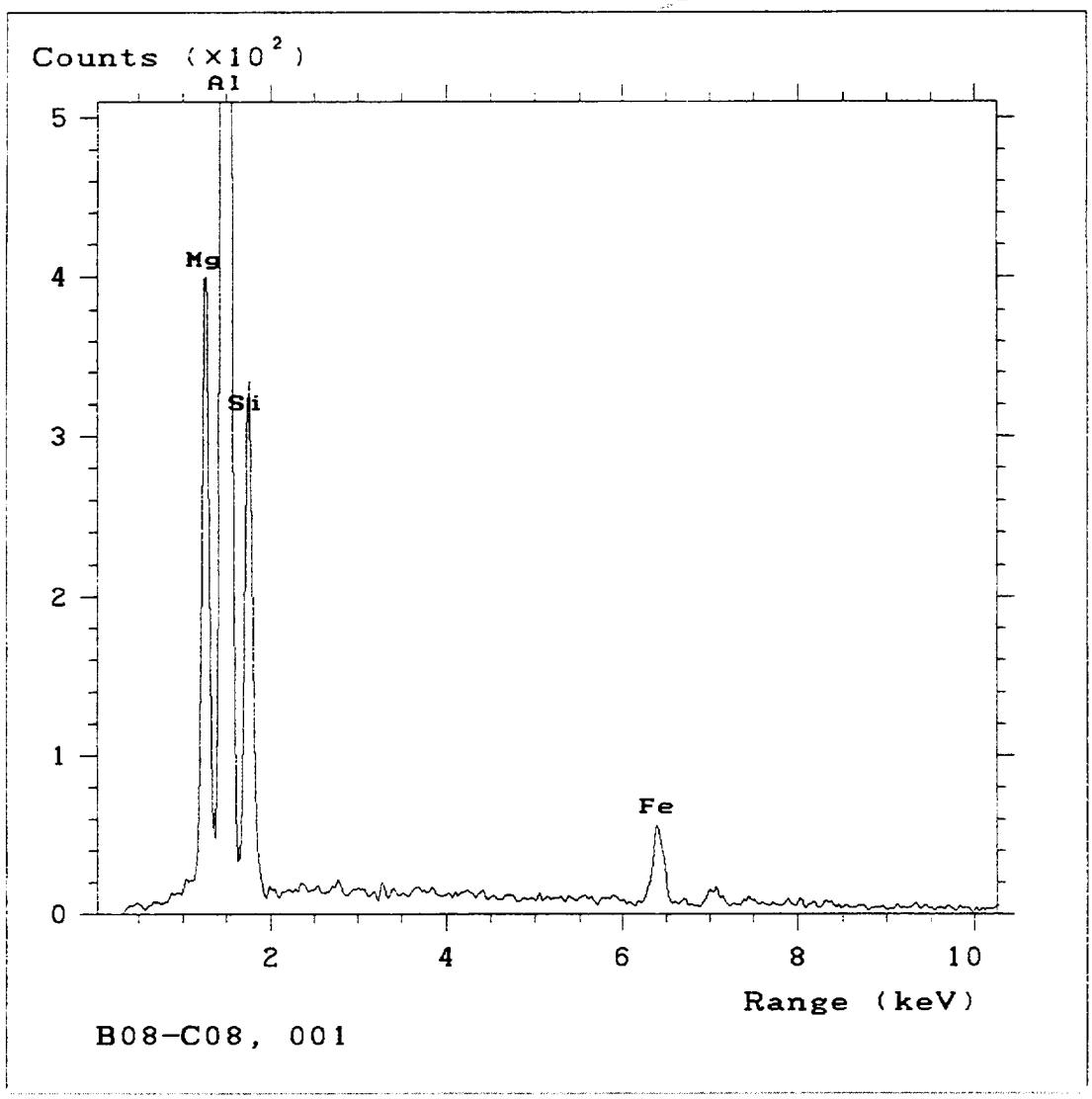

Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B08-C06, 009

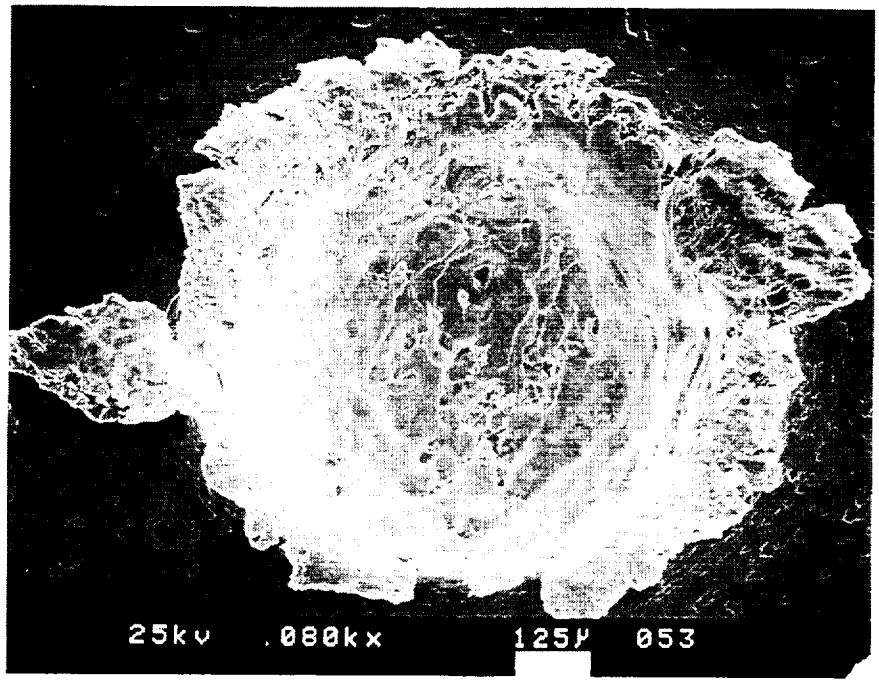

25kv 1.8kx 5.60μ 022

B08-C06 009

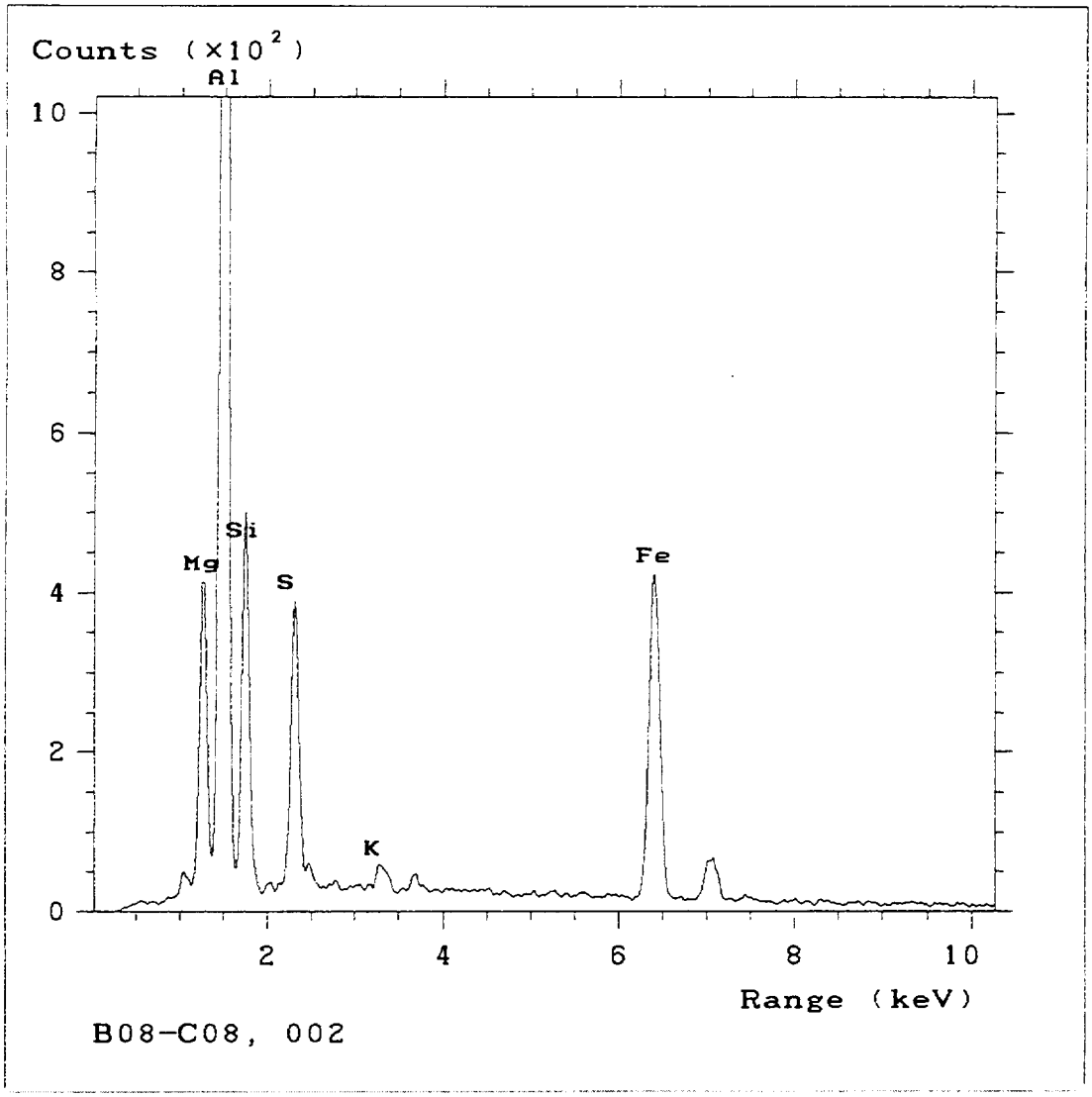
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B08-C08	001	2	73	840	MICROMETEORITIC
	002	31	55	600	MICROMETEORITIC
	003	5	96	60	UNKNOWN
	004	4	125	280	MICROMETEORITIC
	005	19	94	120	UNKNOWN
	006	20	94	40	PAINT
	007	25	77	80	UNKNOWN
	008	22	47	70	UNKNOWN
	009	30	34	110	PAINT
	010	33	38	50	UNKNOWN
	011	31	72	60	MICROMETEORITIC
	012	36	78	250	UNKNOWN
	013	38	129	130	MICROMETEORITIC
	014	43	83	40	STAINLESS STEEL

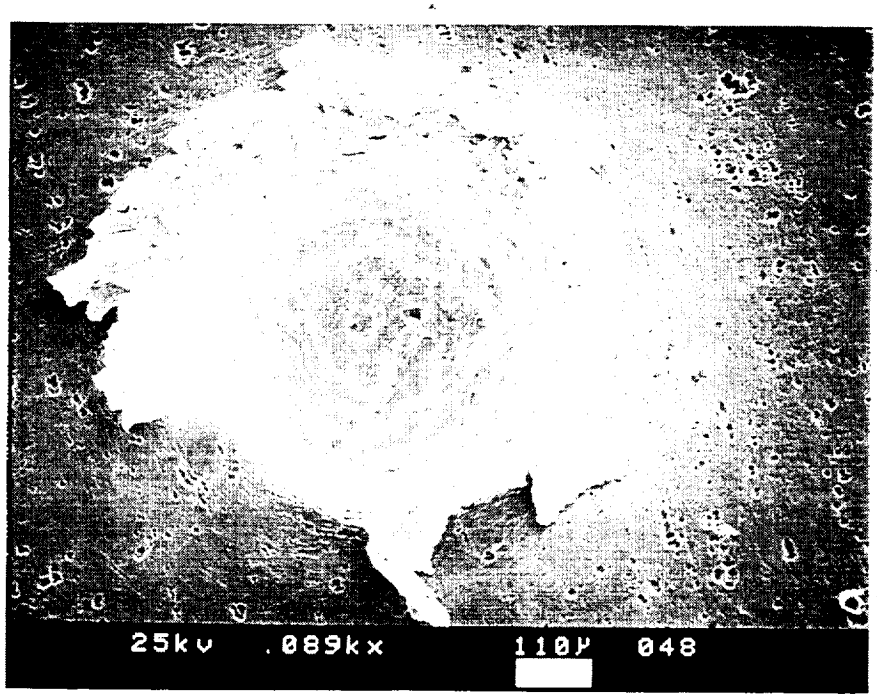




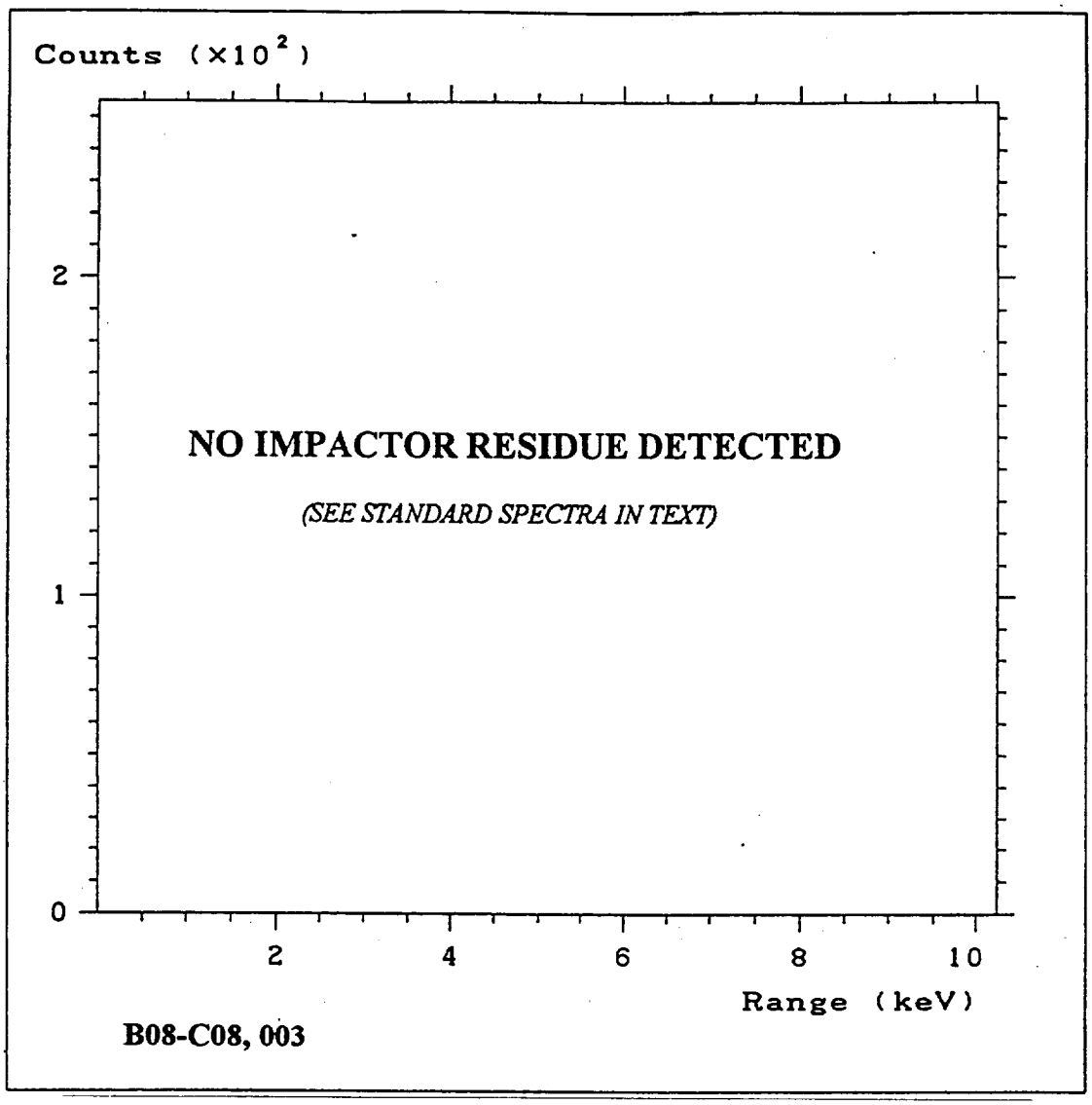


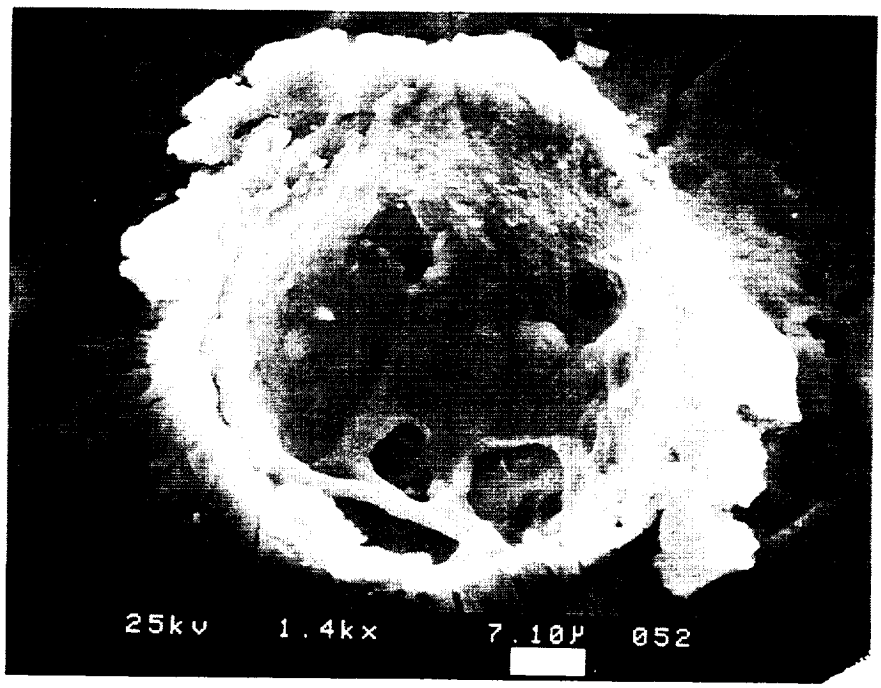
B08-C08 001 MH



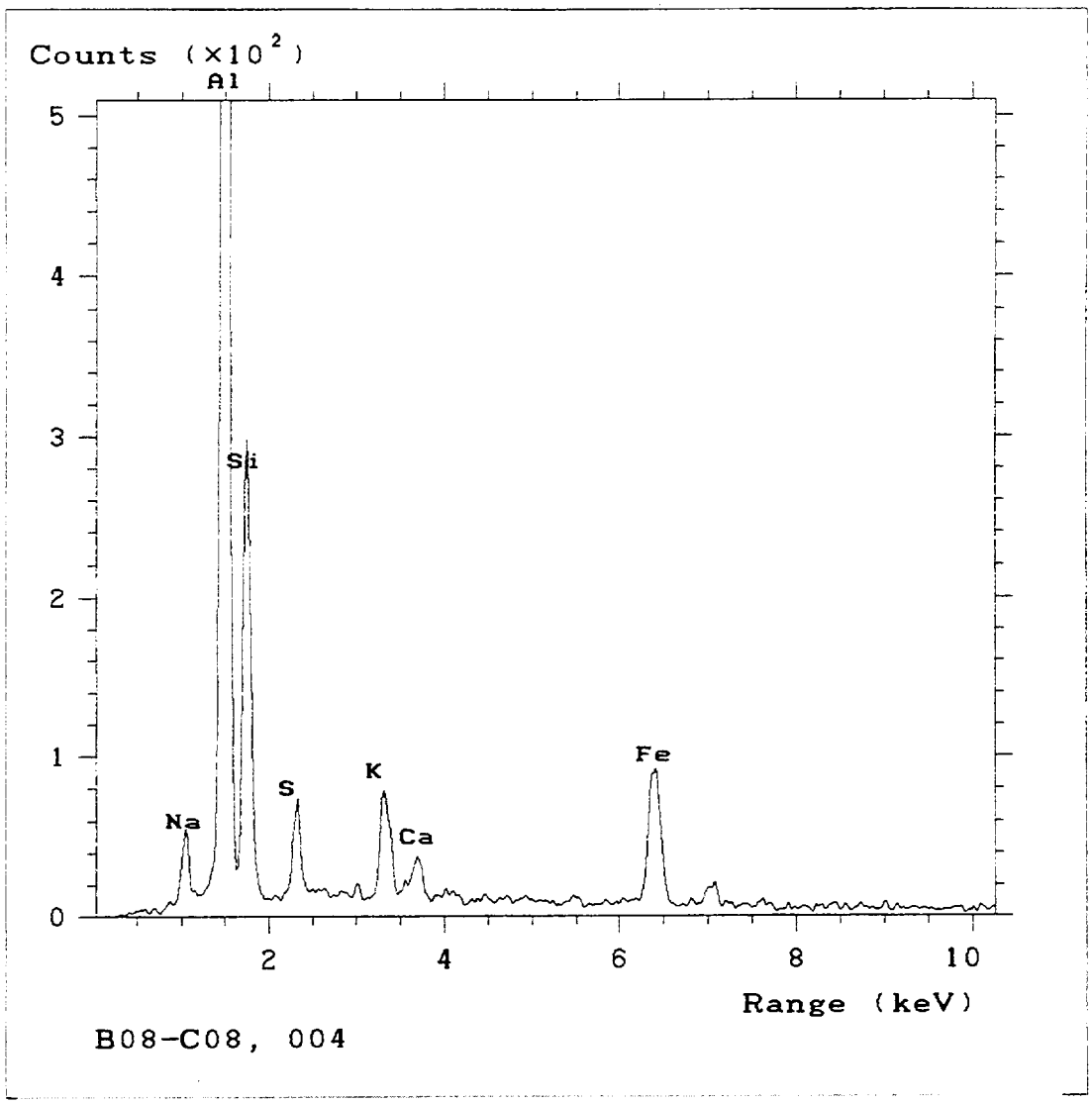


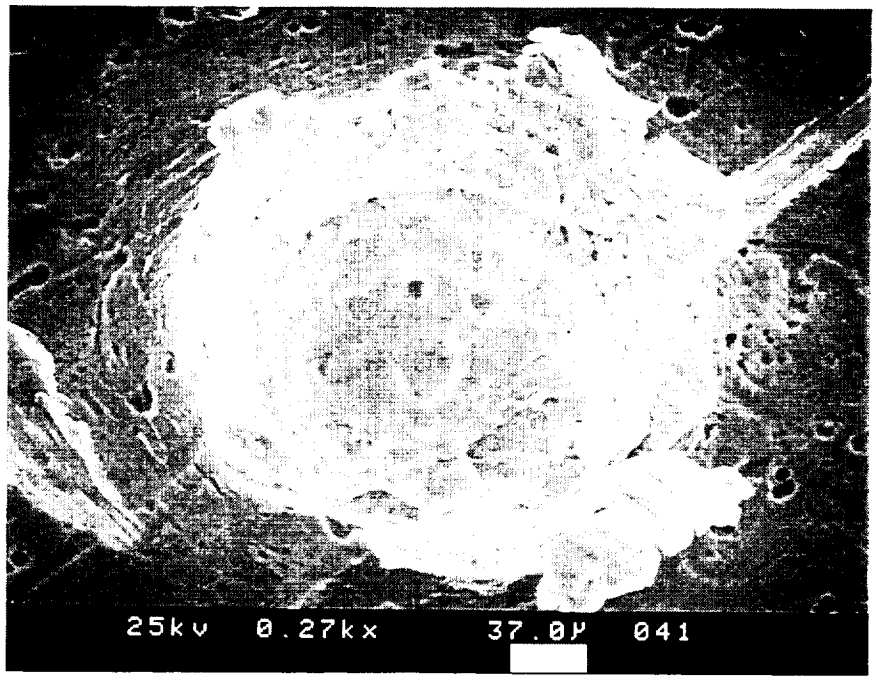
B08-C08 002 mm


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B08-C08, 003

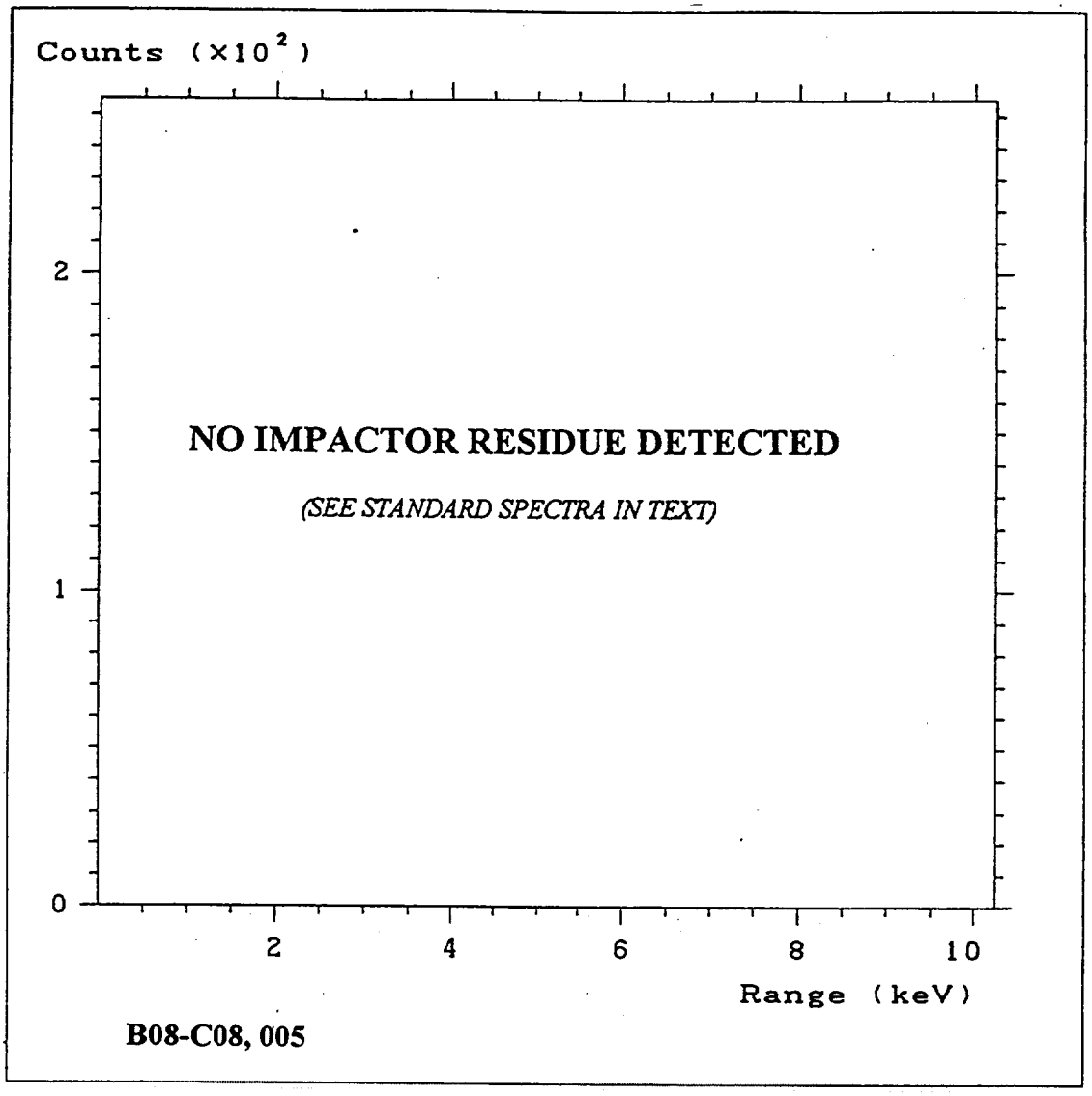

25kv 1.4kx 7.10μ 052

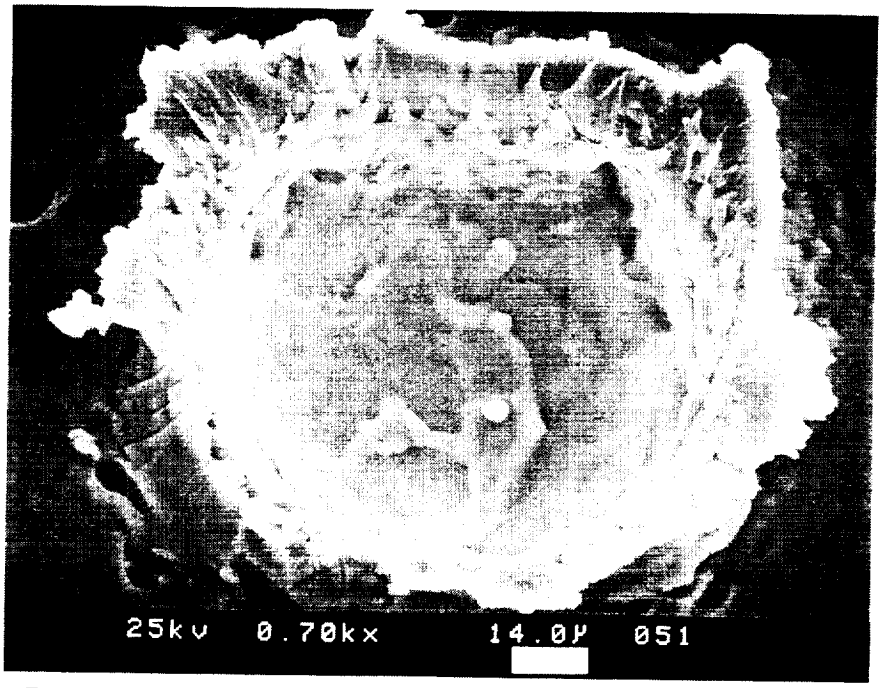
B08-C08 003



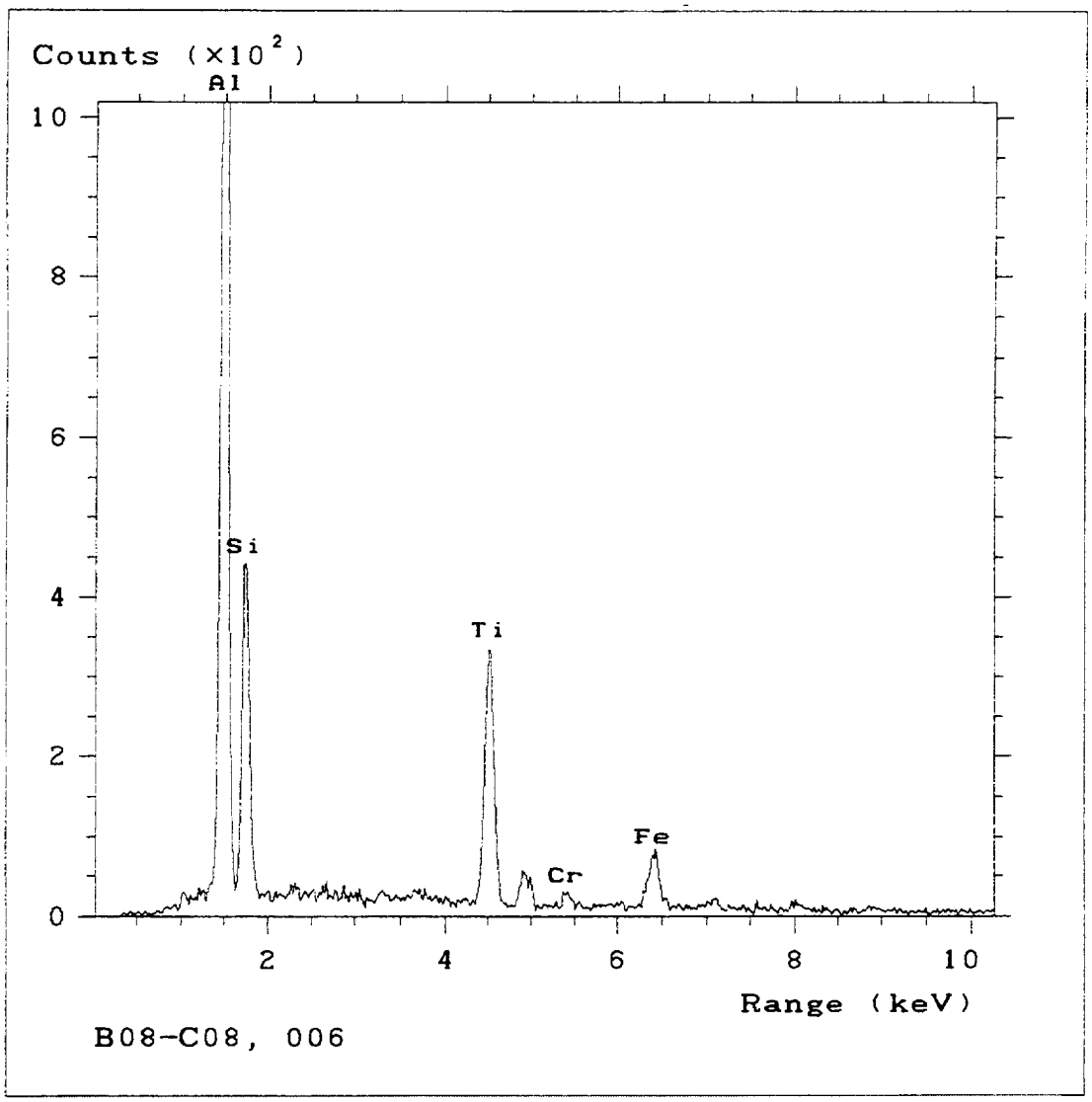


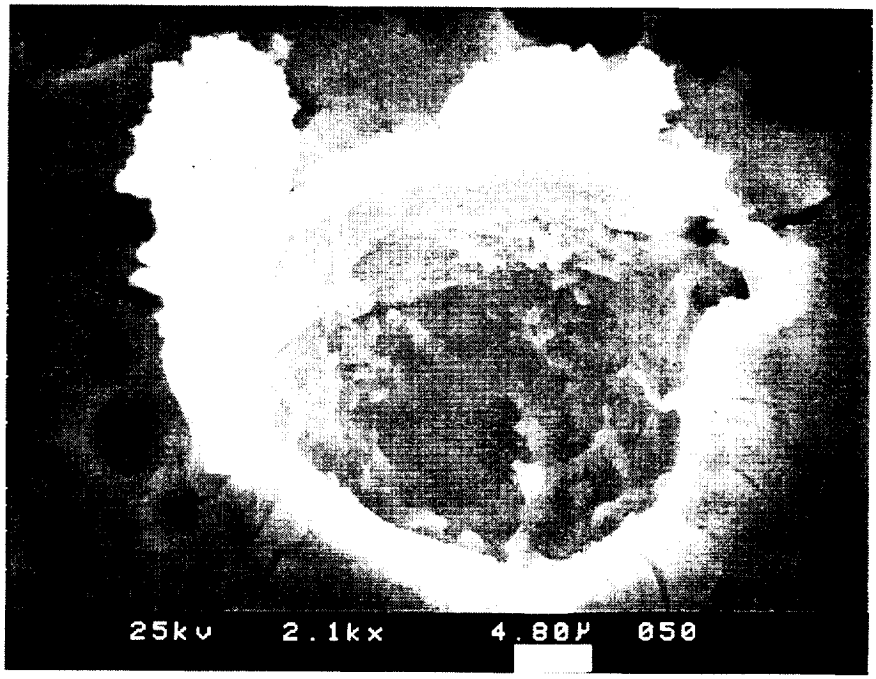
B08 C08 004 mm


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B08-C08, 005

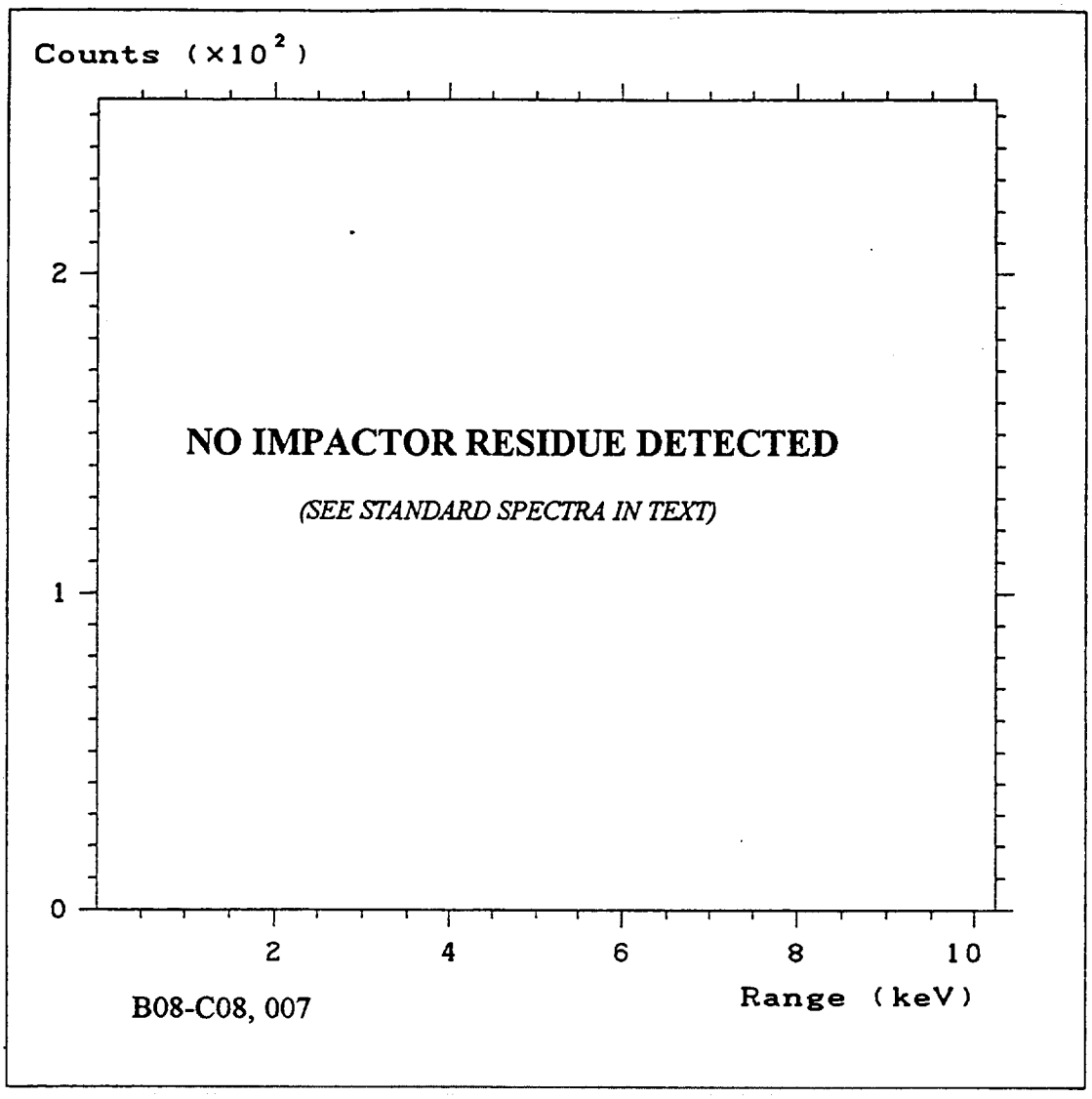

25kv 0.70kx 14.0μ 051

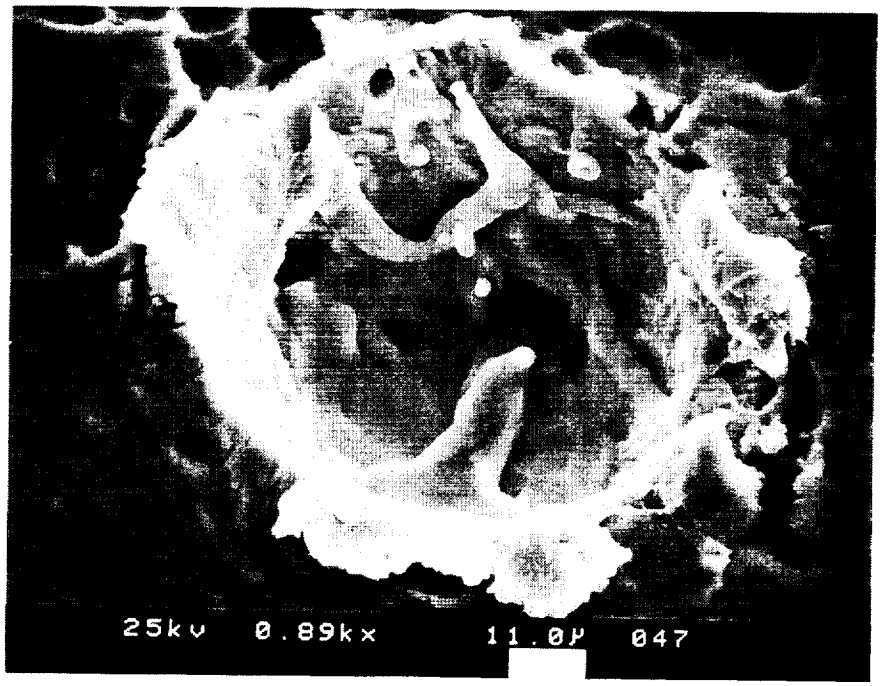
B08-C08 005



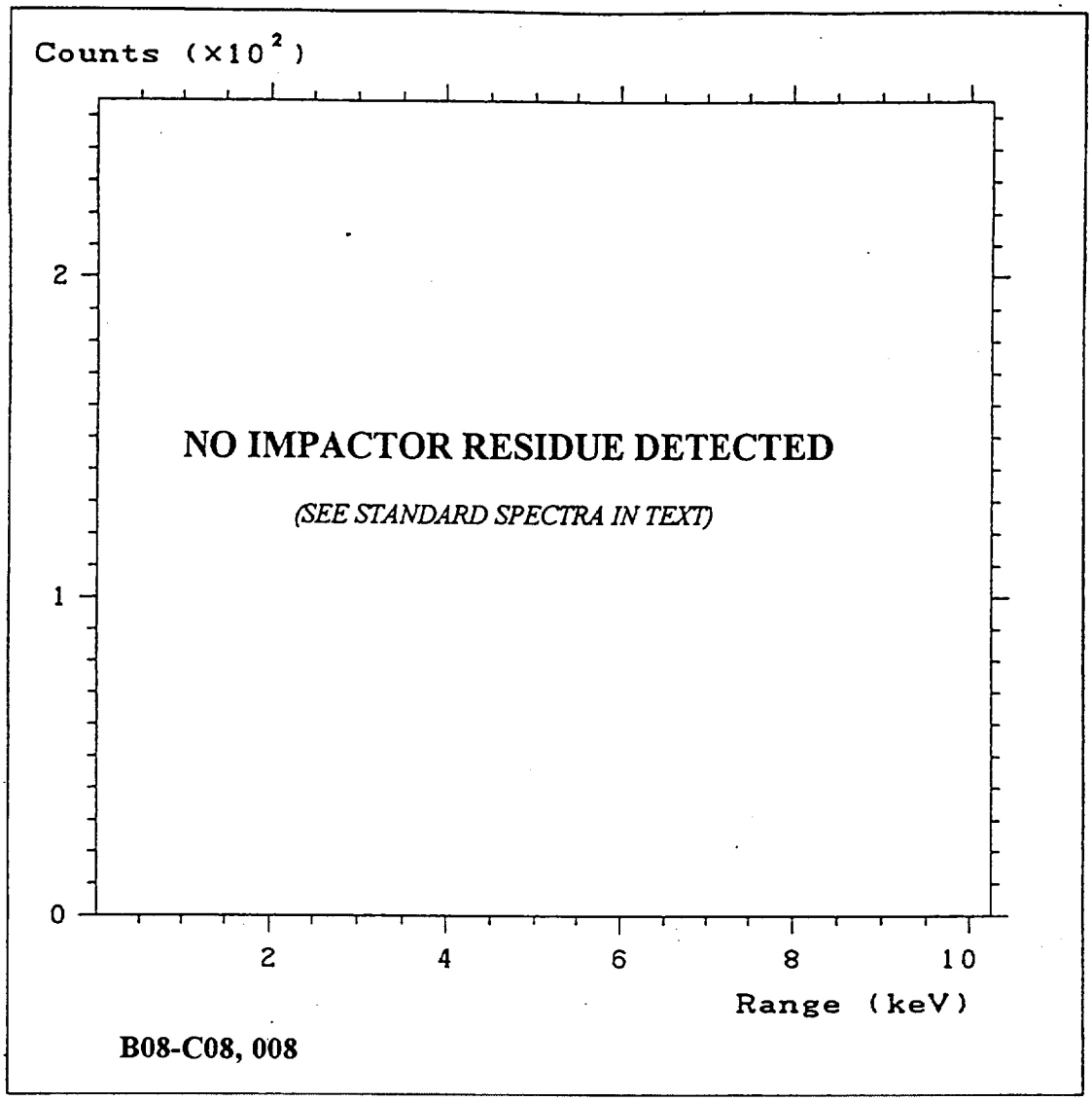


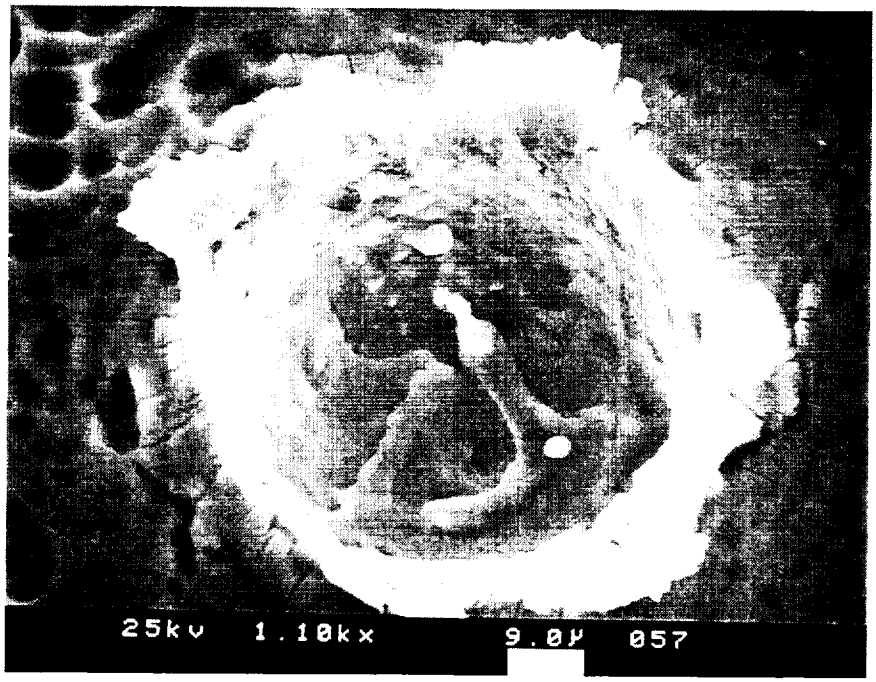
B08-C08 006 PAINT


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
B08-C08, 007
Range (keV)

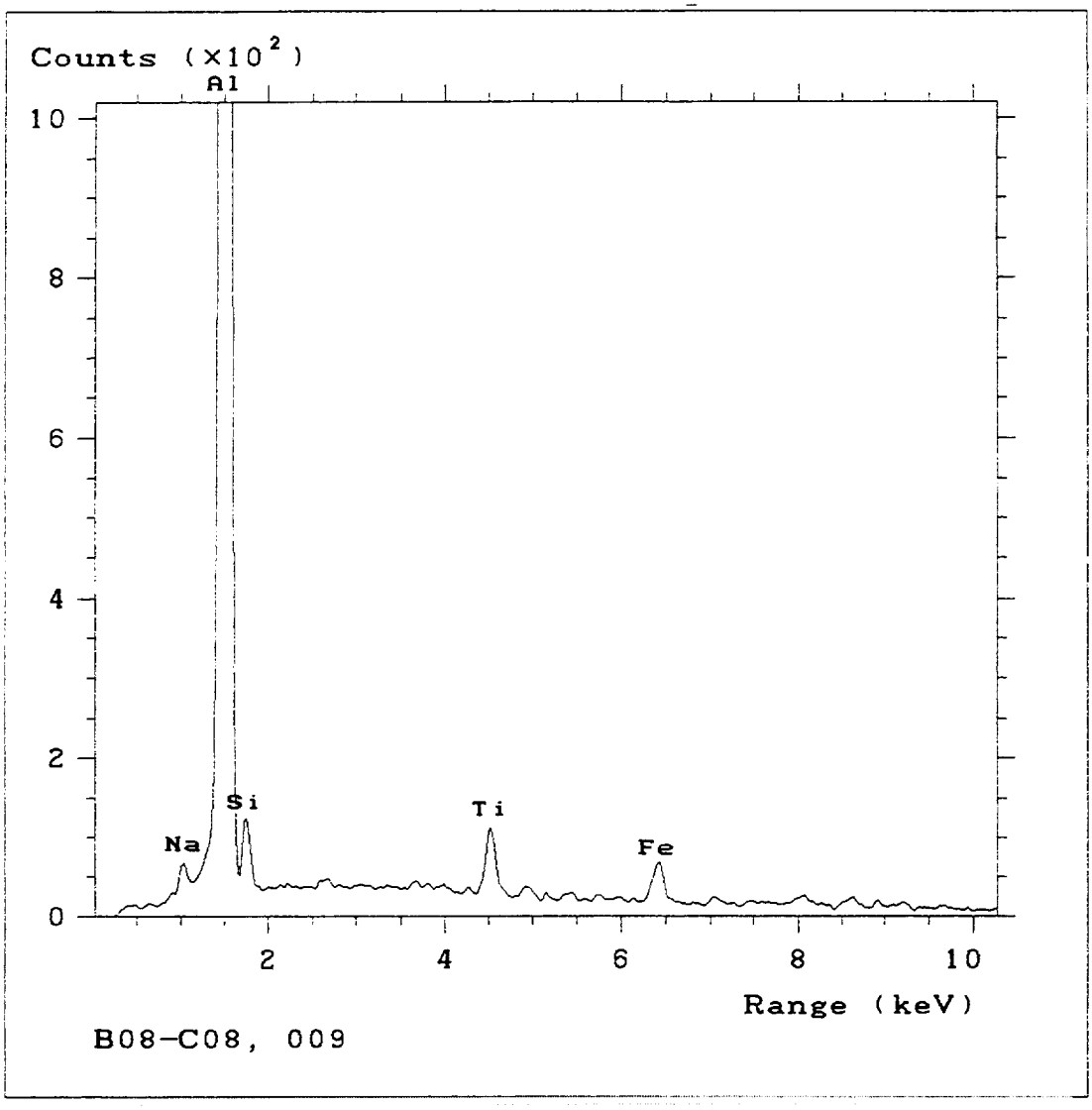

25kv 0.89kx 11.0μ 047

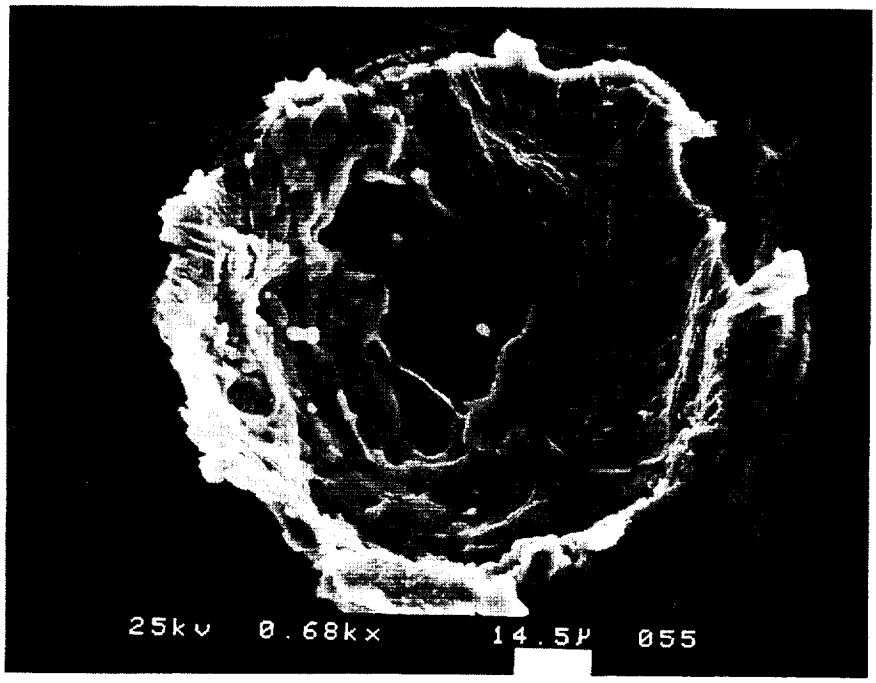
B08-C08 007


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C08, 008

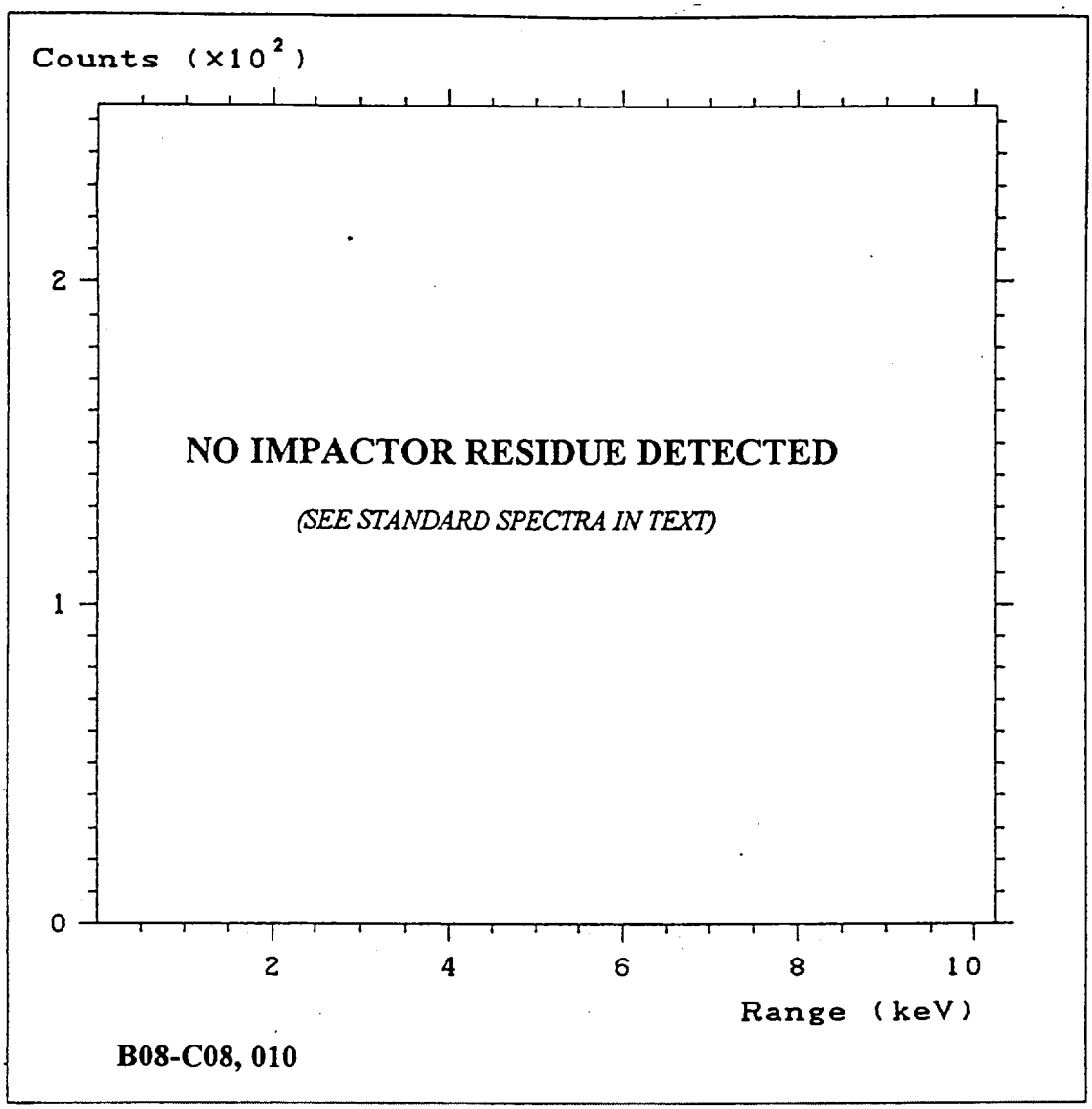

25kv 1.10kx 9.0µ 057

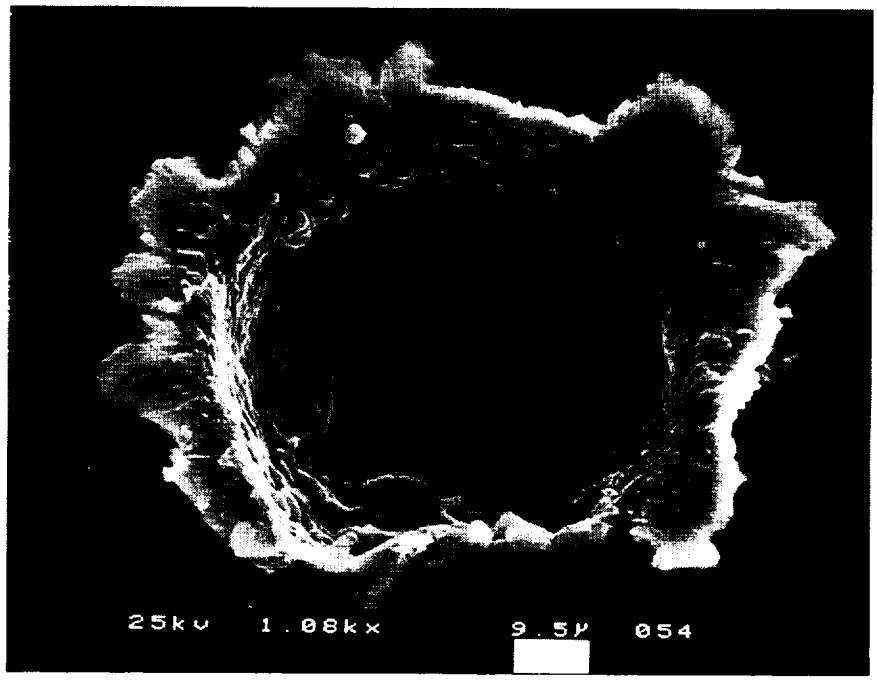
B08-C08 008



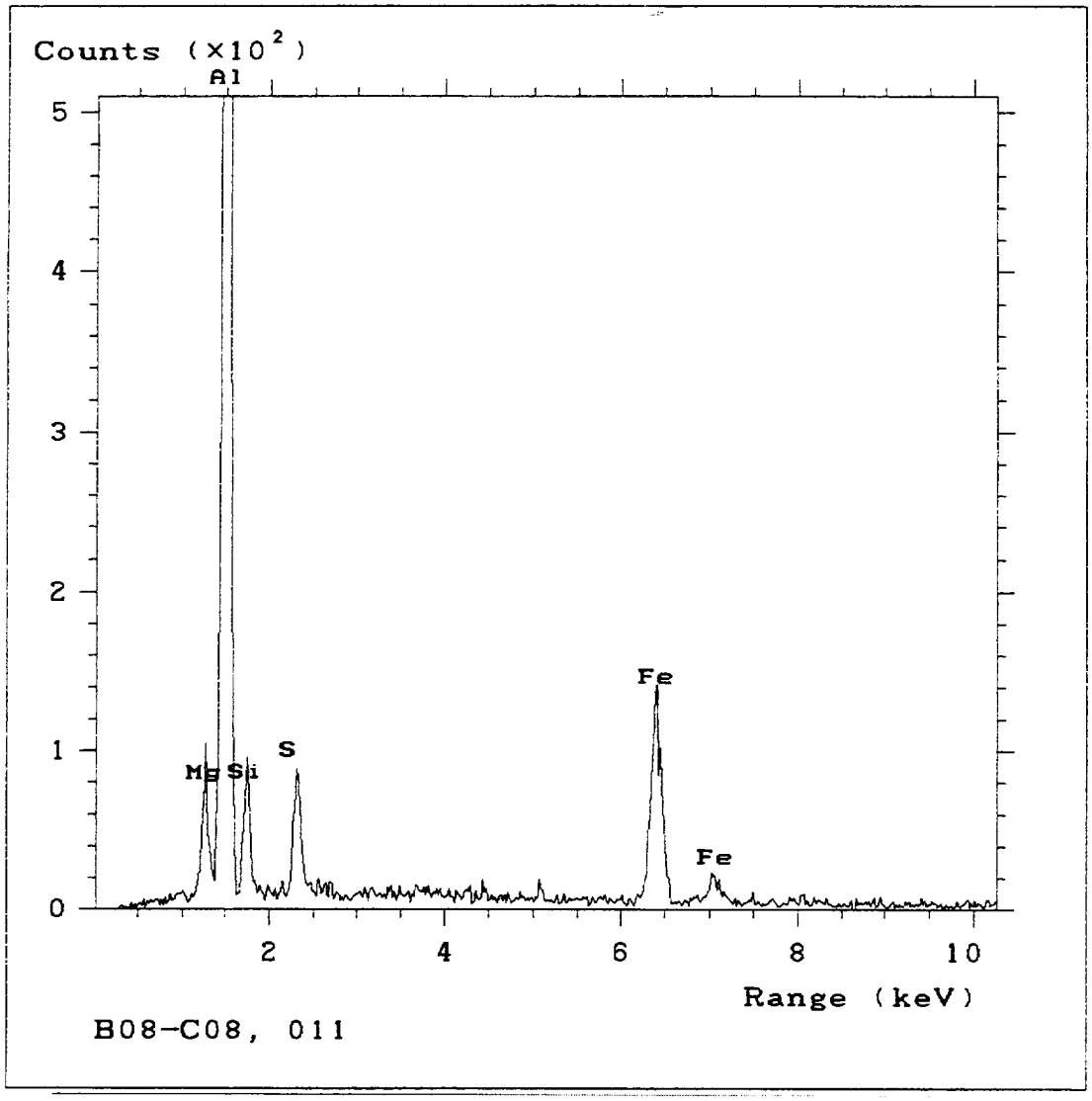


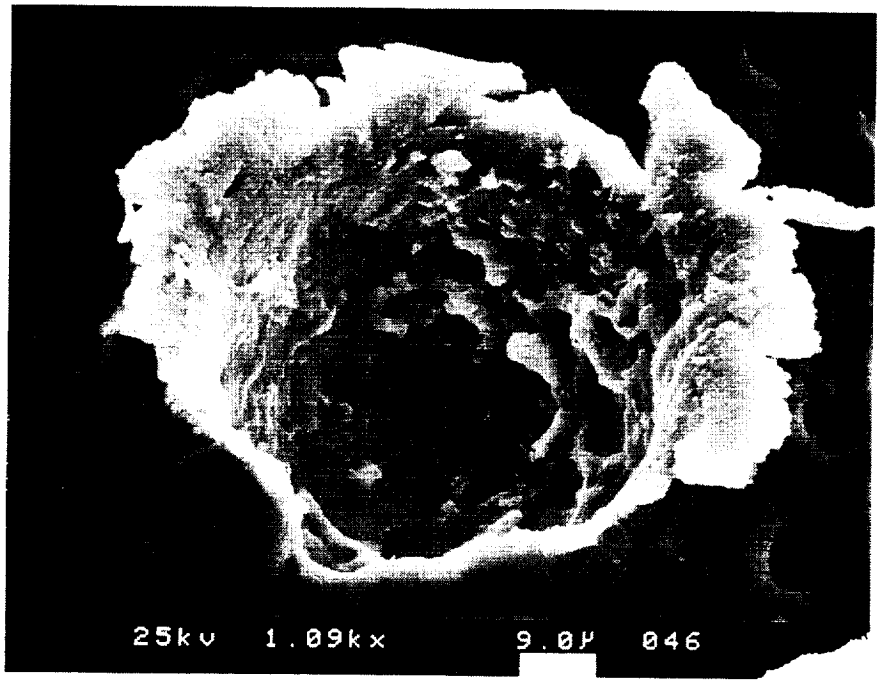
B08-C08 009 PRINT


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-C08, 010

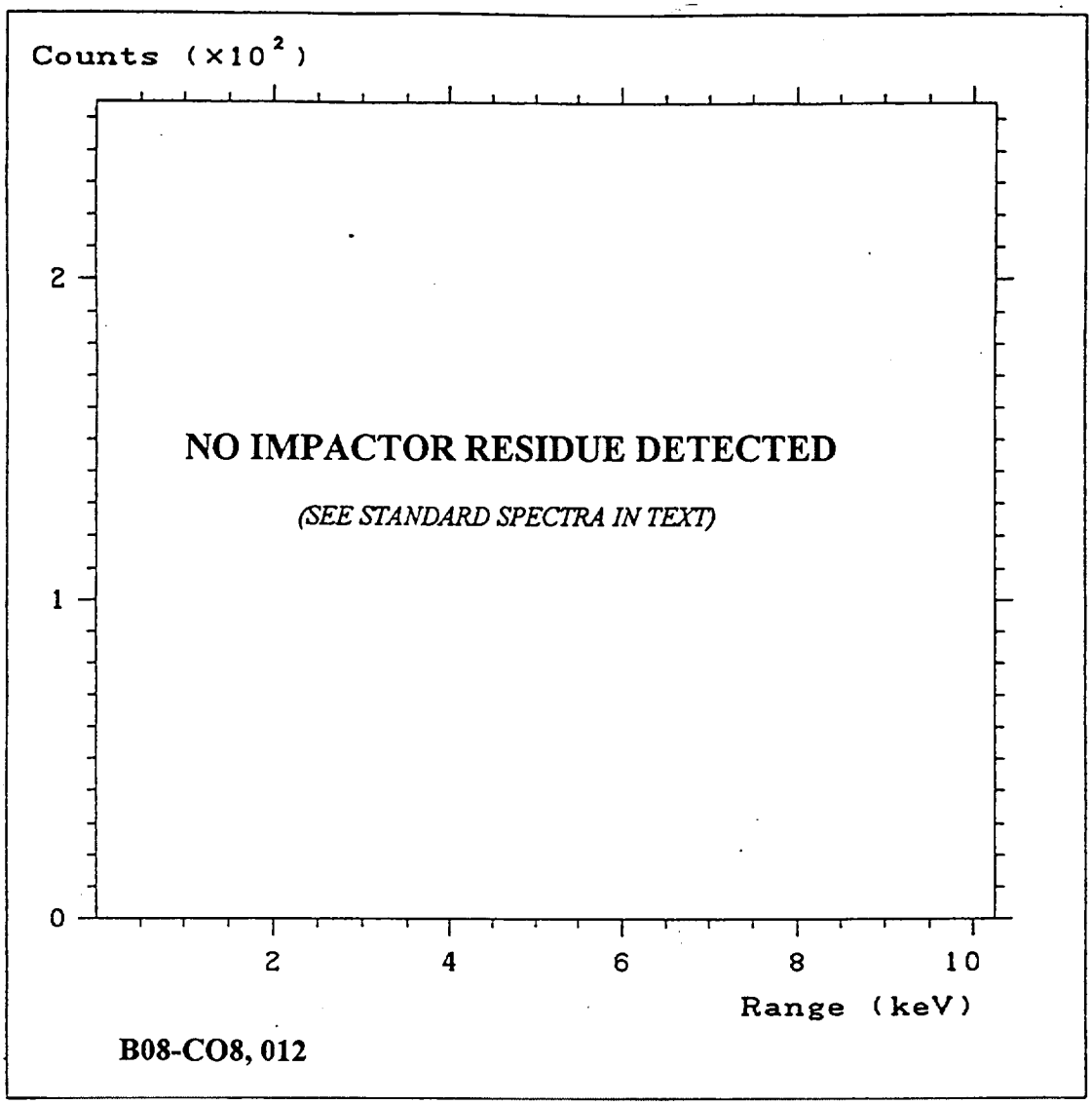

25kv 1.08kx 9.5μ 054

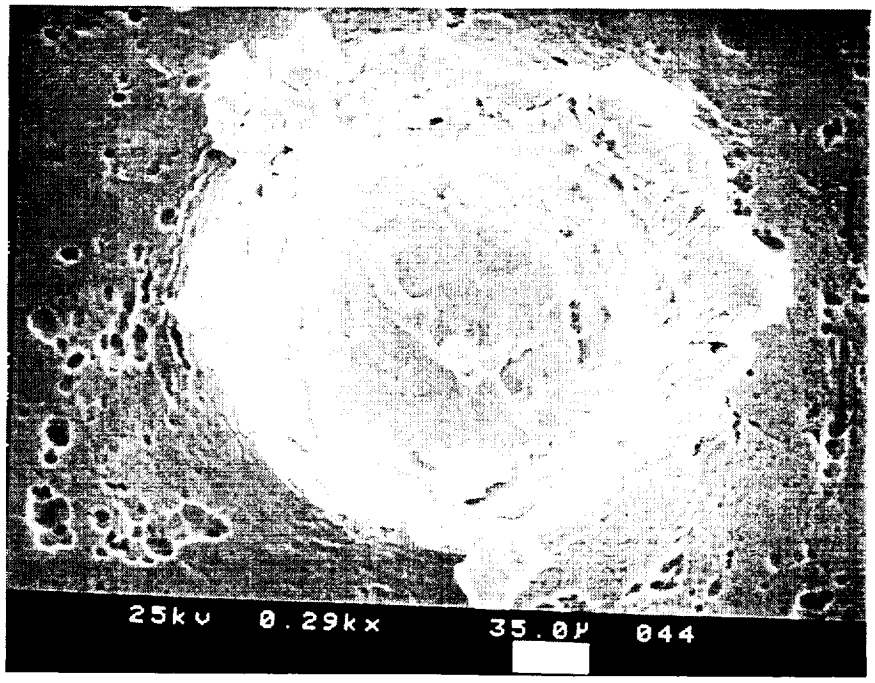
B08-C08 010



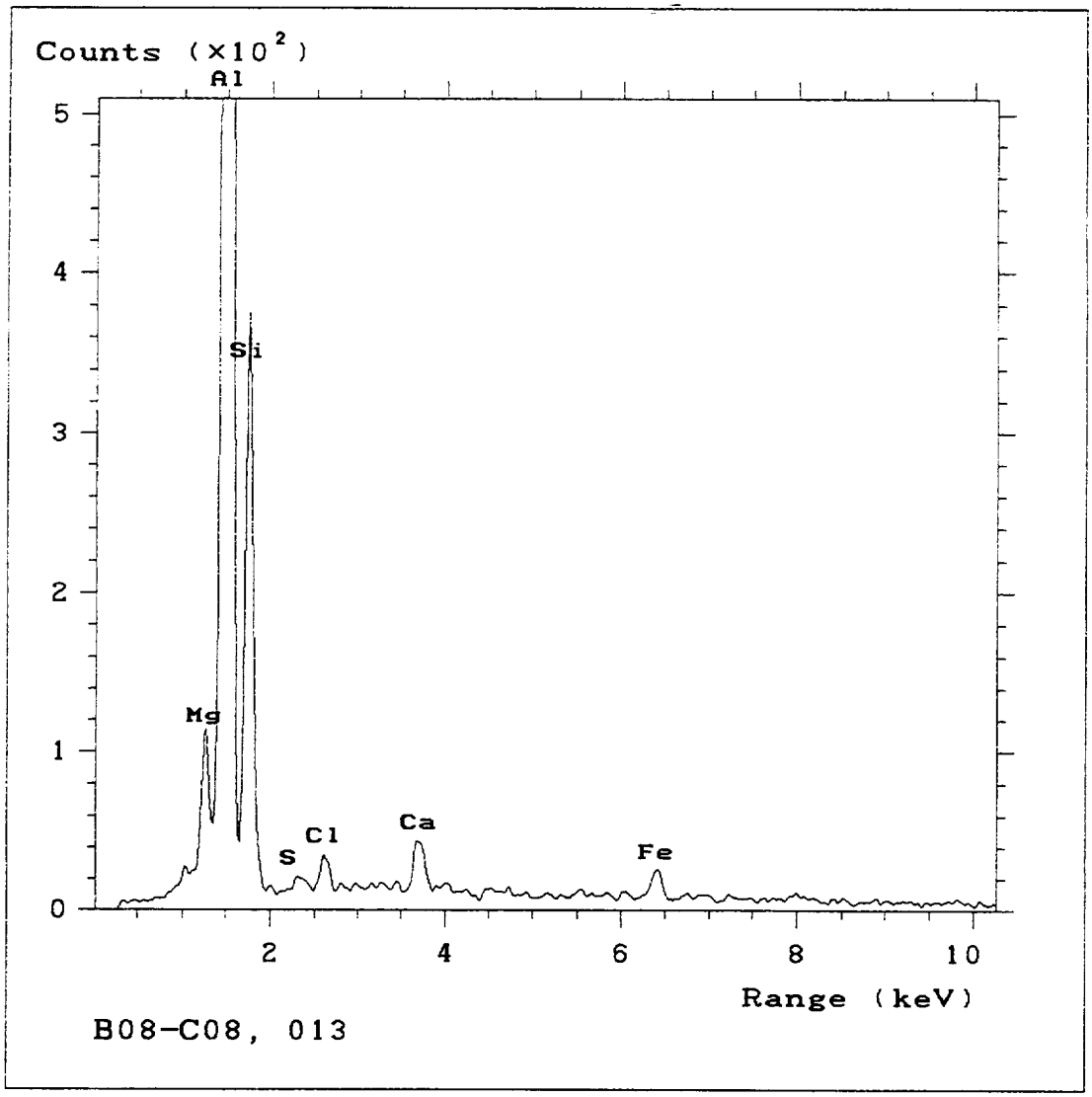


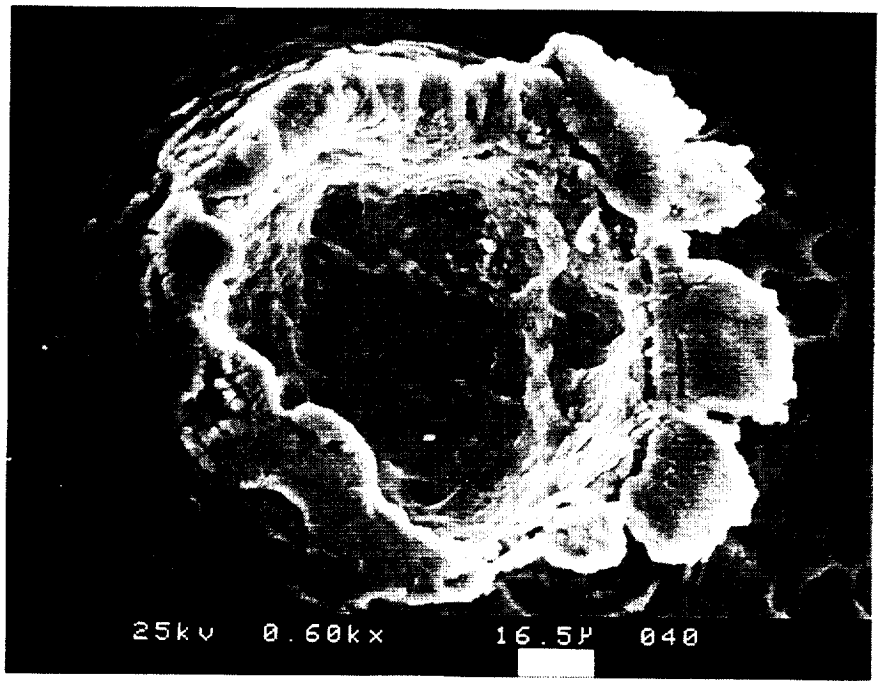
B08-C08 011 mm


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B08-CO8, 012

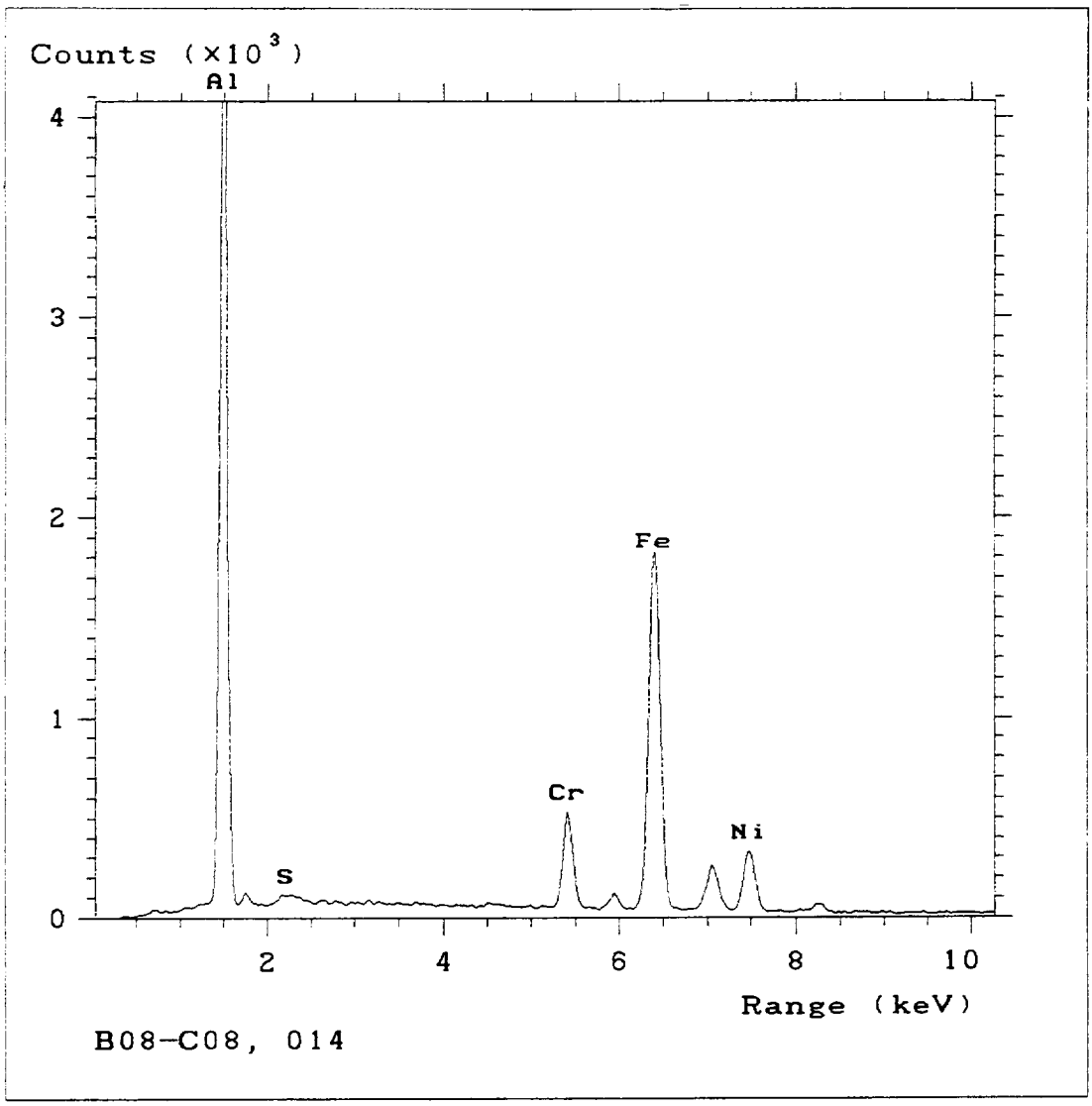

25kv 0.29kx 35.0μ 044

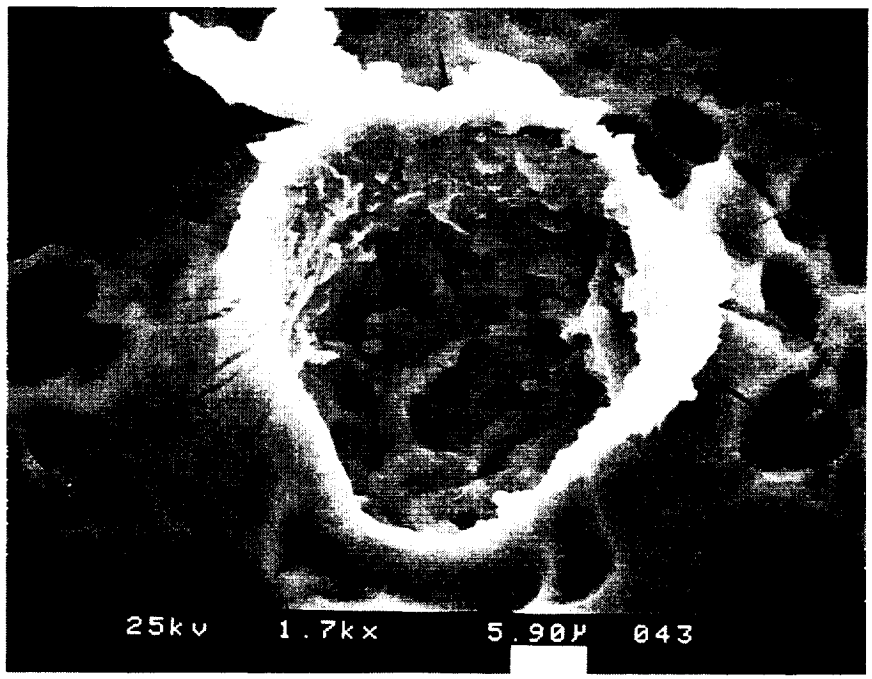
B08-C08 012


Counts (×10²)
Al
Si
Mg
S
Cl
Ca
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B08-C08, 013


25kv 0.60kx 16.5μ 040

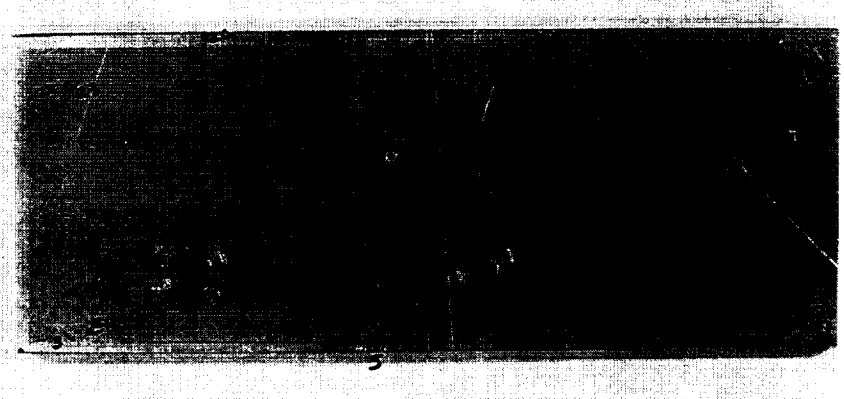
B08-C08 c#3 mm



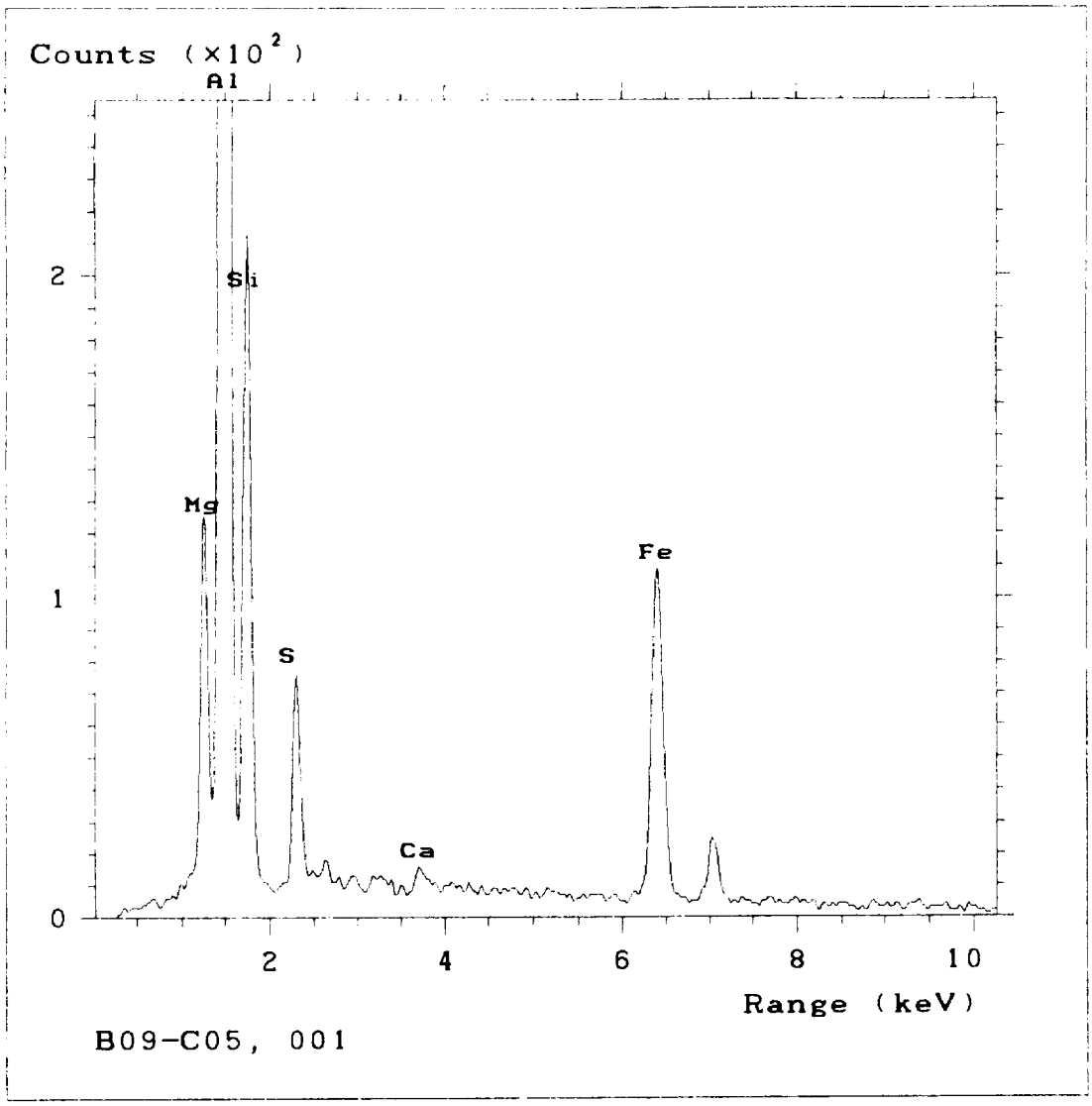


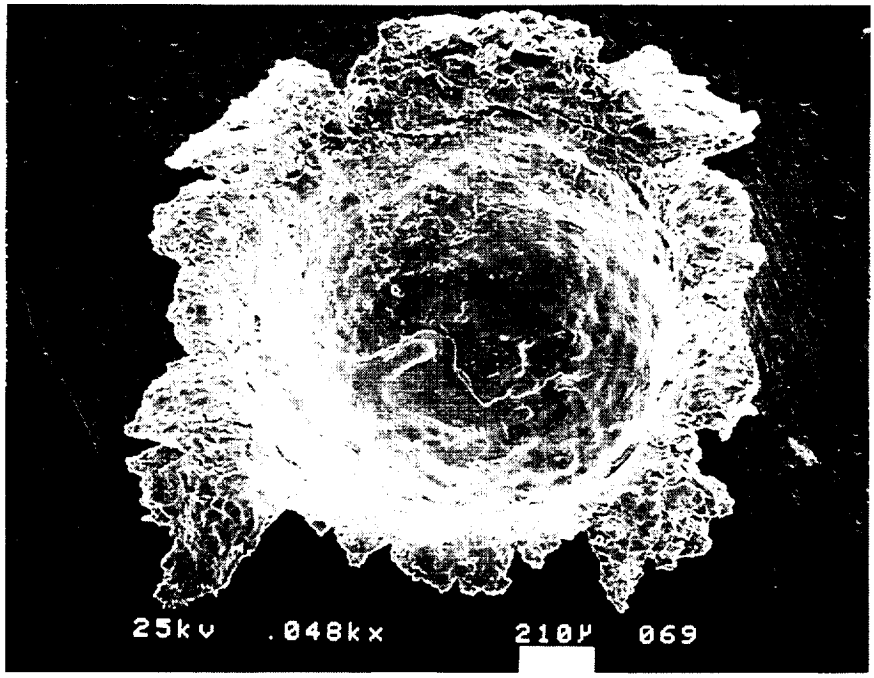
B08-C08 014 SS

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B09-C05	001	59	29	1000	MICROMETEORITIC
	002	10	2	50	PAINT
	003	9	1	60	PAINT
	004	16	3	8	NOT AN IMPACT
	005	55	1	100	ORGANIC
	006	86	5	200	UNKNOWN
	007	93	7	260	MICROMETEORITIC
	008	122	7	50	???
	009	58	12	80	MICROMETEORITIC
	010	56	11	150	MICROMETEORITIC
	011	42	11	130	MICROMETEORITIC
	012	50	19	40	MICROMETEORITIC
	013	57	20	80	UNKNOWN
	014	105	22	110	UNKNOWN
	015	118	22	50	STAINLESS STEEL
	016	102	25	40	UNKNOWN
	017	80	29	60	MICROMETEORITIC
	018	78	33	50	STAINLESS STEEL
	019	44	29	70	UNKNOWN
	020	37	26	80	PAINT
	021	28	29	140	MICROMETEORITIC
	022	9	36	110	MICROMETEORITIC
	023	11	38	40	UNKNOWN
	024	36	40	50	PAINT
	025	111	41	350	UNKNOWN
	026	33	44	40	UNKNOWN
	027	123	7	35	PAINT
	028	123	6	30	UNKNOWN

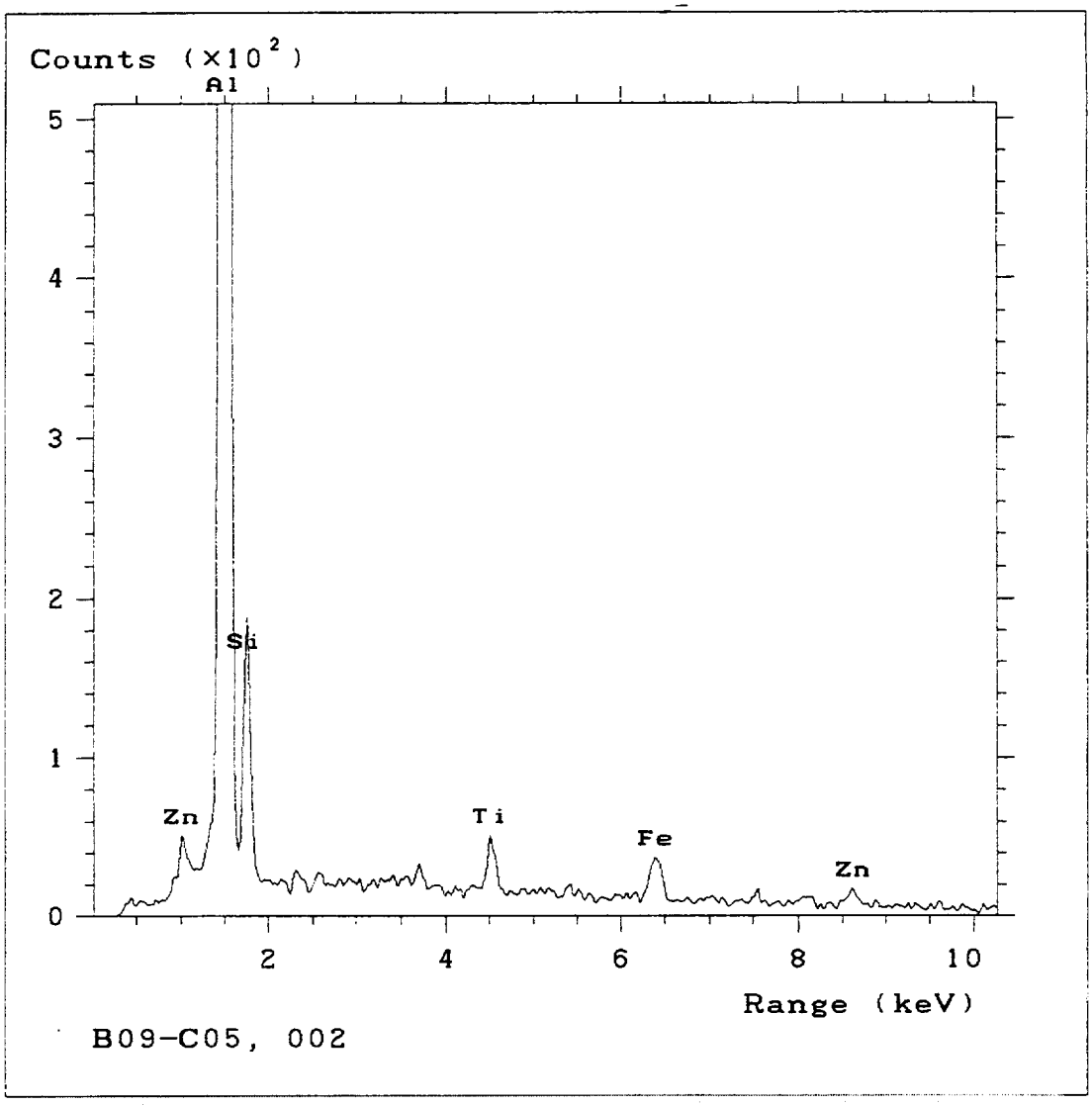


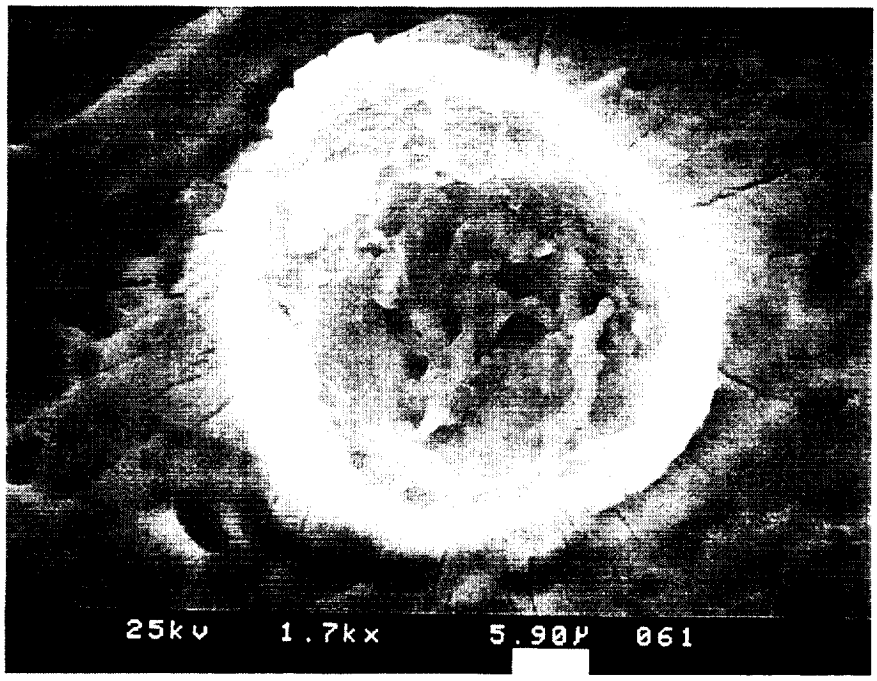
B09-C05



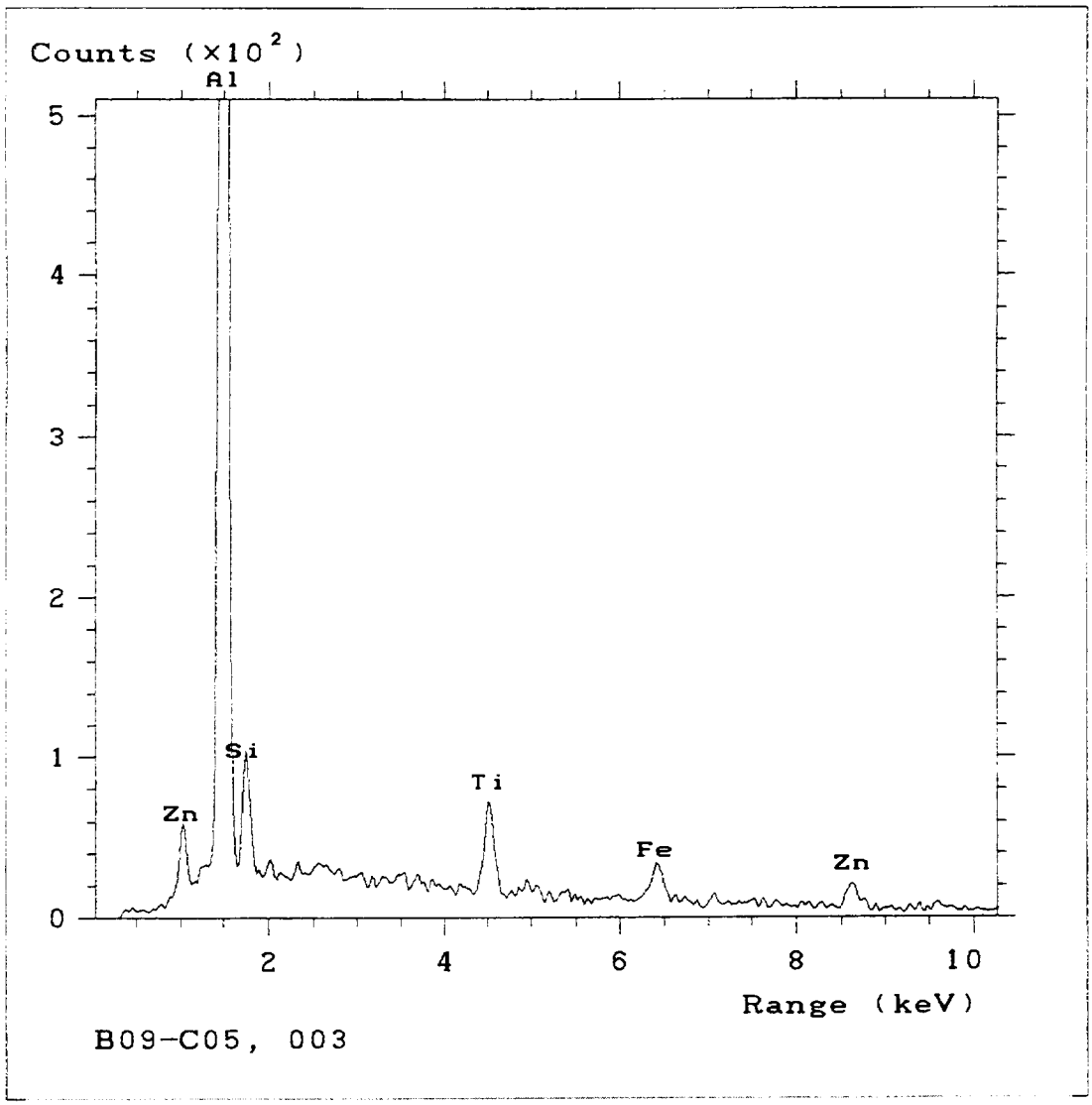


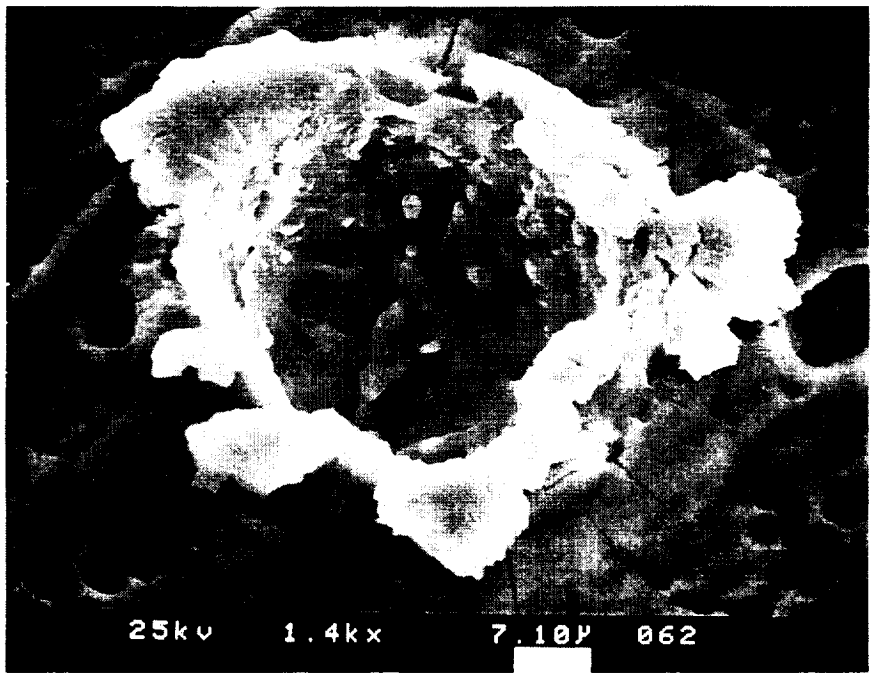
B09-C05 001 MM



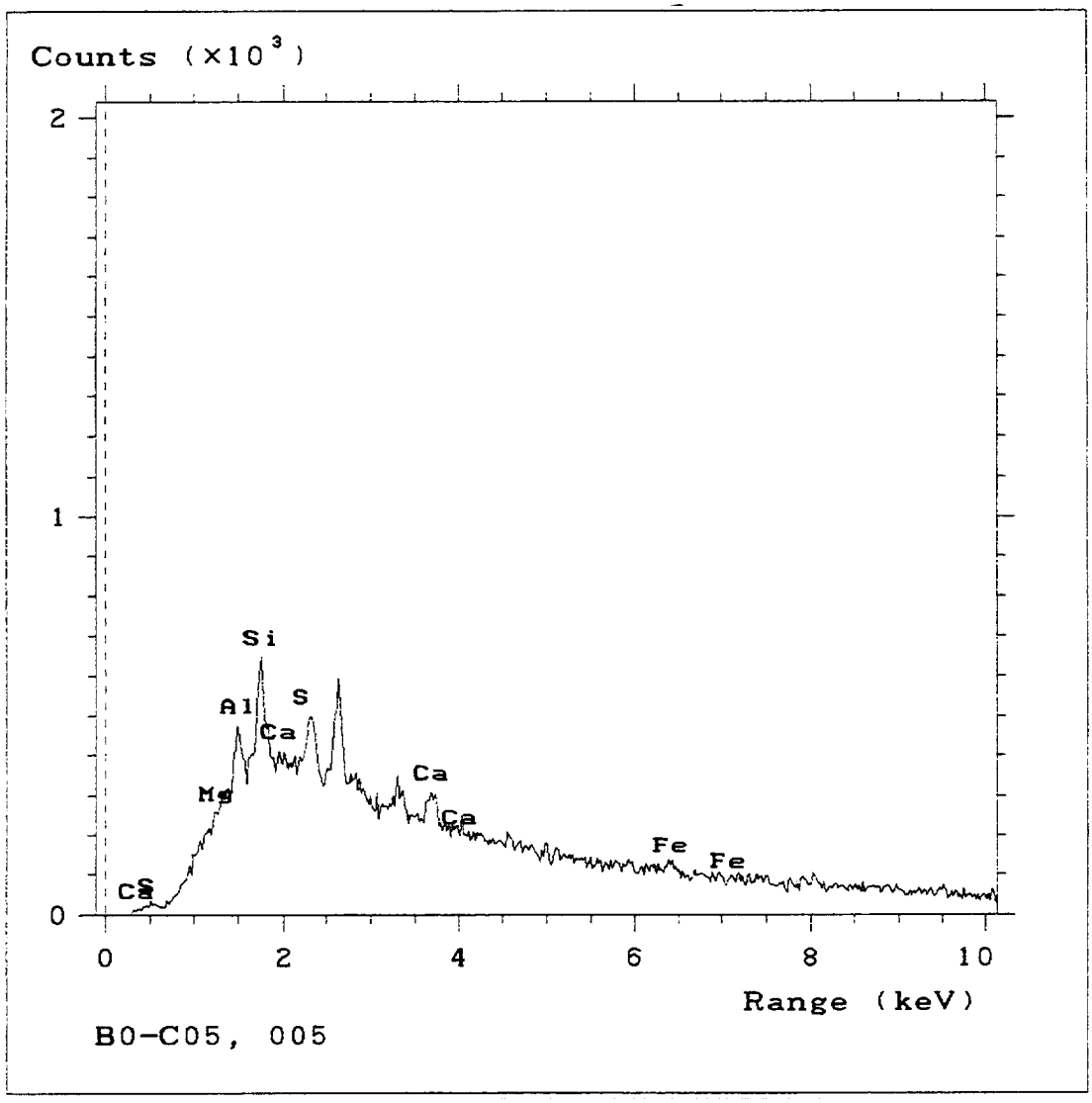


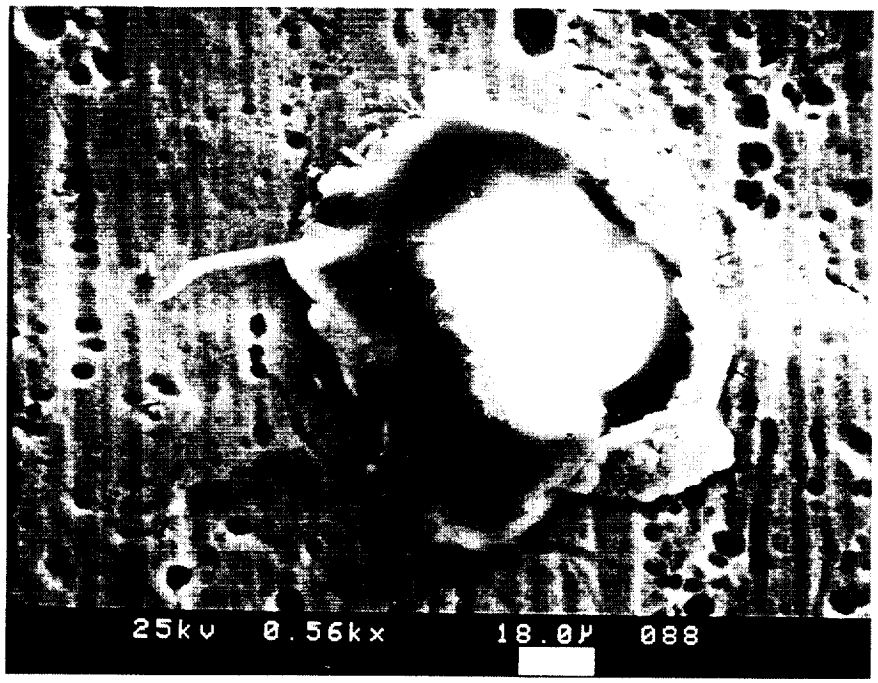
B09-C05 002 PAUL



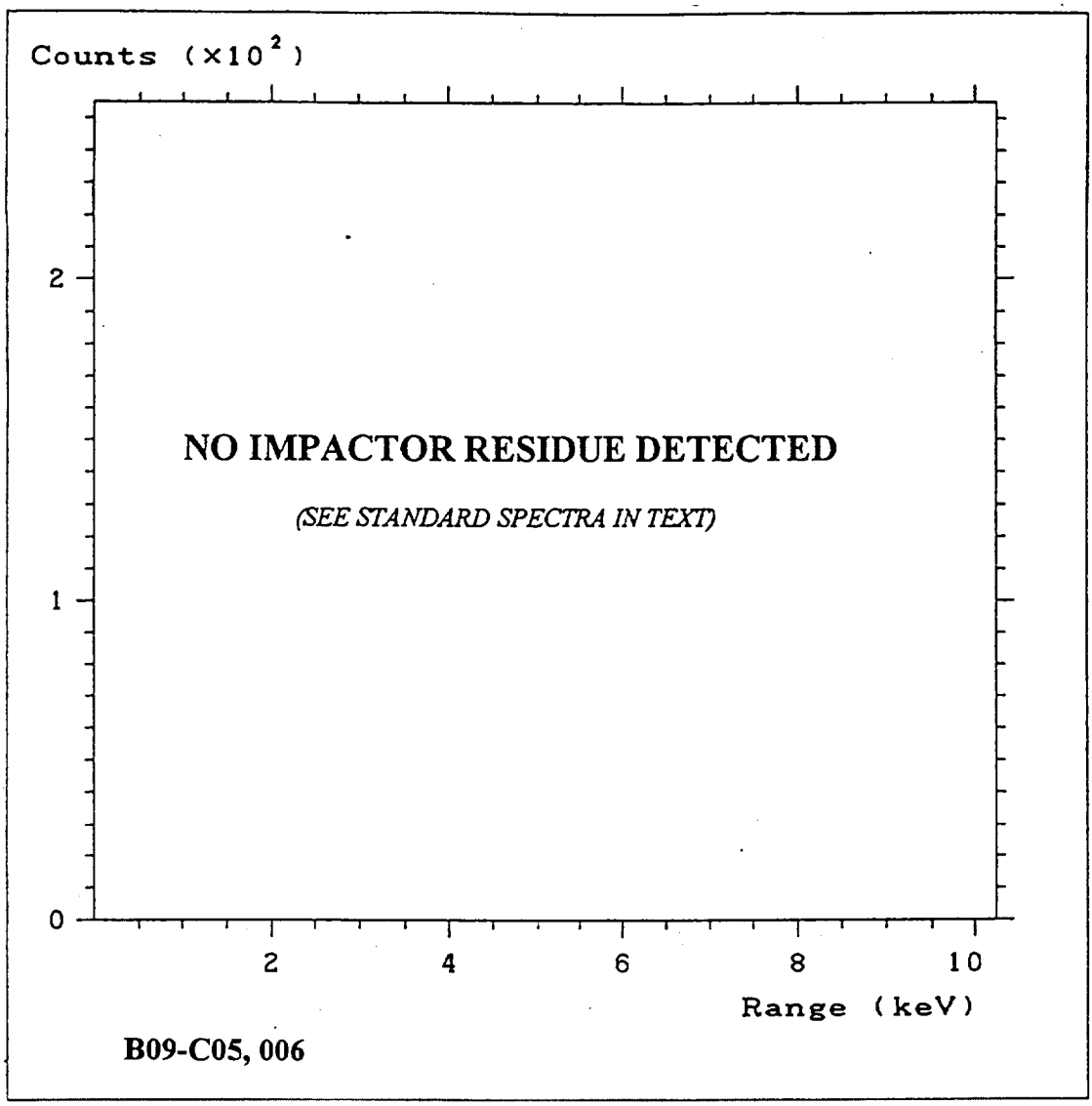


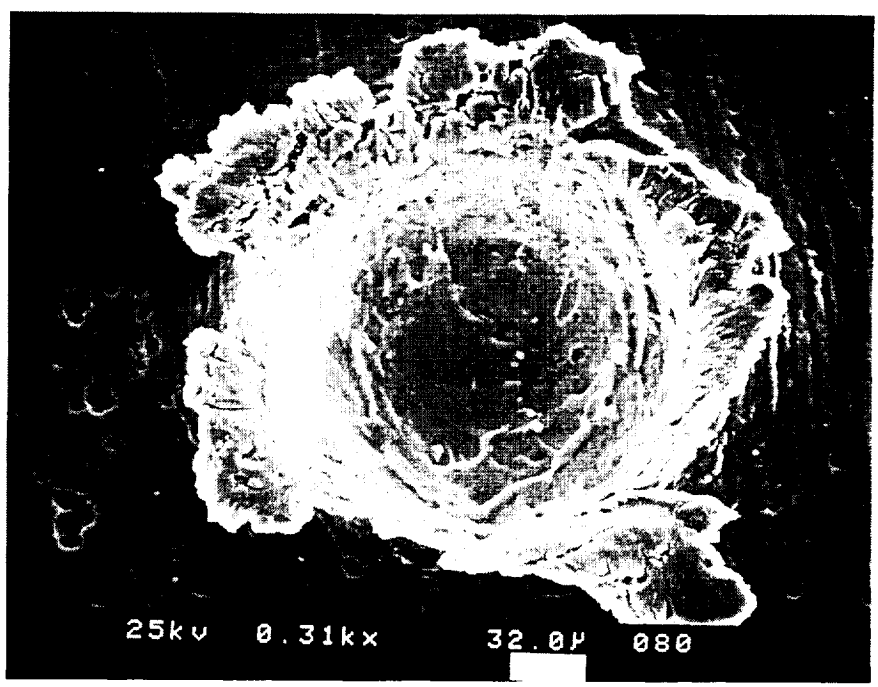
B09-C05 003 PAINT



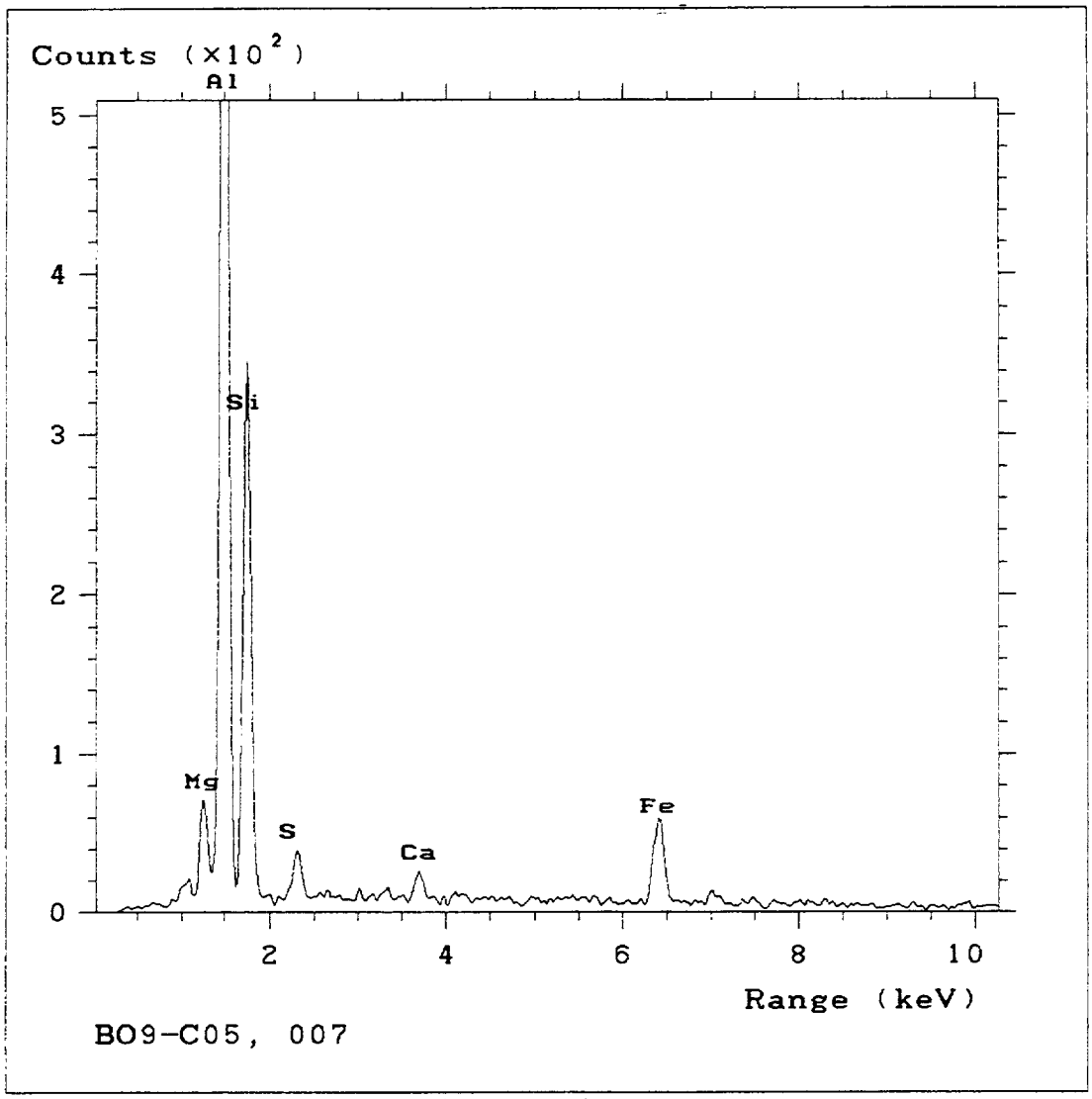


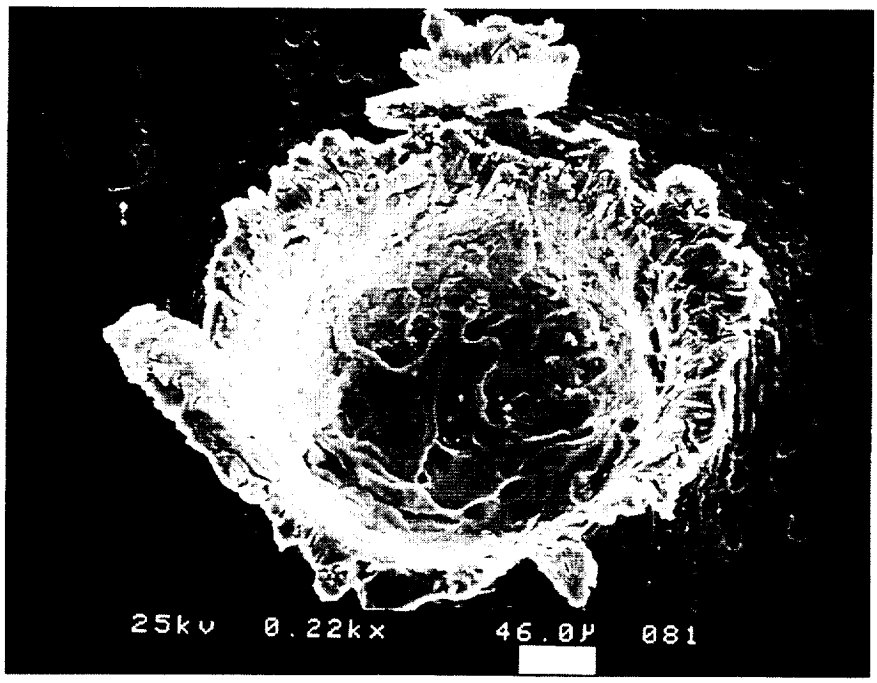
B09-C05 005 ORGANIC


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B09-C05, 006

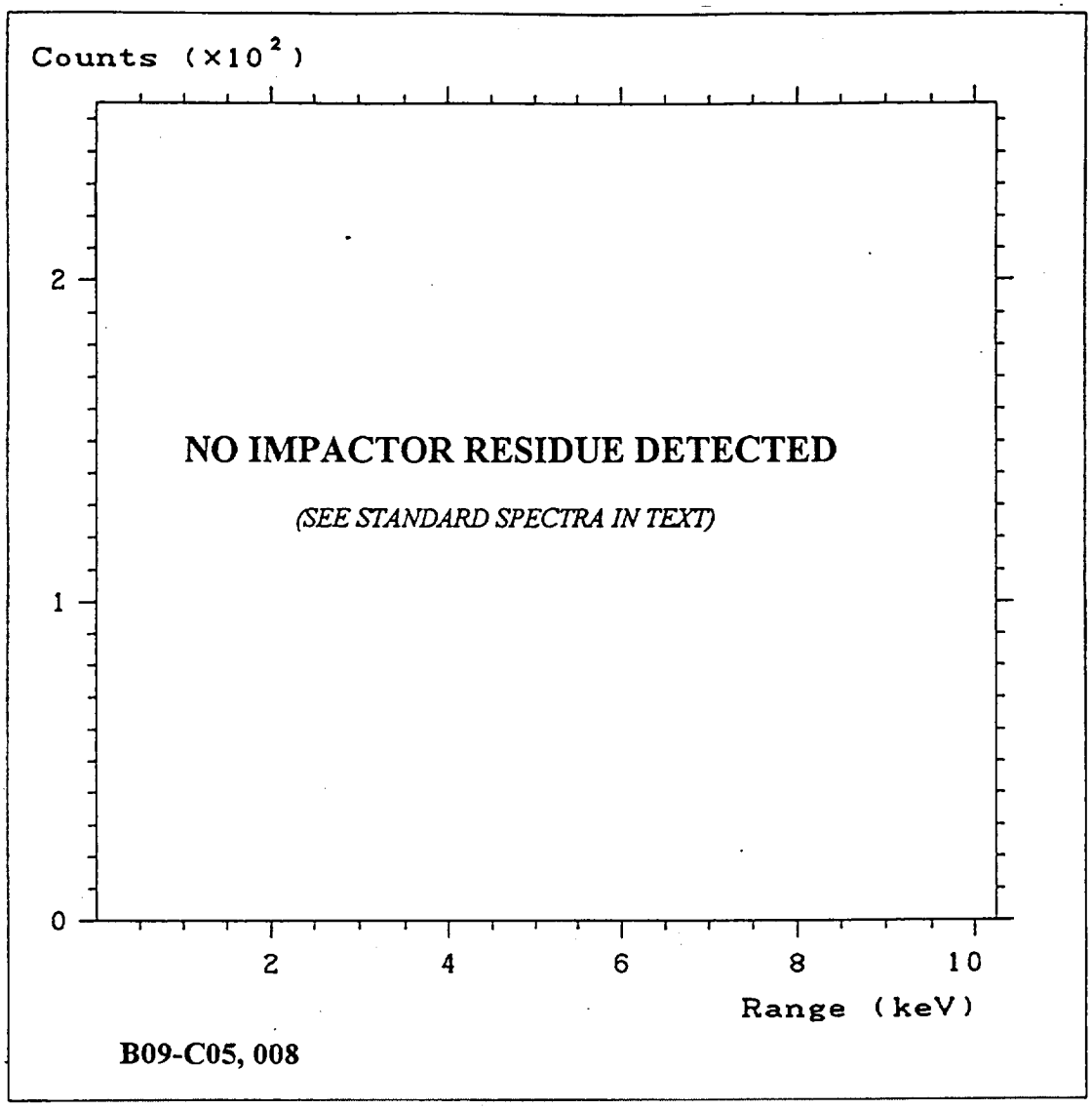

25kv 0.31kx 32.0µ 080

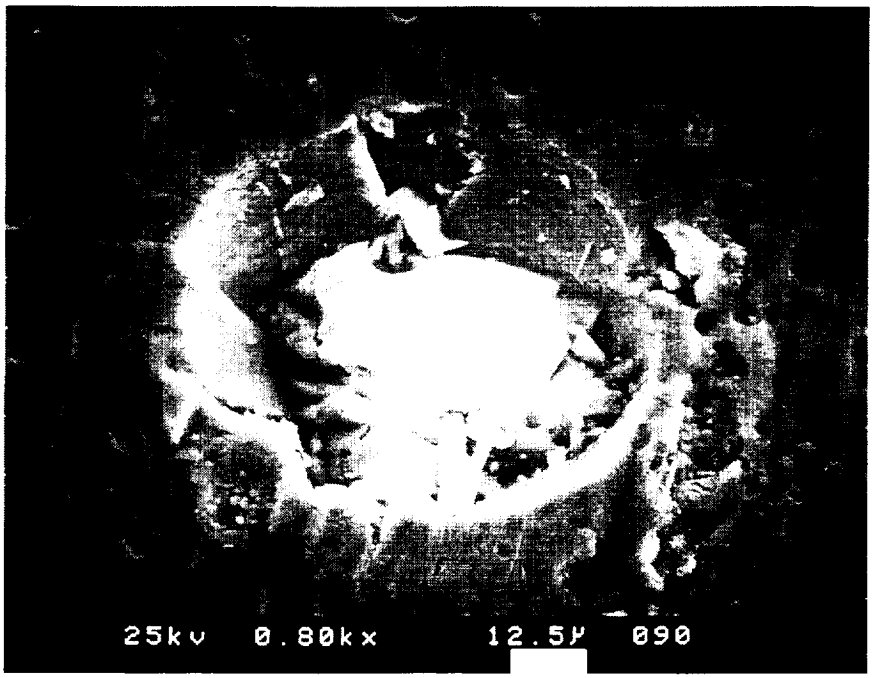
B09-C05 006



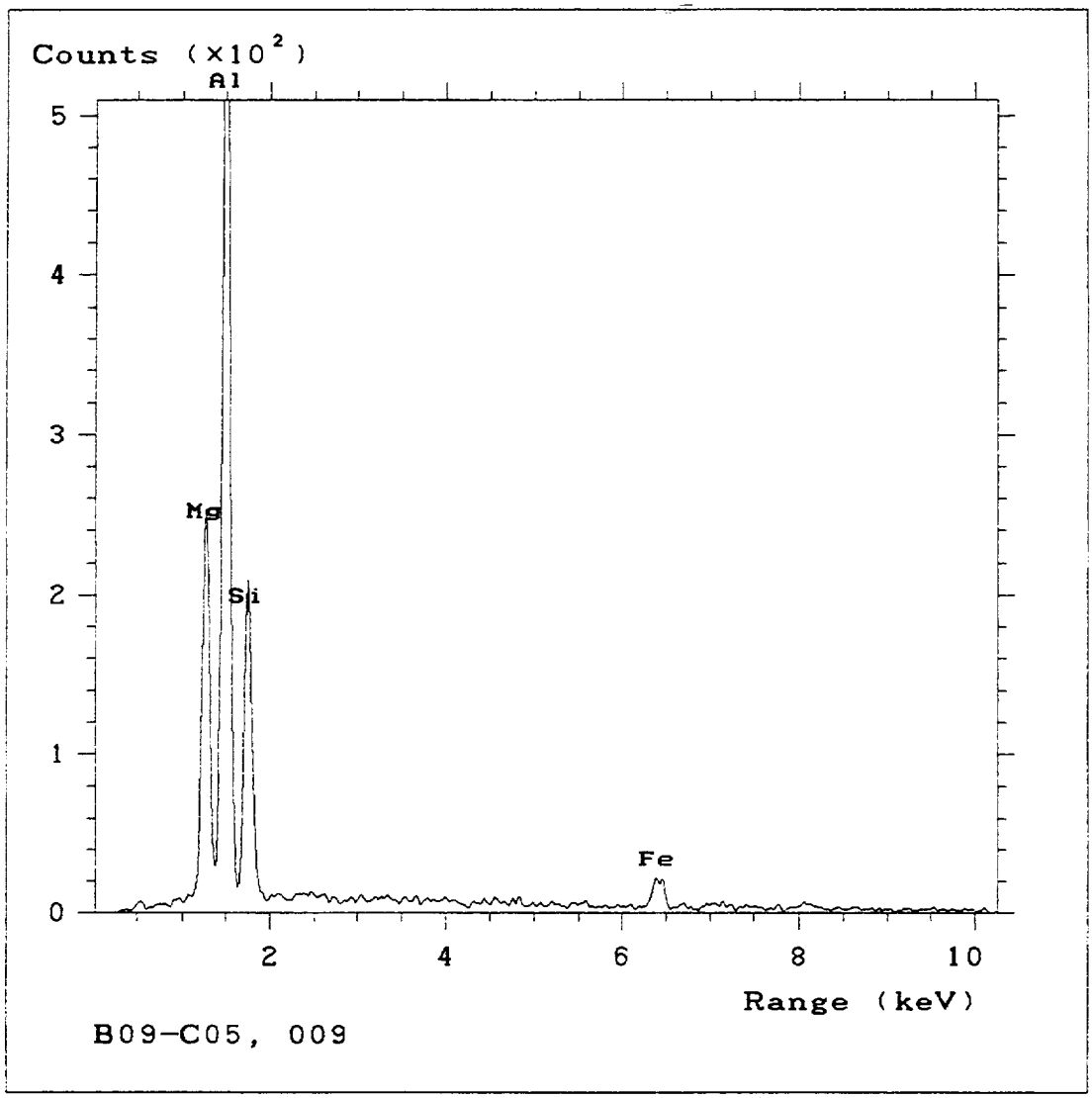


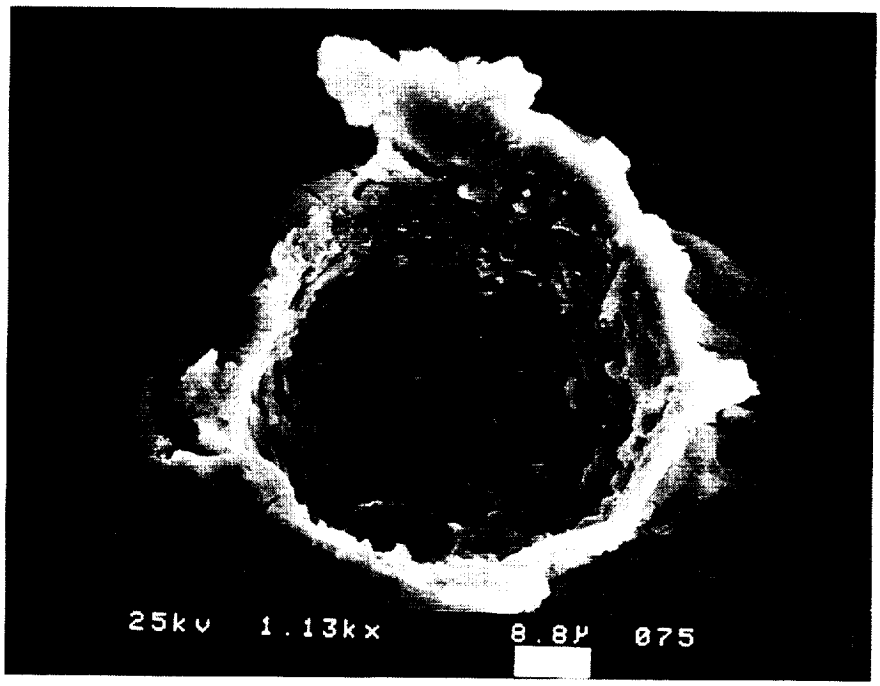
B09 - C05 007 MN


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B09-C05, 008

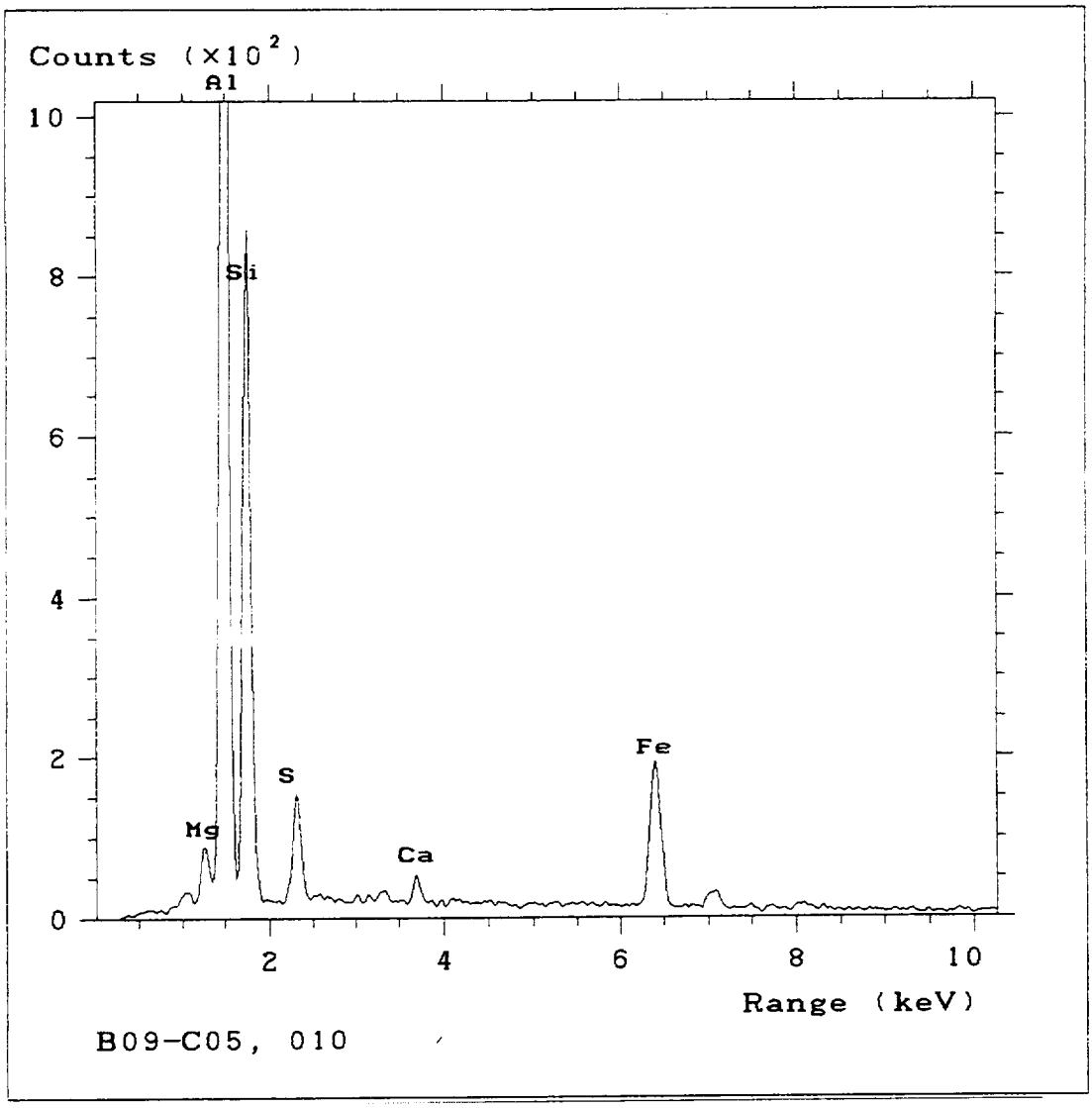

25kv 0.80kx 12.5µ 090

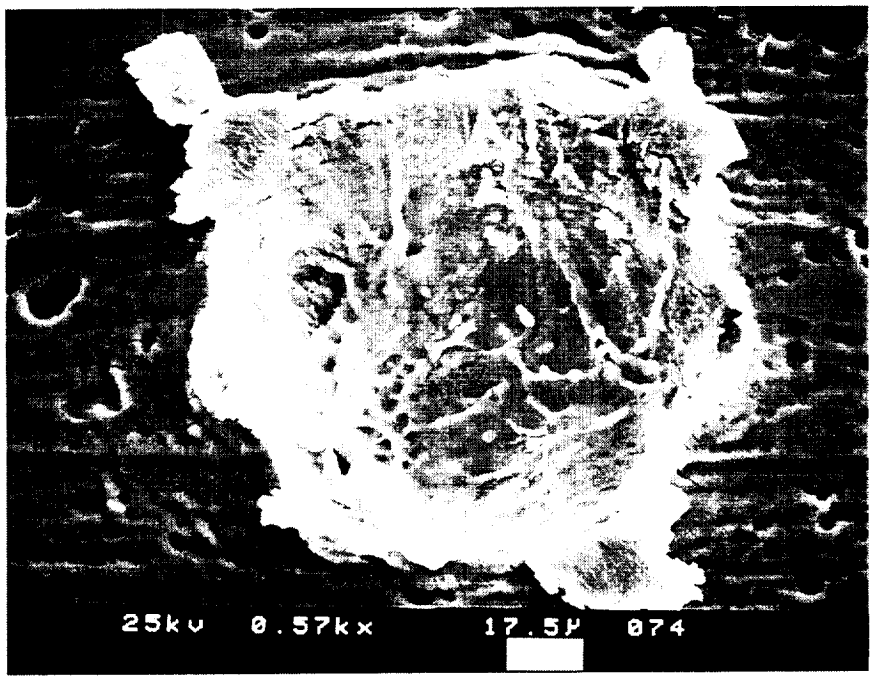
B09-C05 008 ?



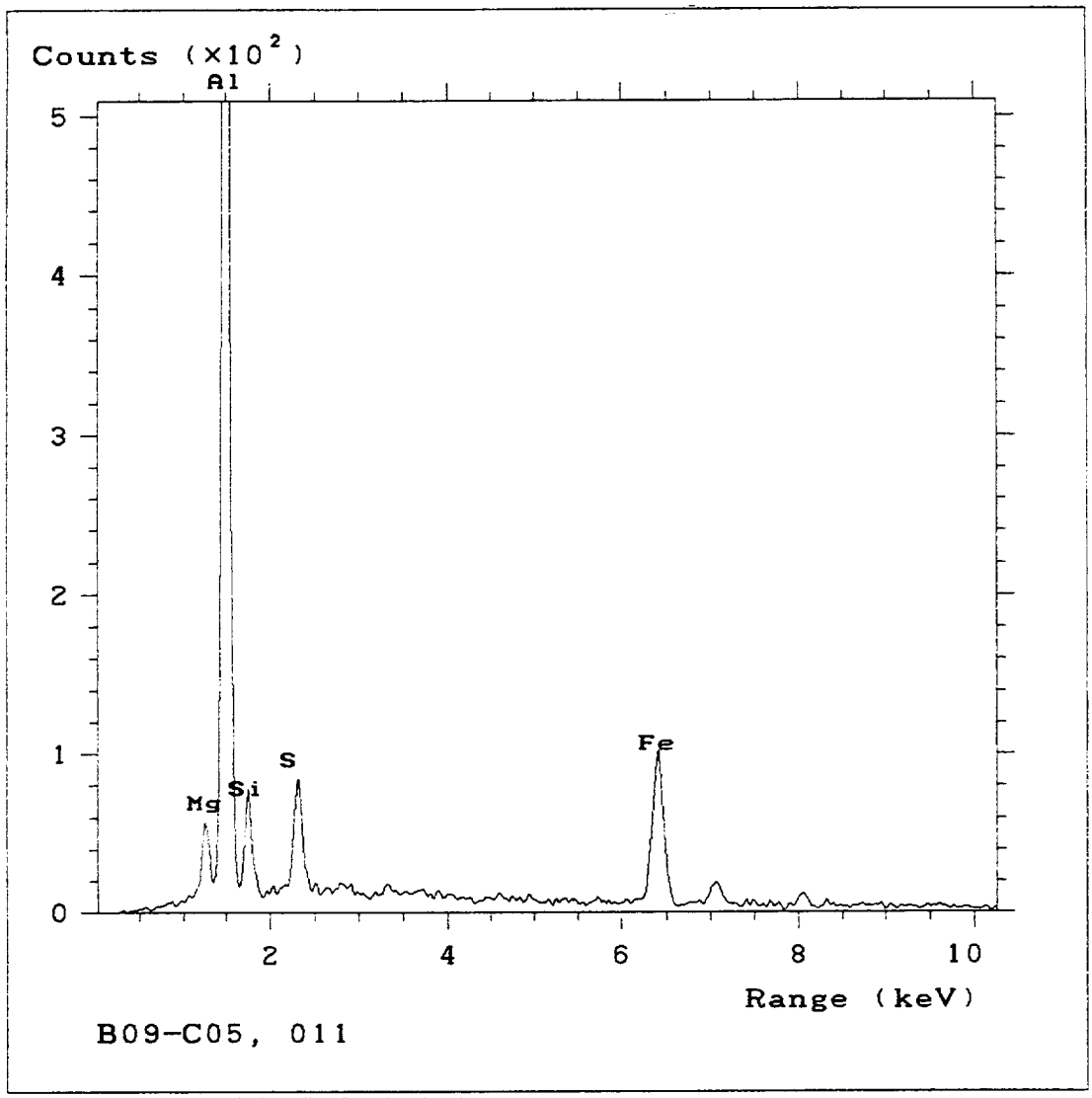


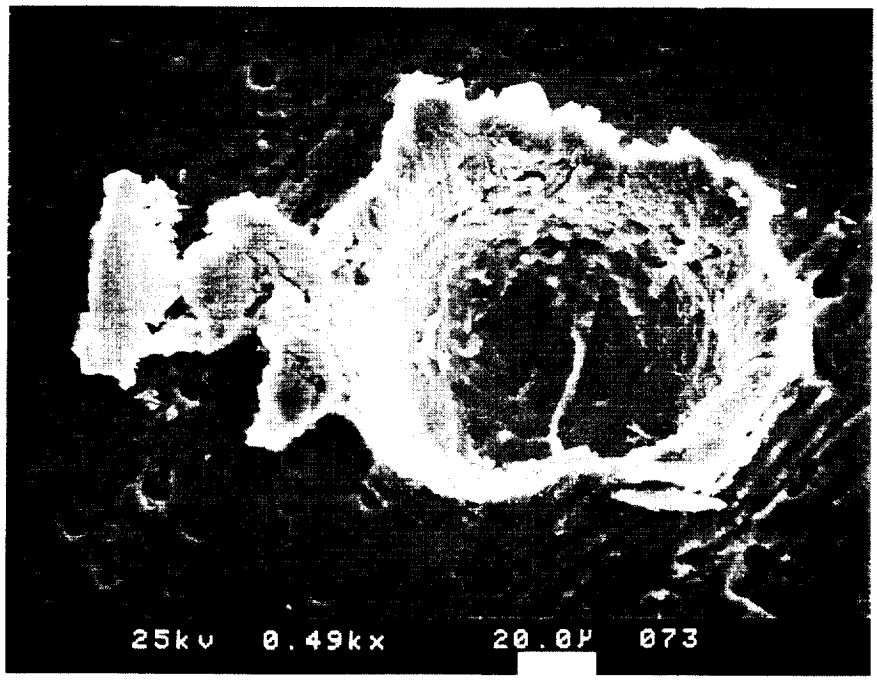
B09-C05 009 mm



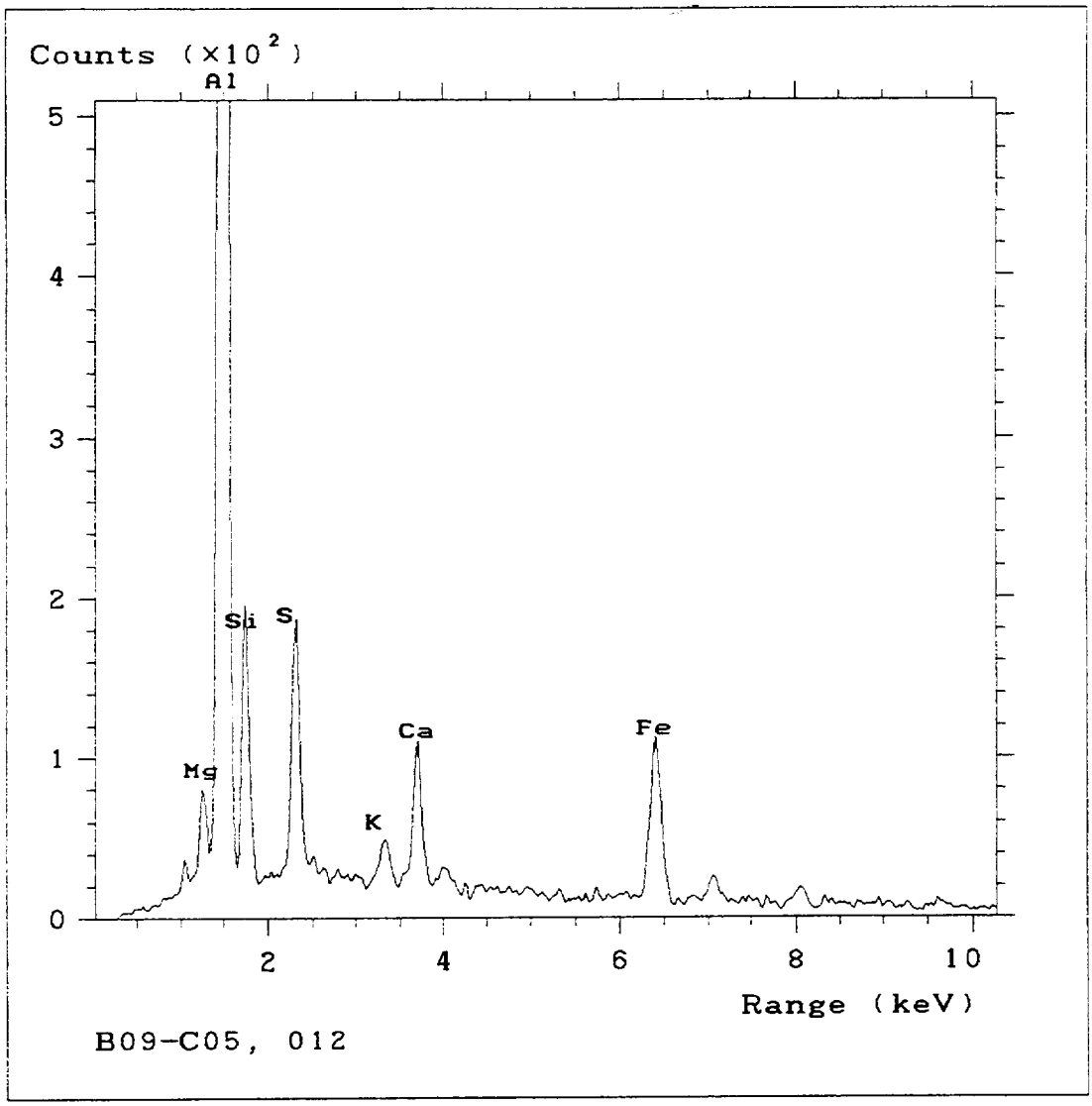


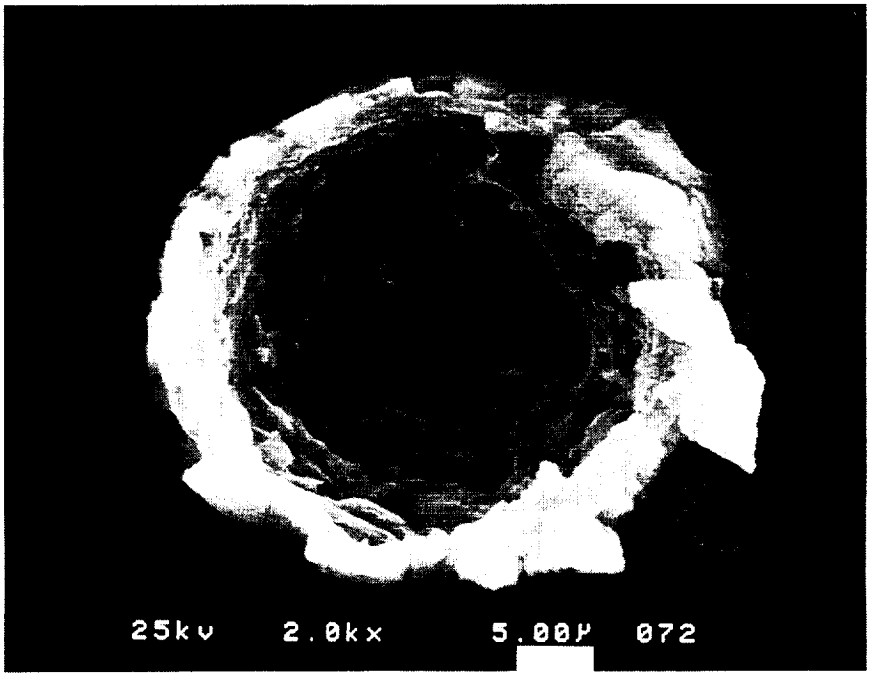
B09 - C05 010 MCV



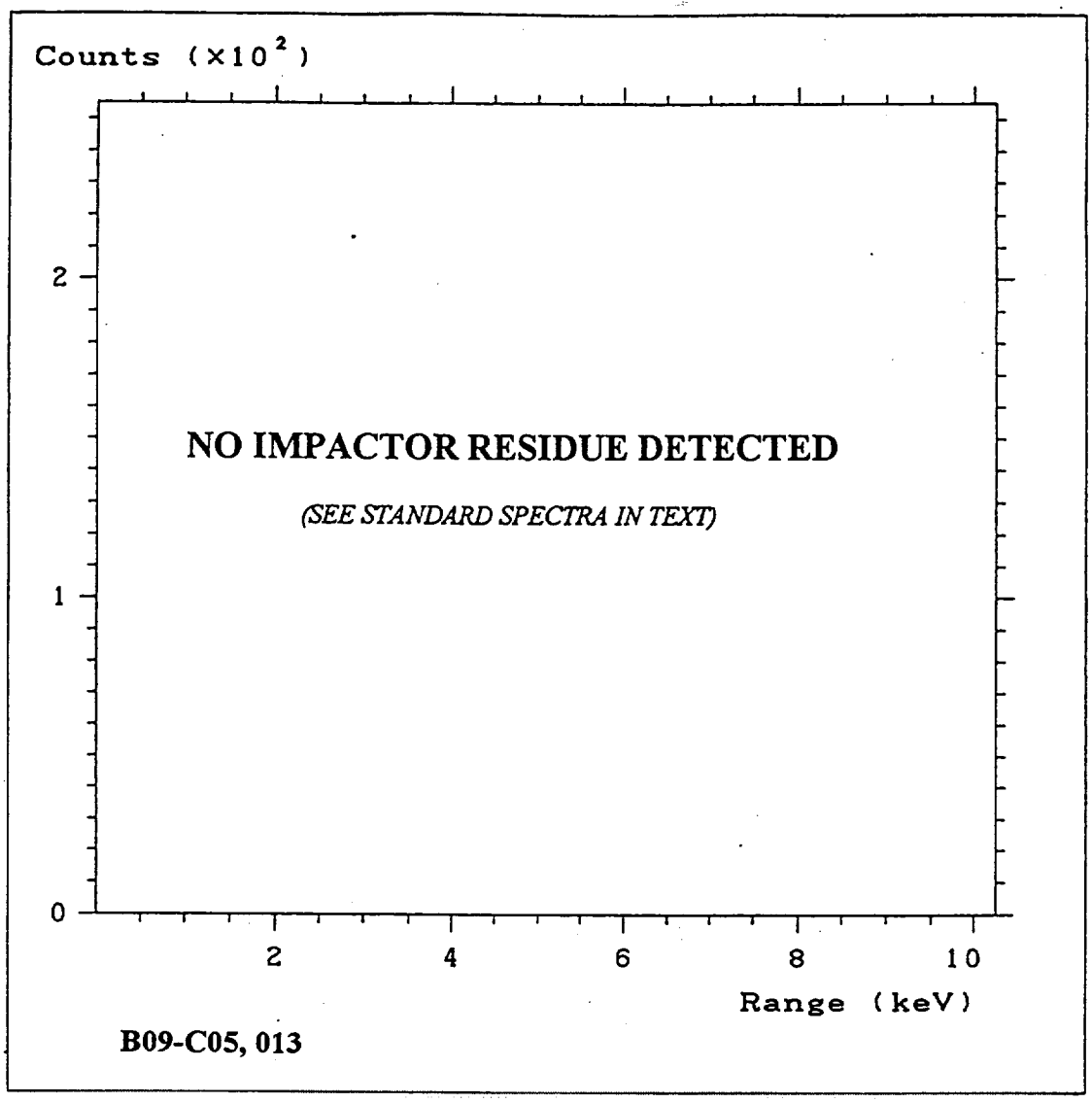


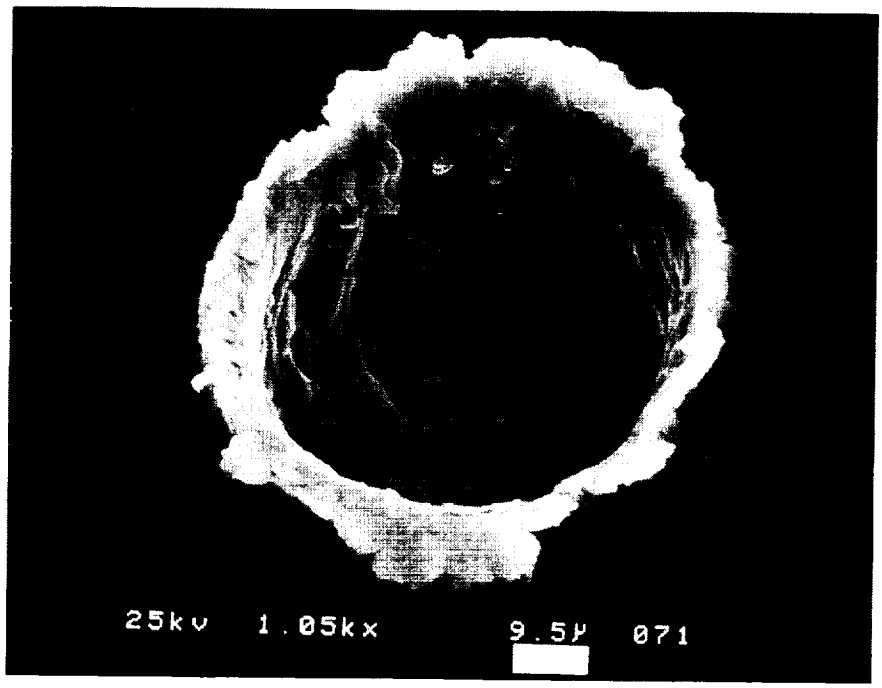
B09-C05 011 mm



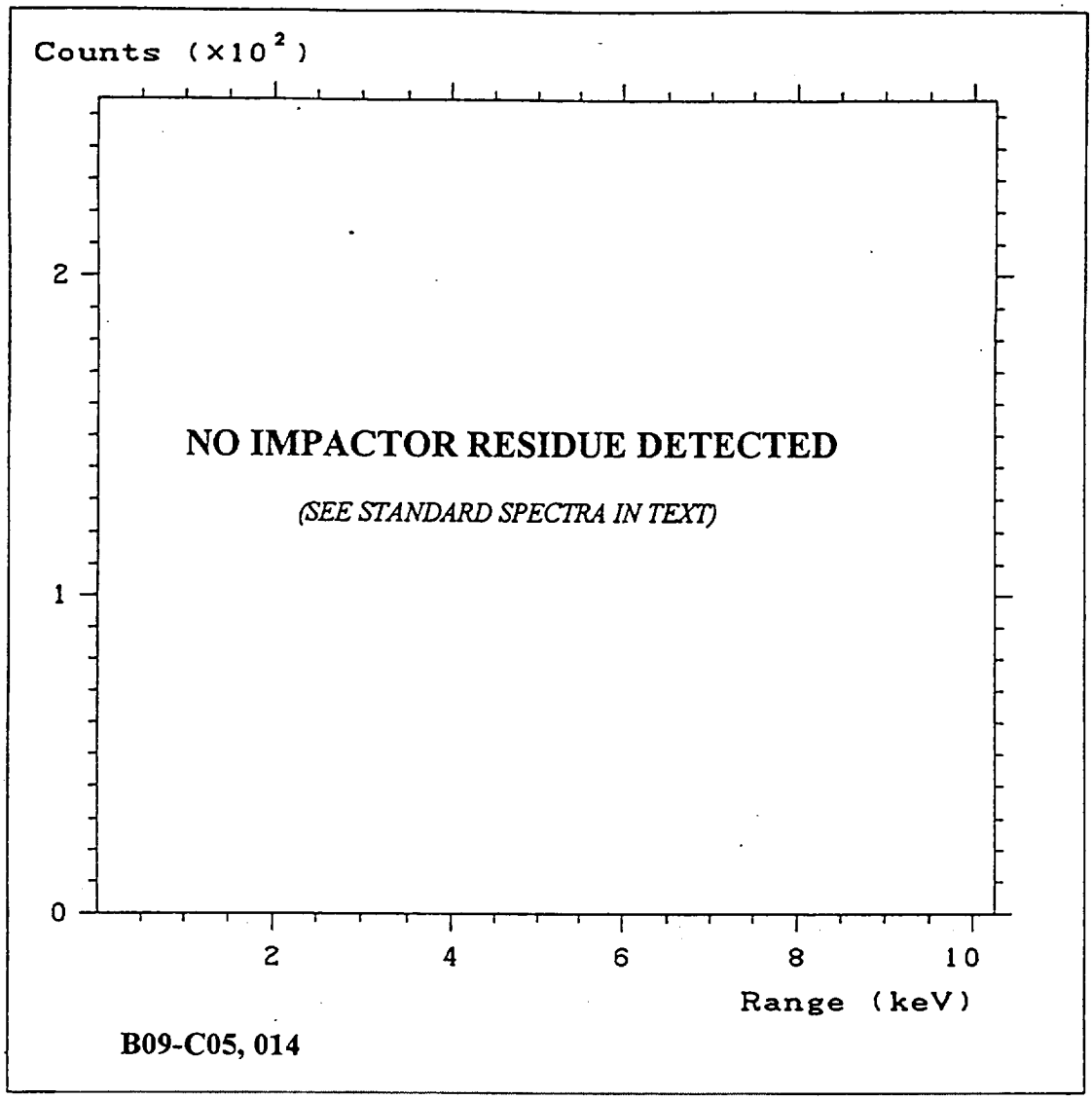


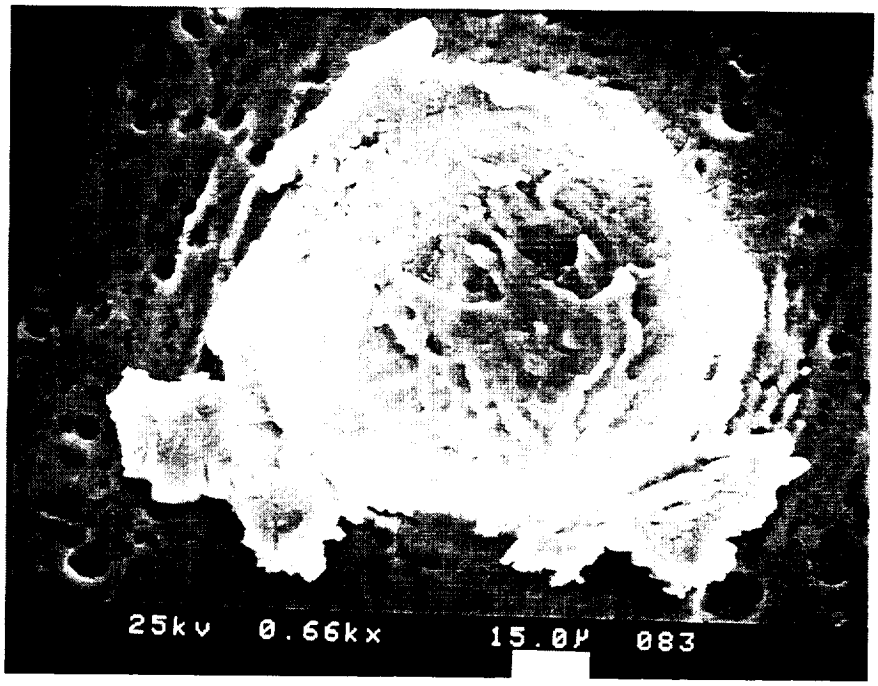
B09-C05 012 mm


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B09-C05, 013

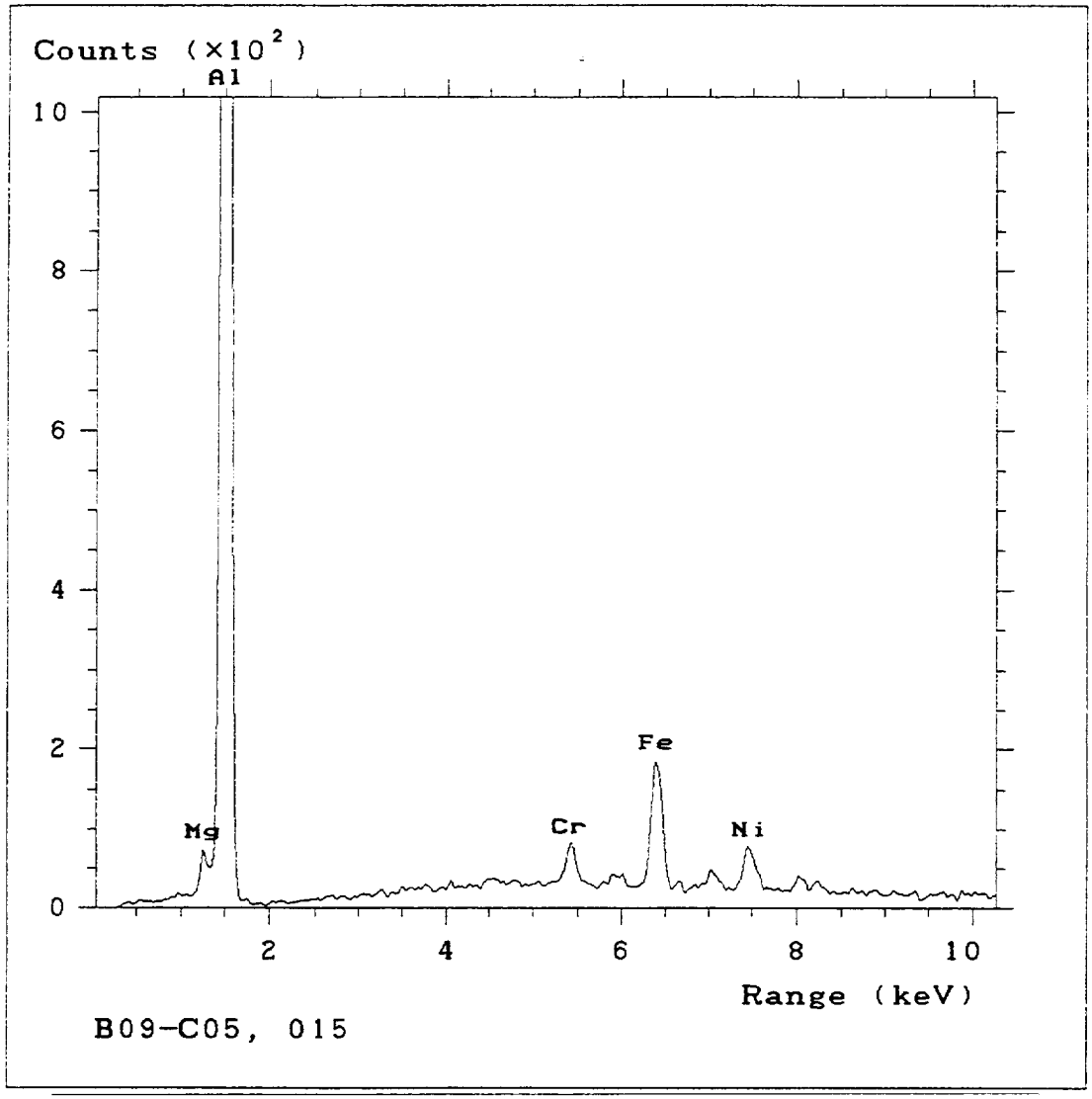

25kv 1.05kx 9.5μ 071

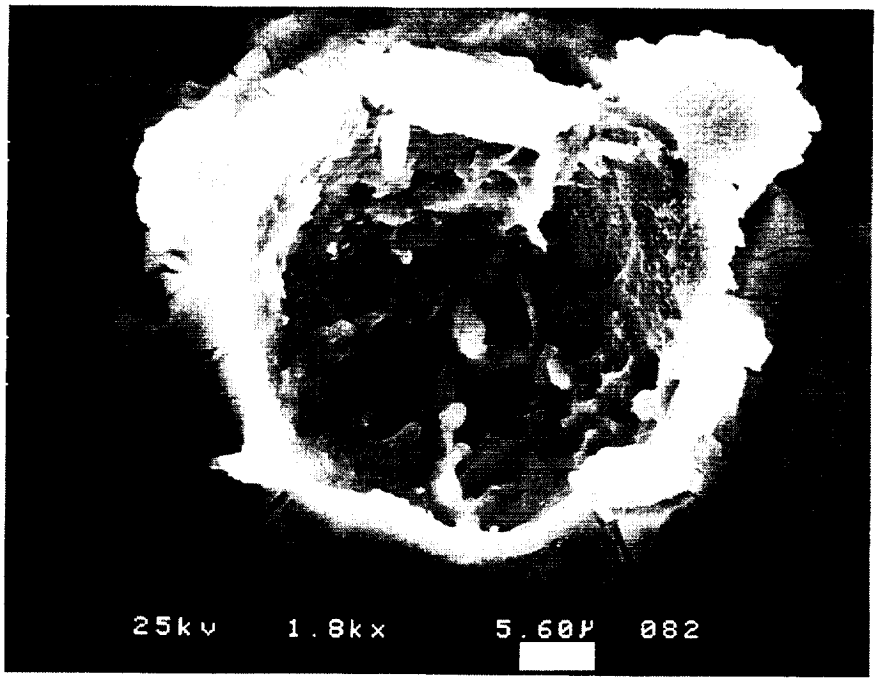
B09-C05 013


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B09-C05, 014

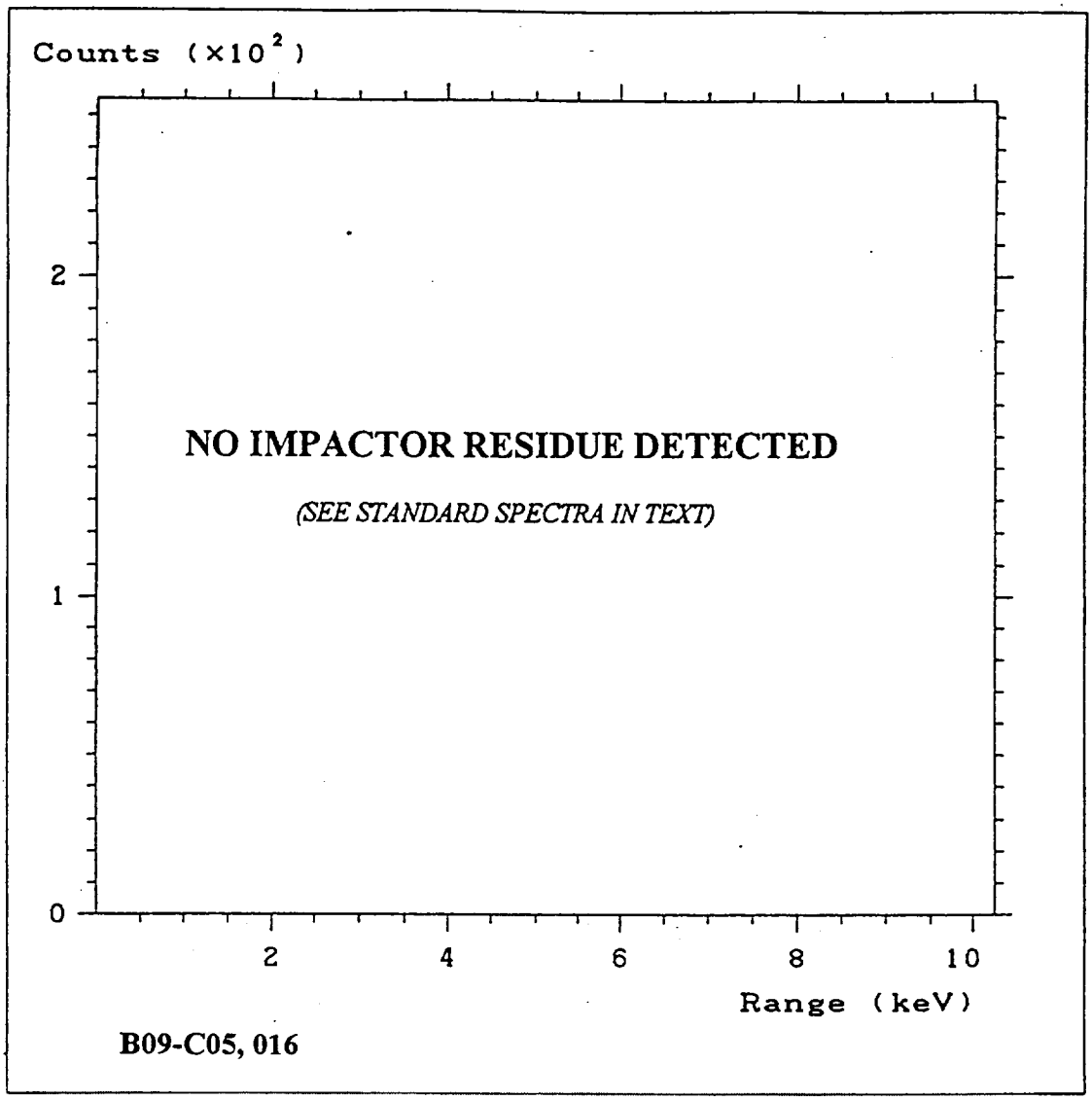

25kv 0.66kx 15.0µ 083

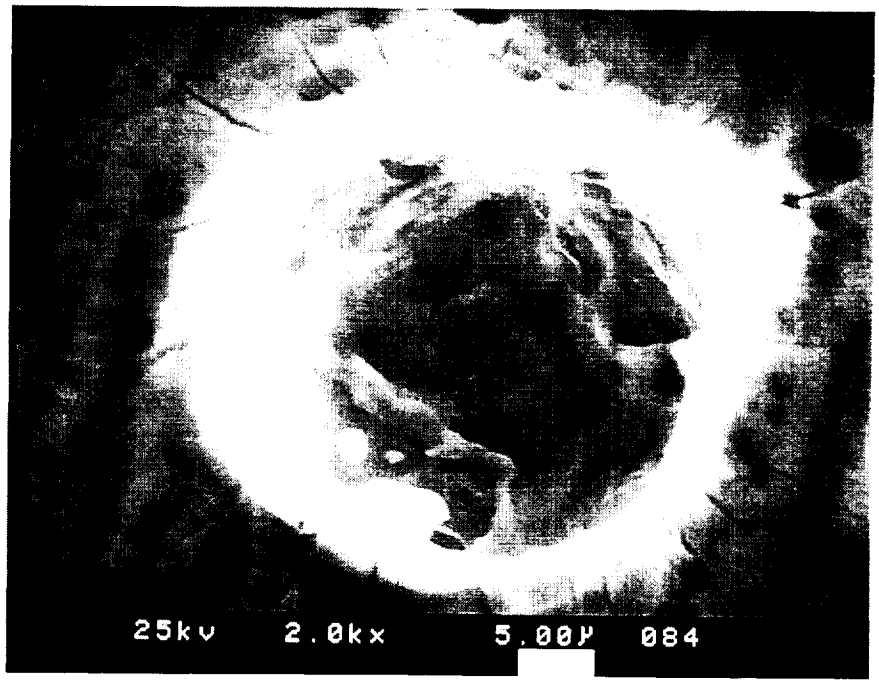
B09-C05 014



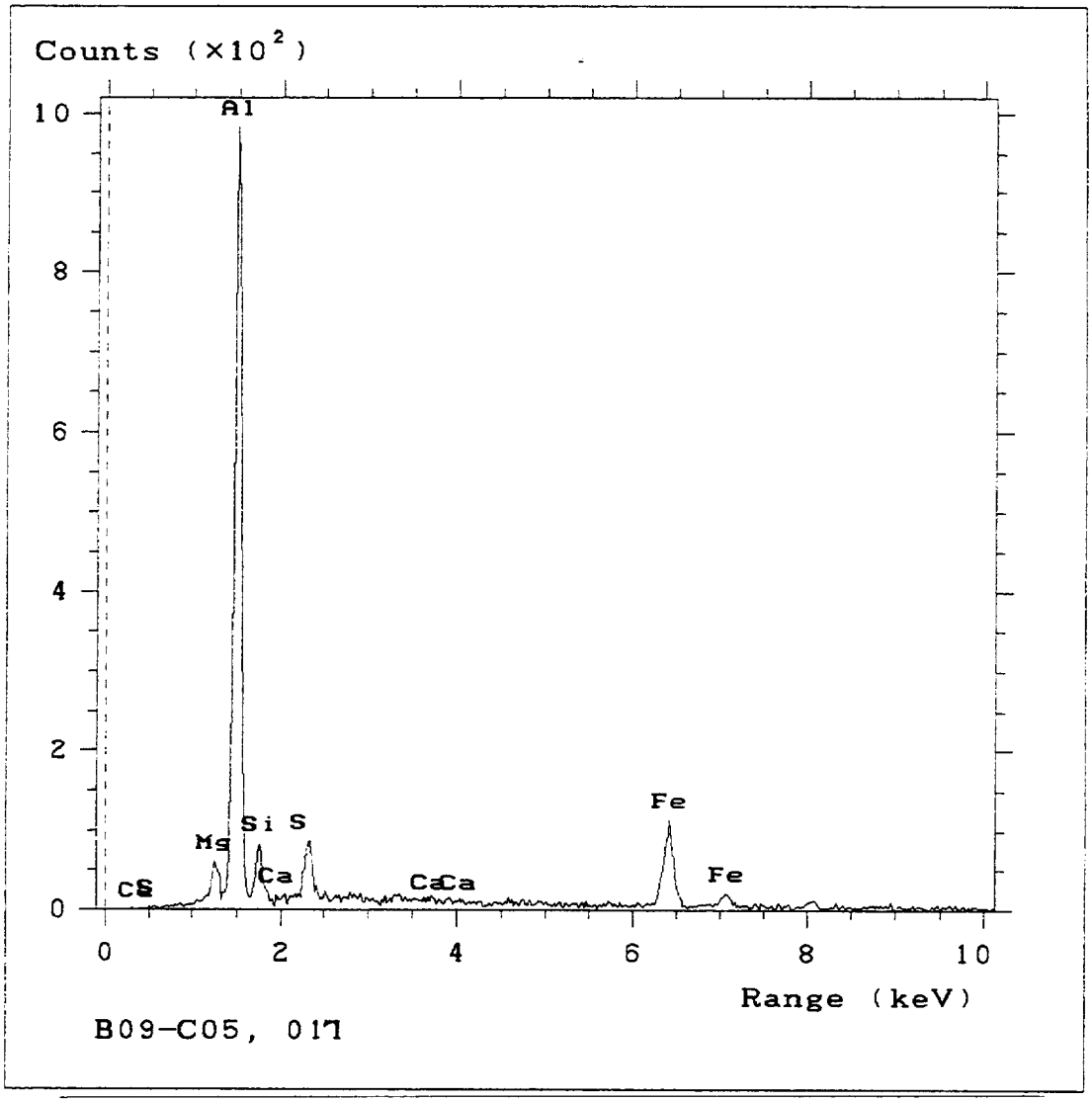


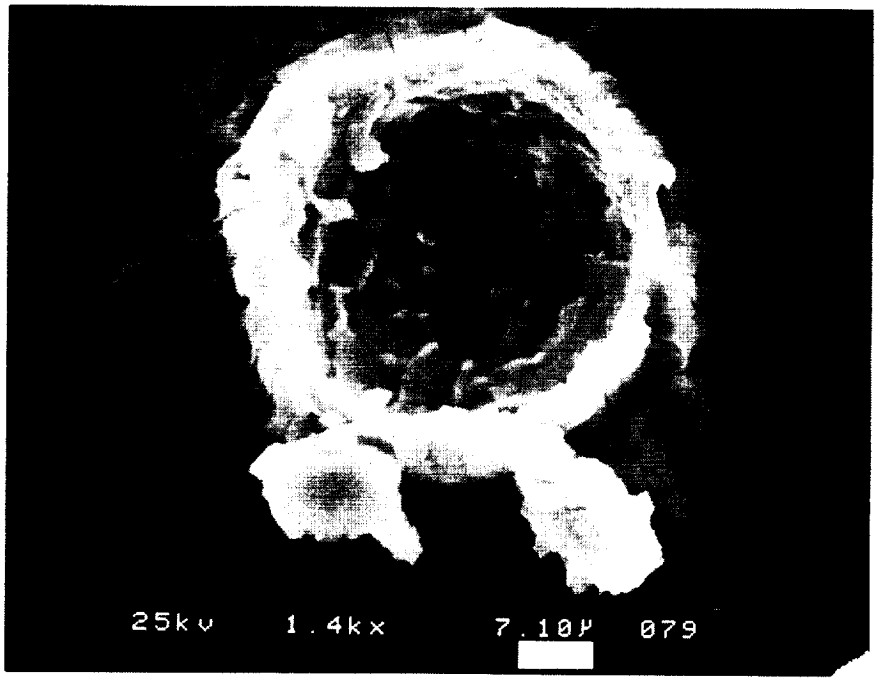
B09 - C05 015 SS


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B09-C05, 016

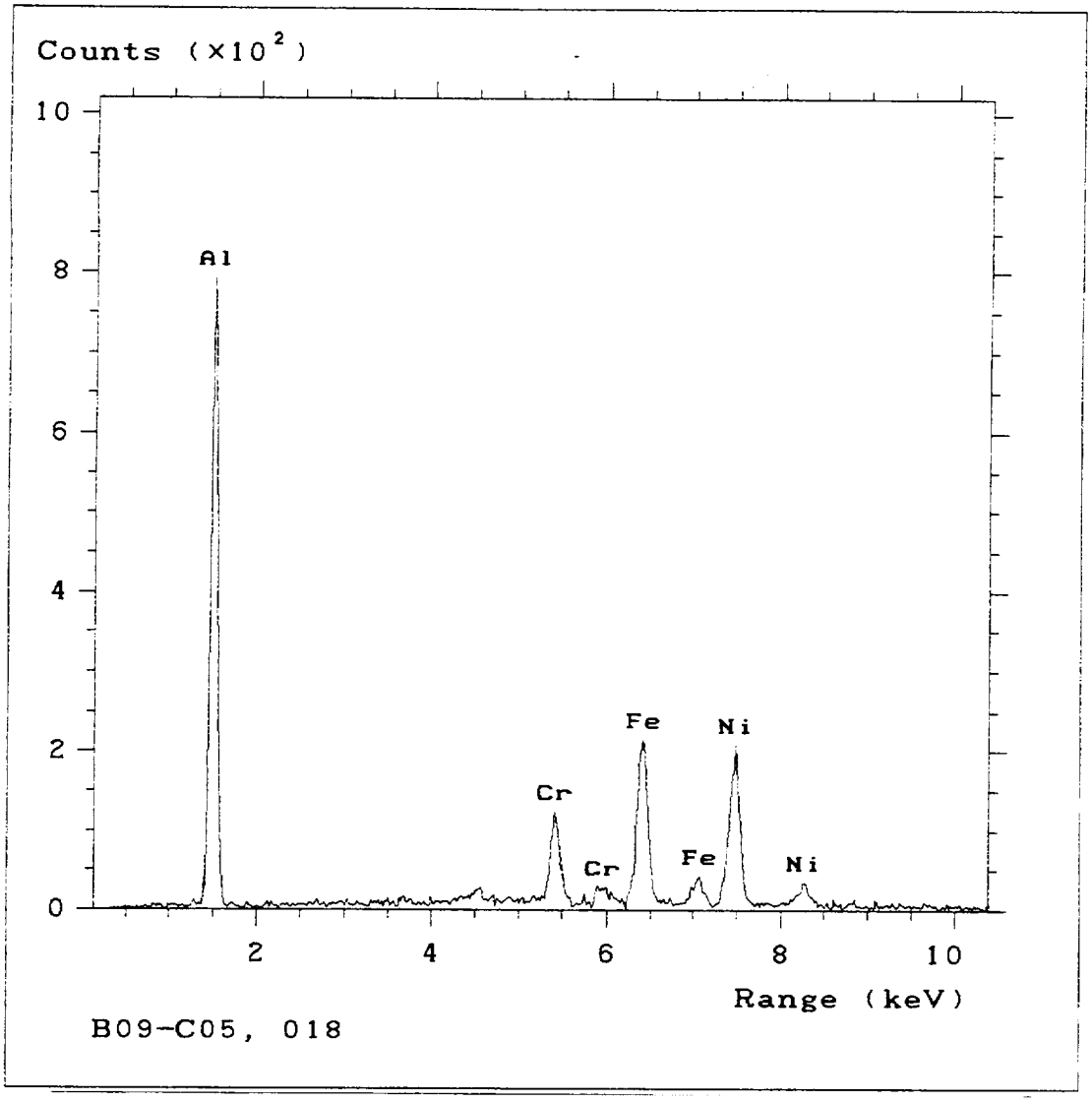

25kv 2.0kx 5.00µ 084

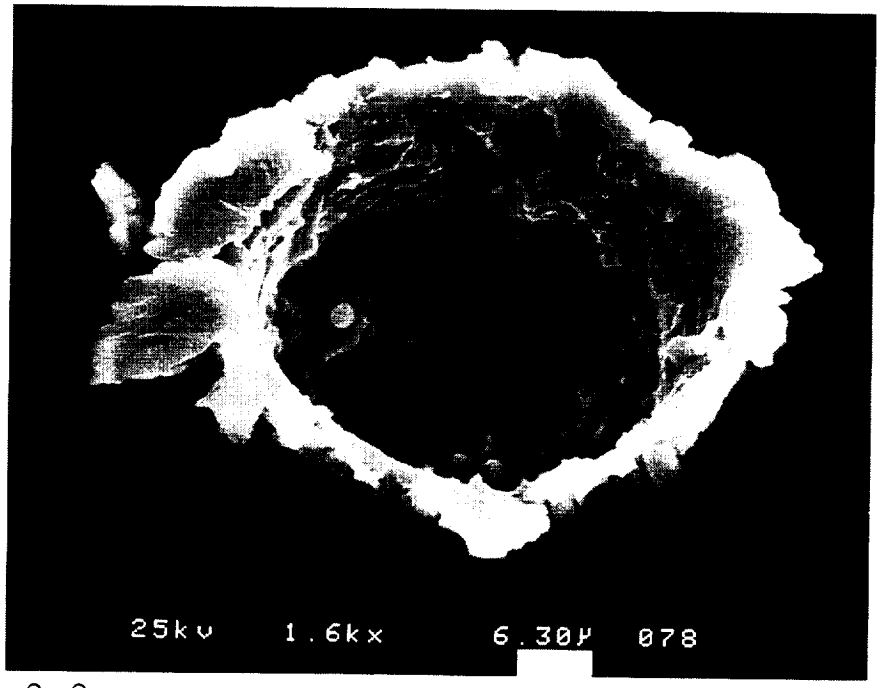
B09-C05 016


Counts (×10²)
Al
Mg
Si
S
Ca
Ca
Ca
Fe
Fe
Range (keV)
B09-C05, 017

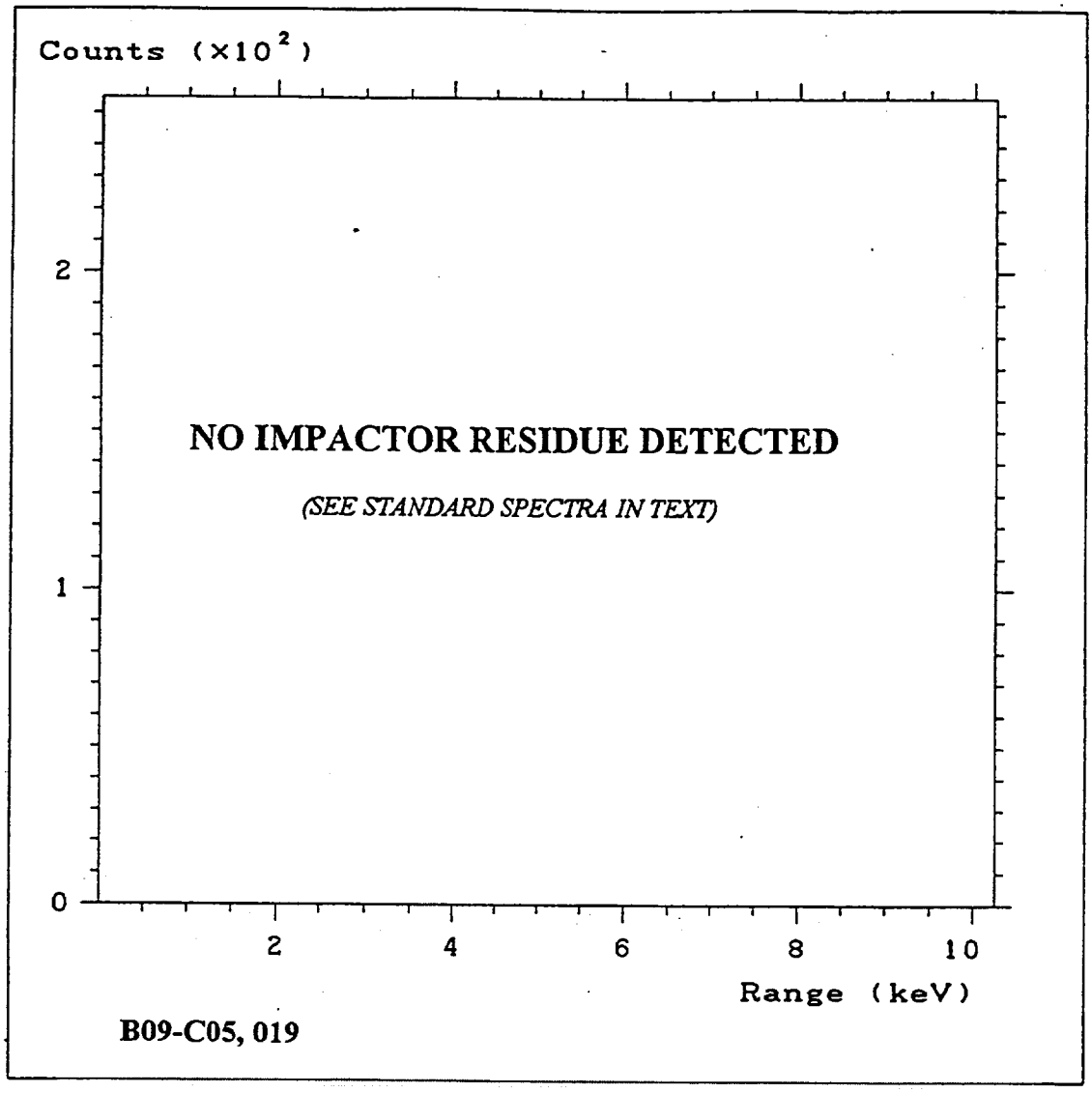

25kv 1.4kx 7.10μ 079

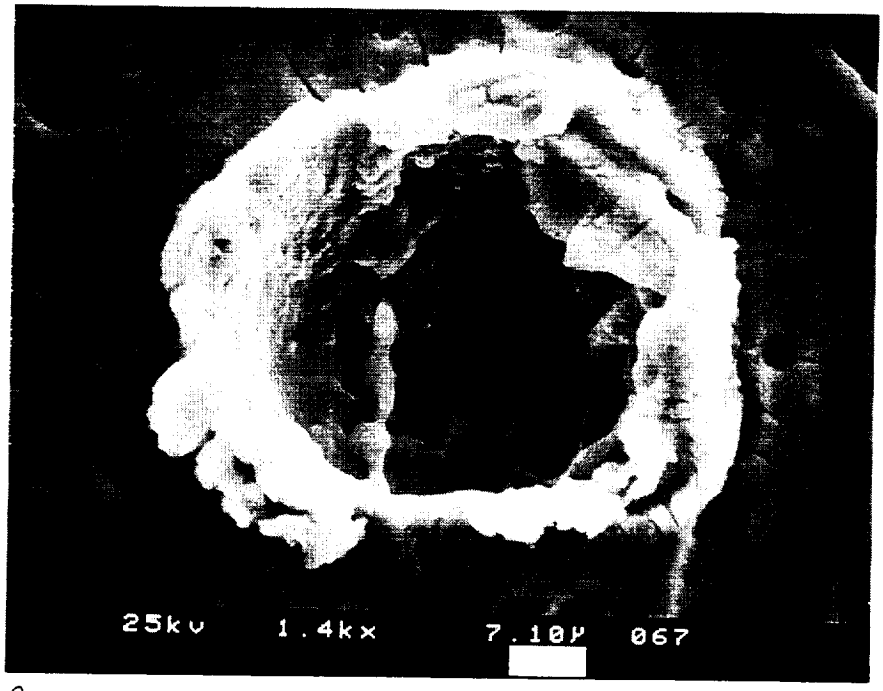
B09-C05 017



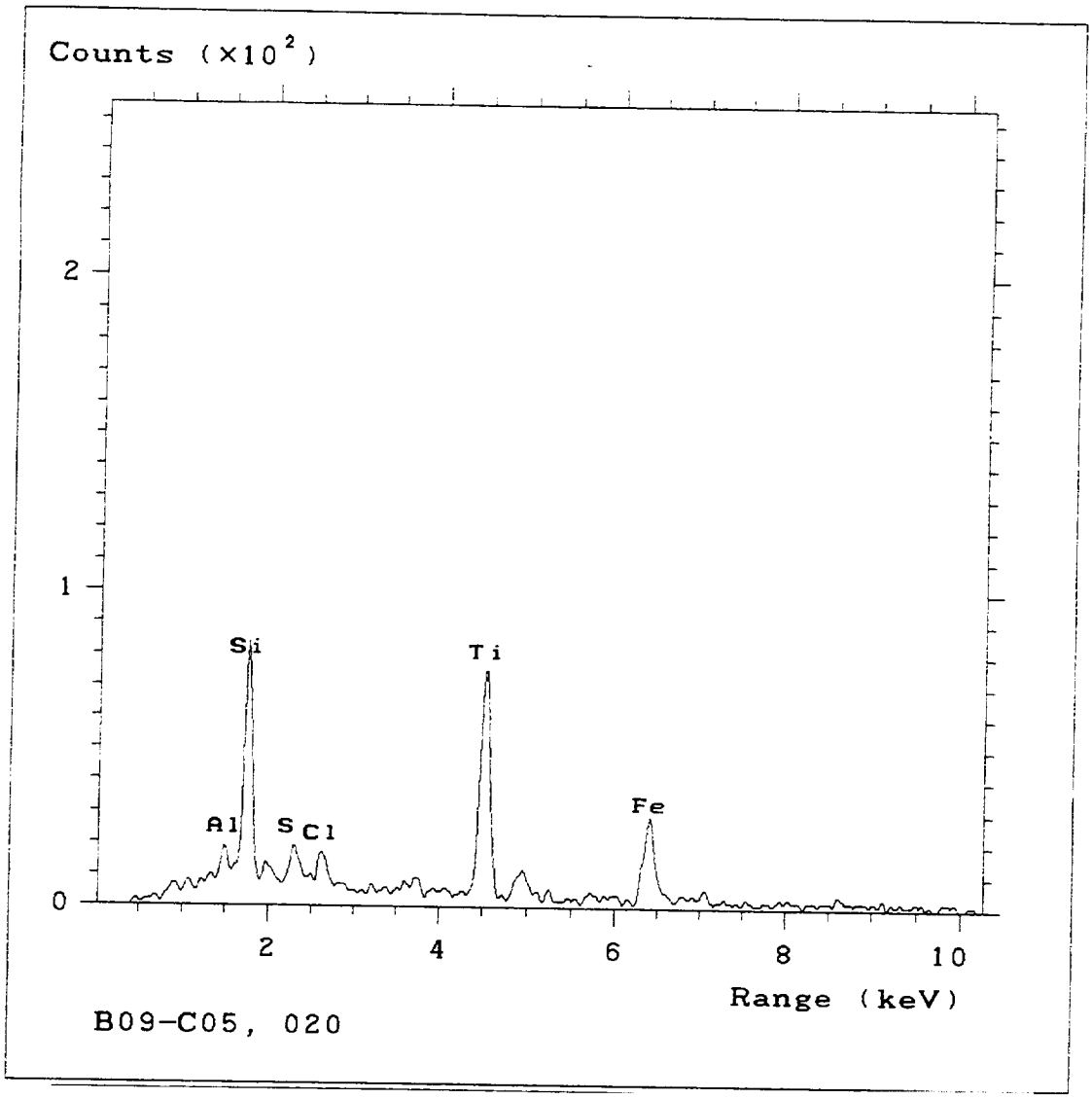


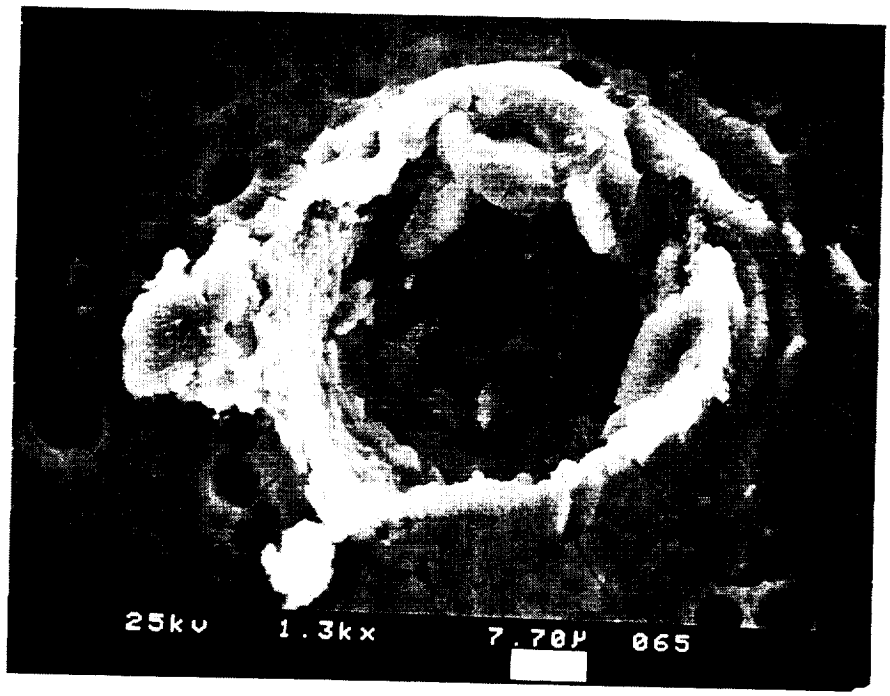
B09-C05 018 SS


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B09-C05, 019

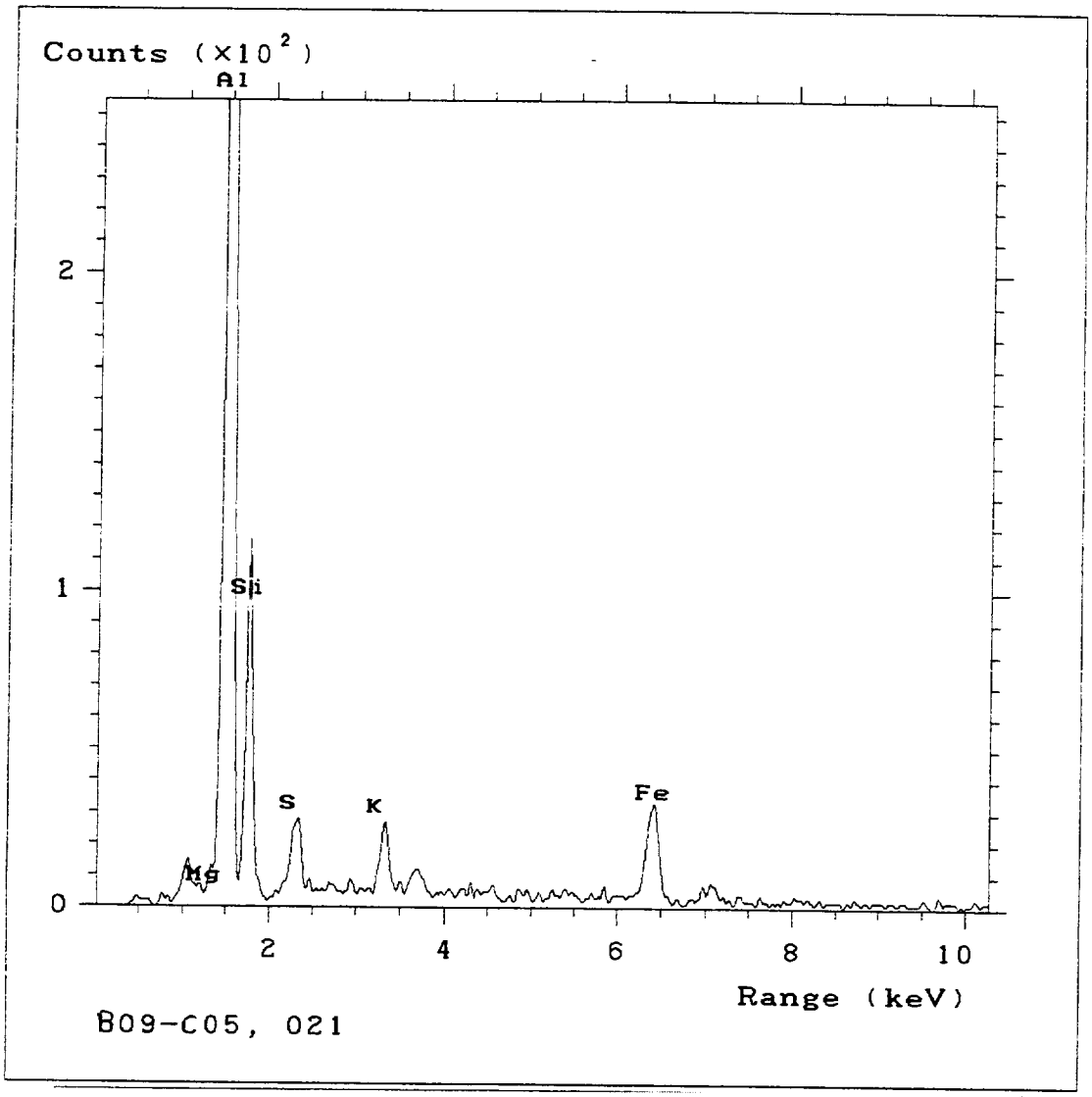

25kv 1.4kx 7.10μ 067

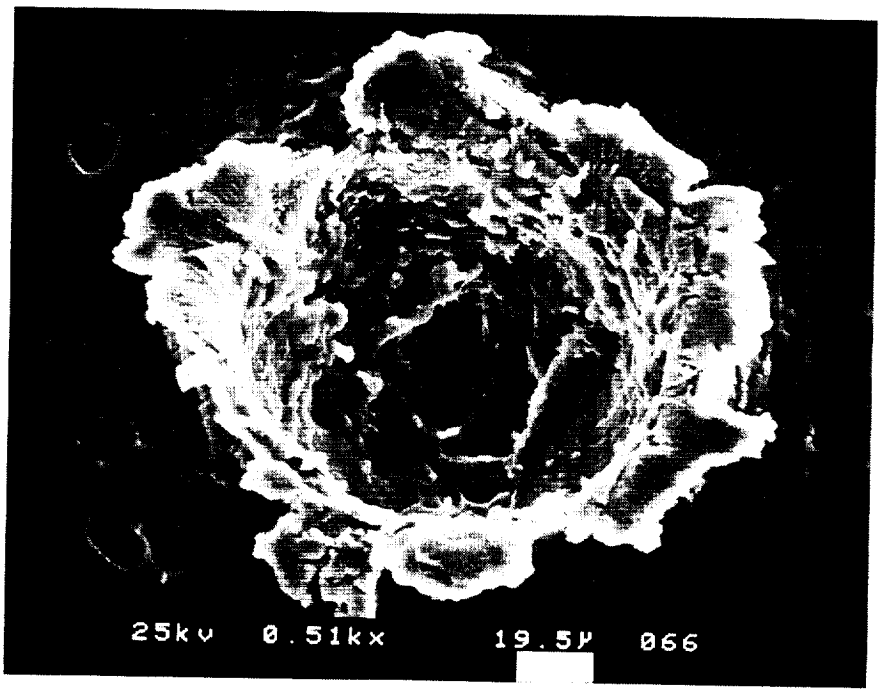
B09-C05 019



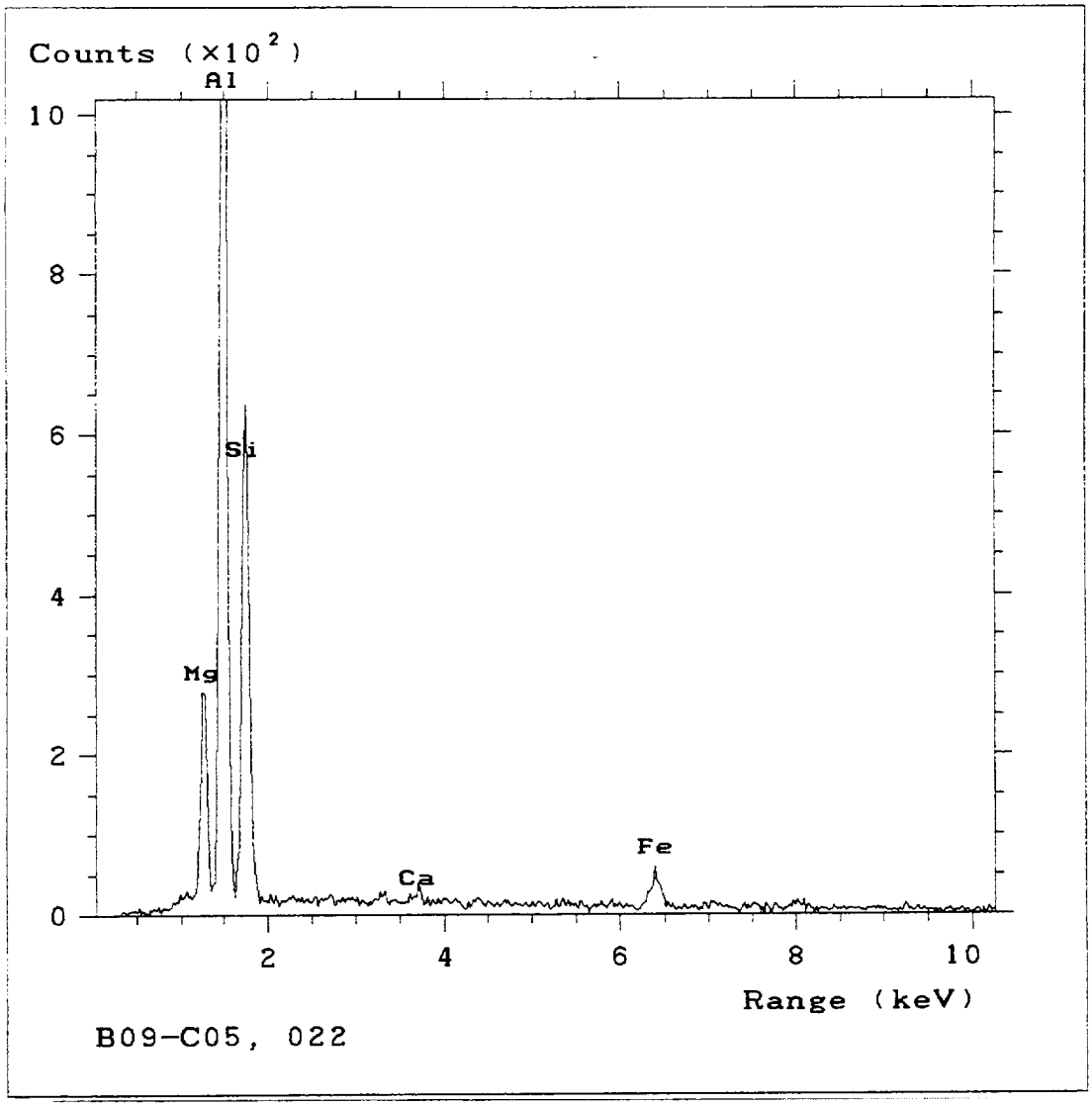


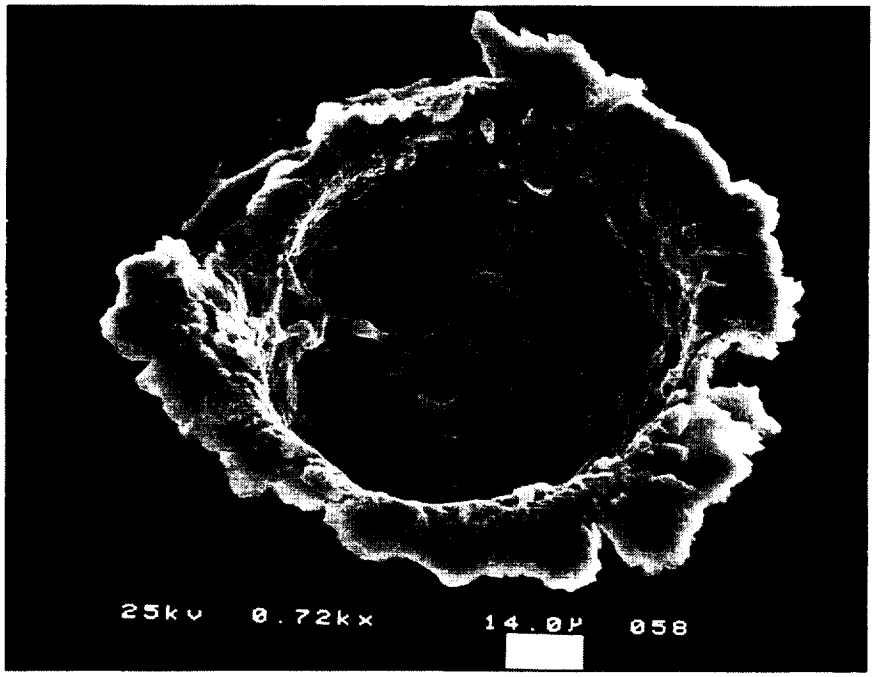
B09-C05 020 PAINT


Counts (x10²)
Al
Si
S
K
Fe
Mg
0
1
2
2
4
6
8
10
Range (keV)
B09-C05, 021

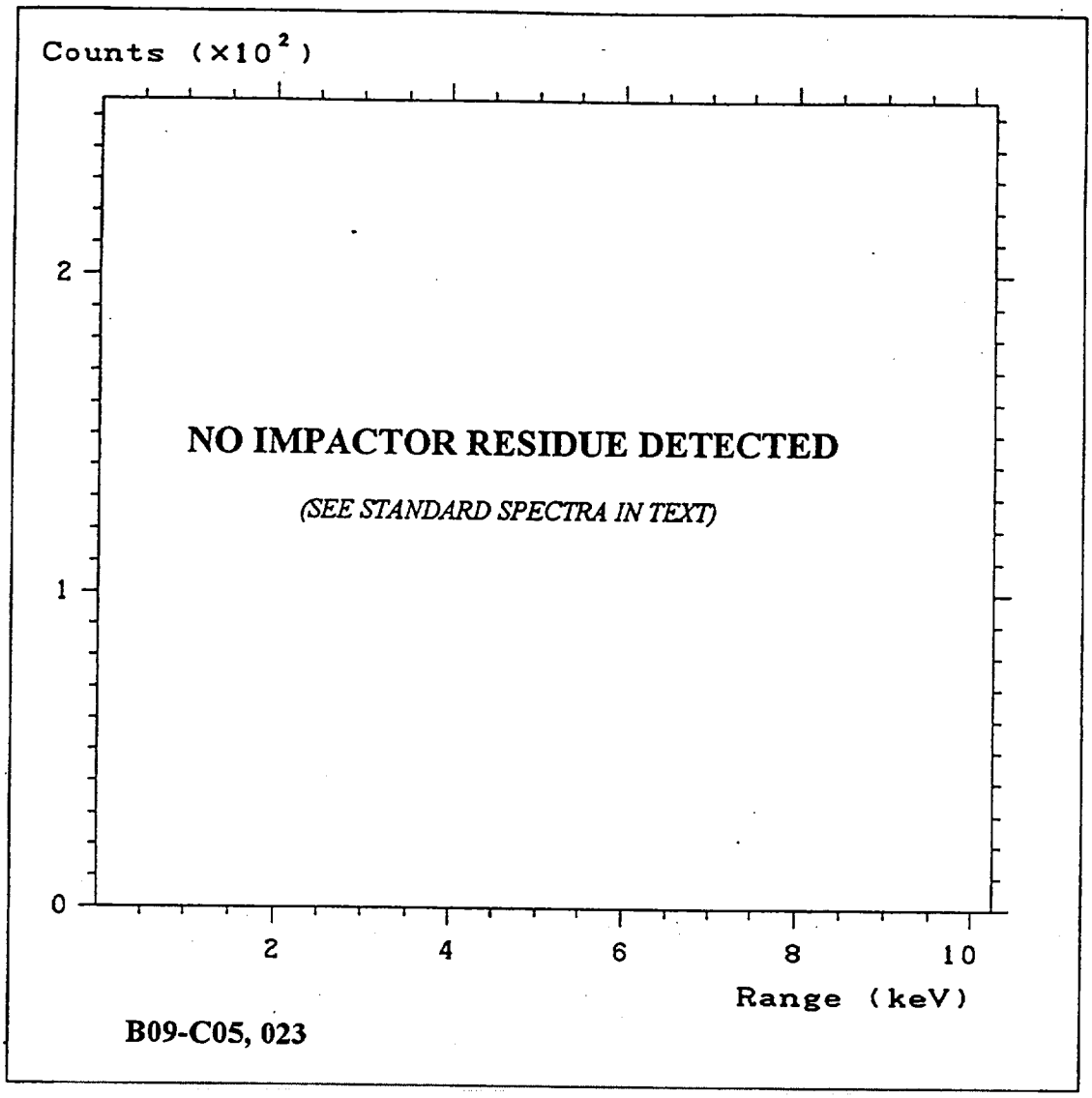

25kv 0.51kx 19.5µ 066

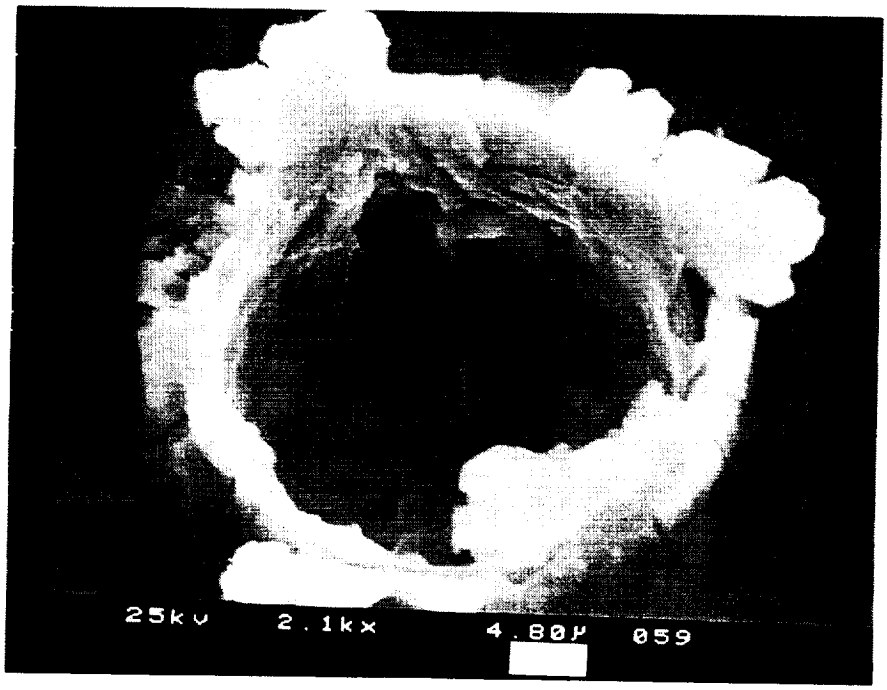
B09-C05 021



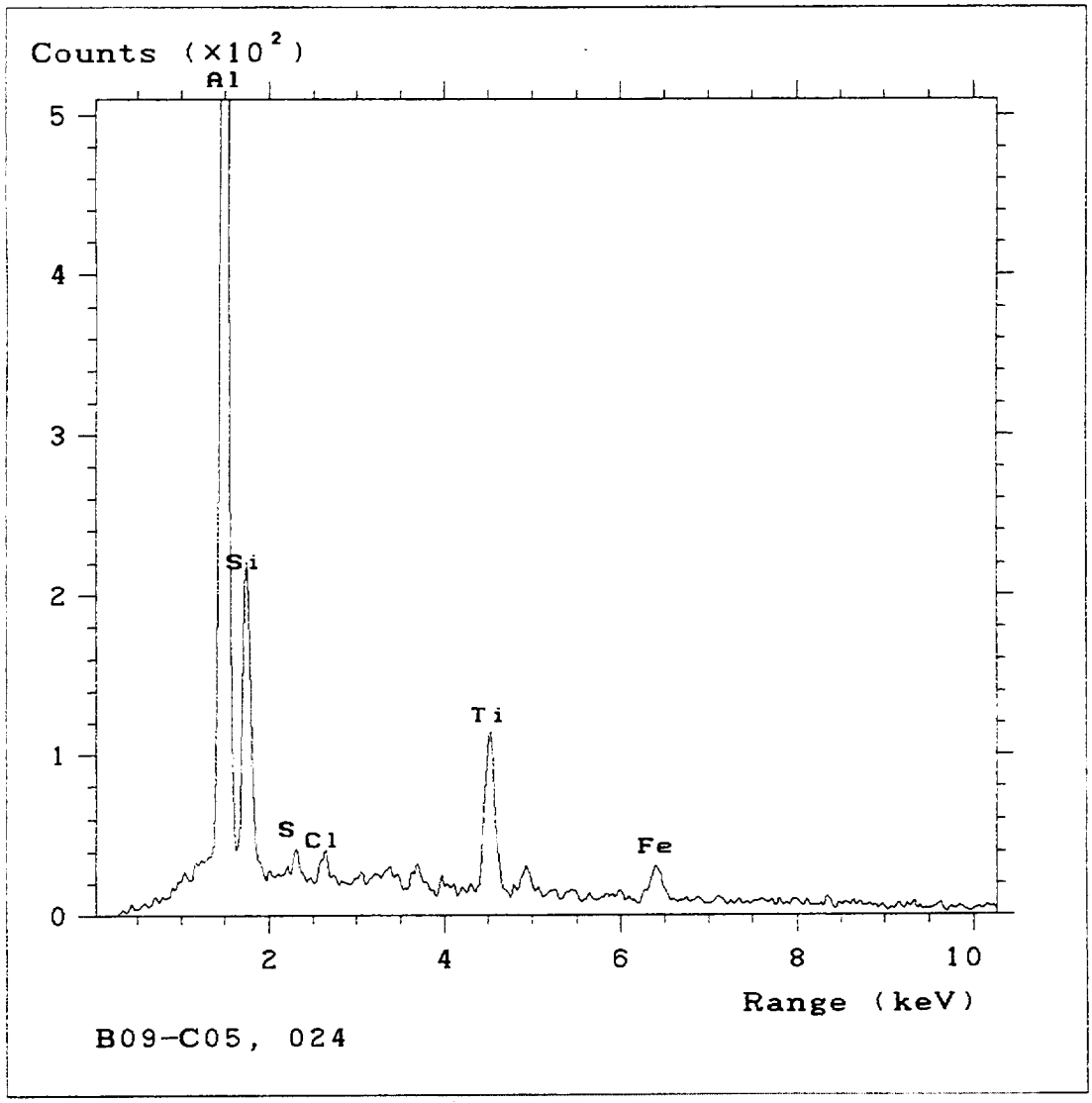


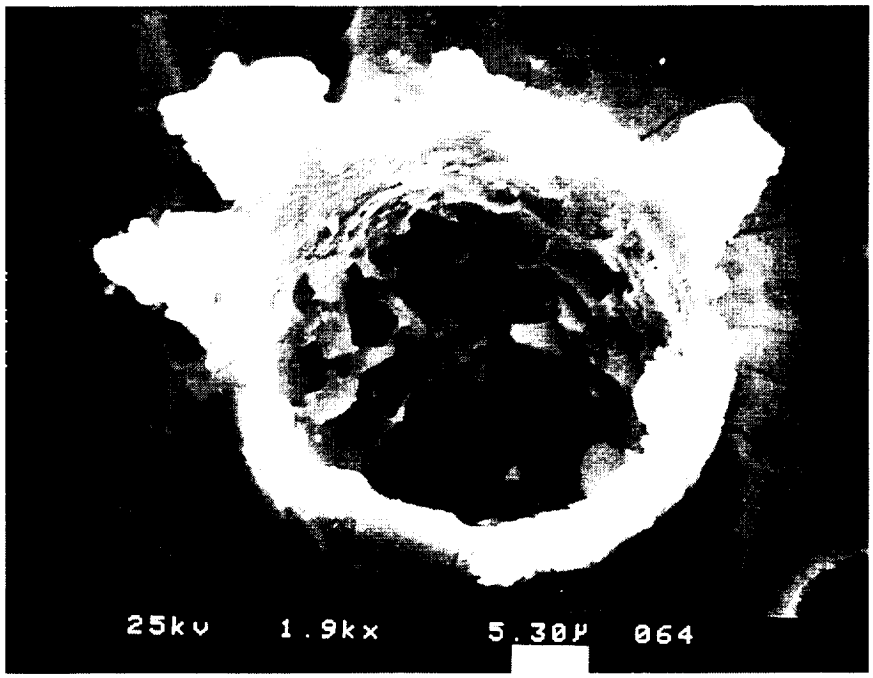
B09 - C05 022 mm


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B09-C05, 023

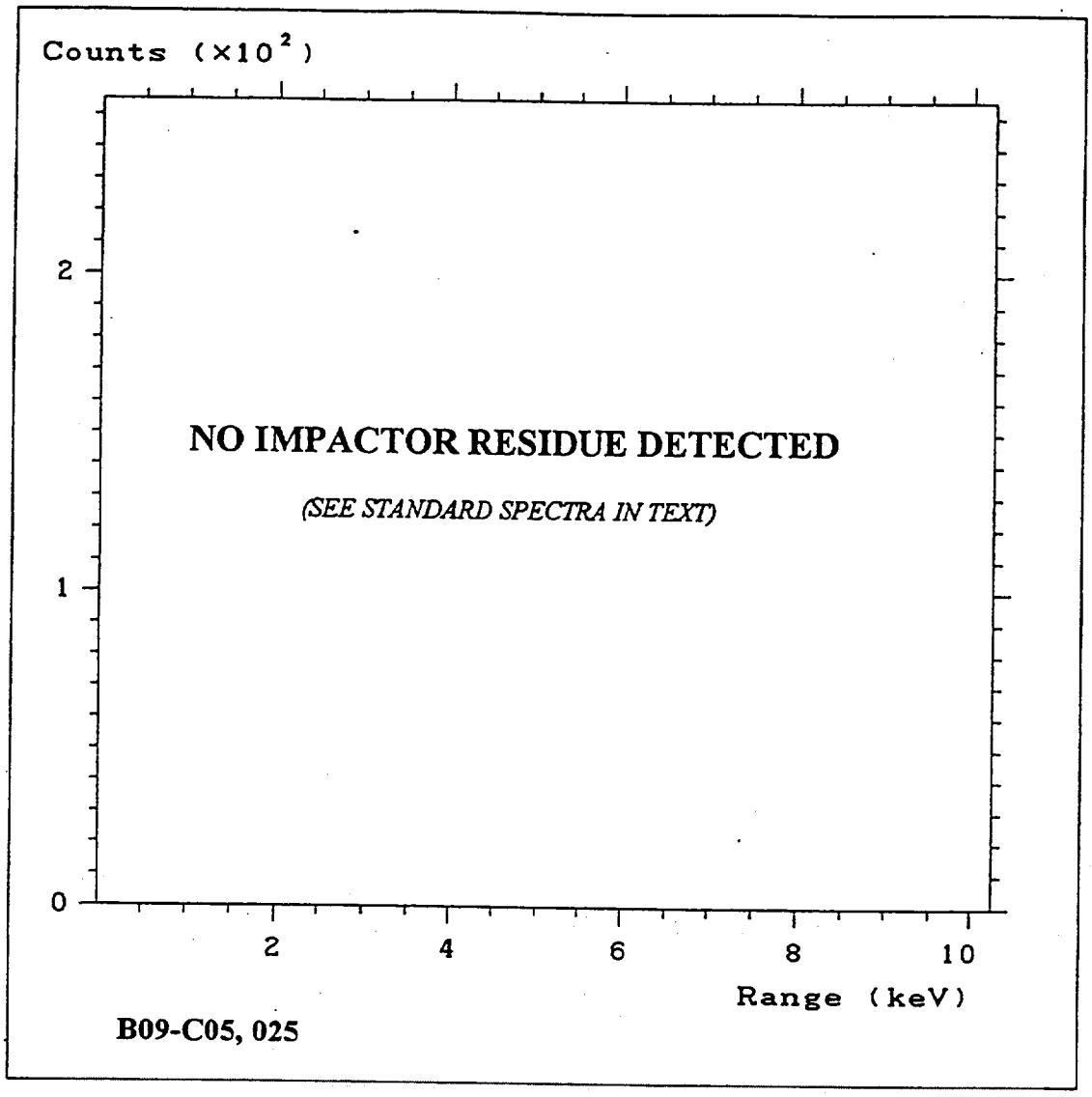

25kv 2.1kx 4.80μ 059

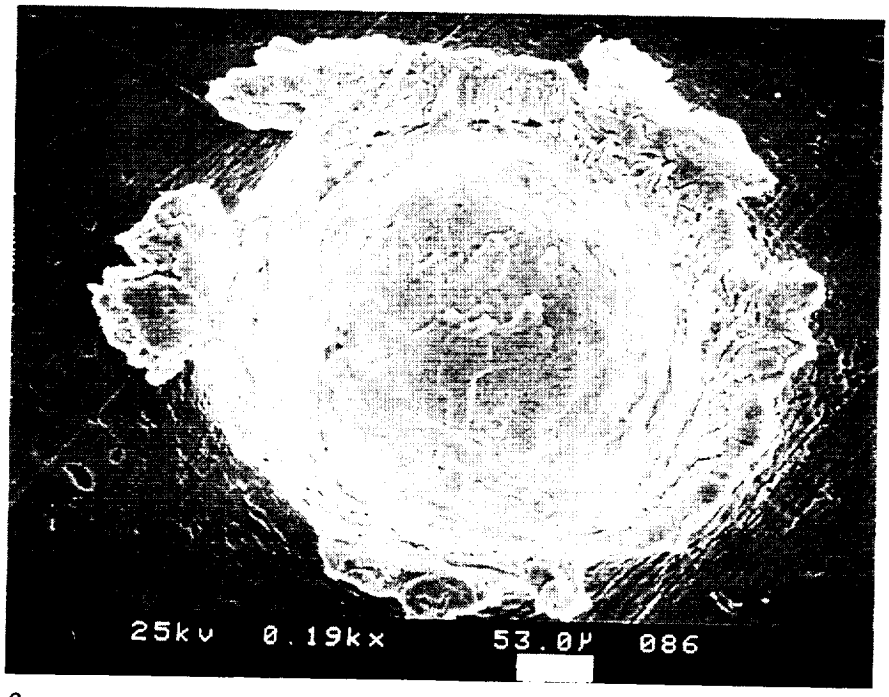
B09-C05 023



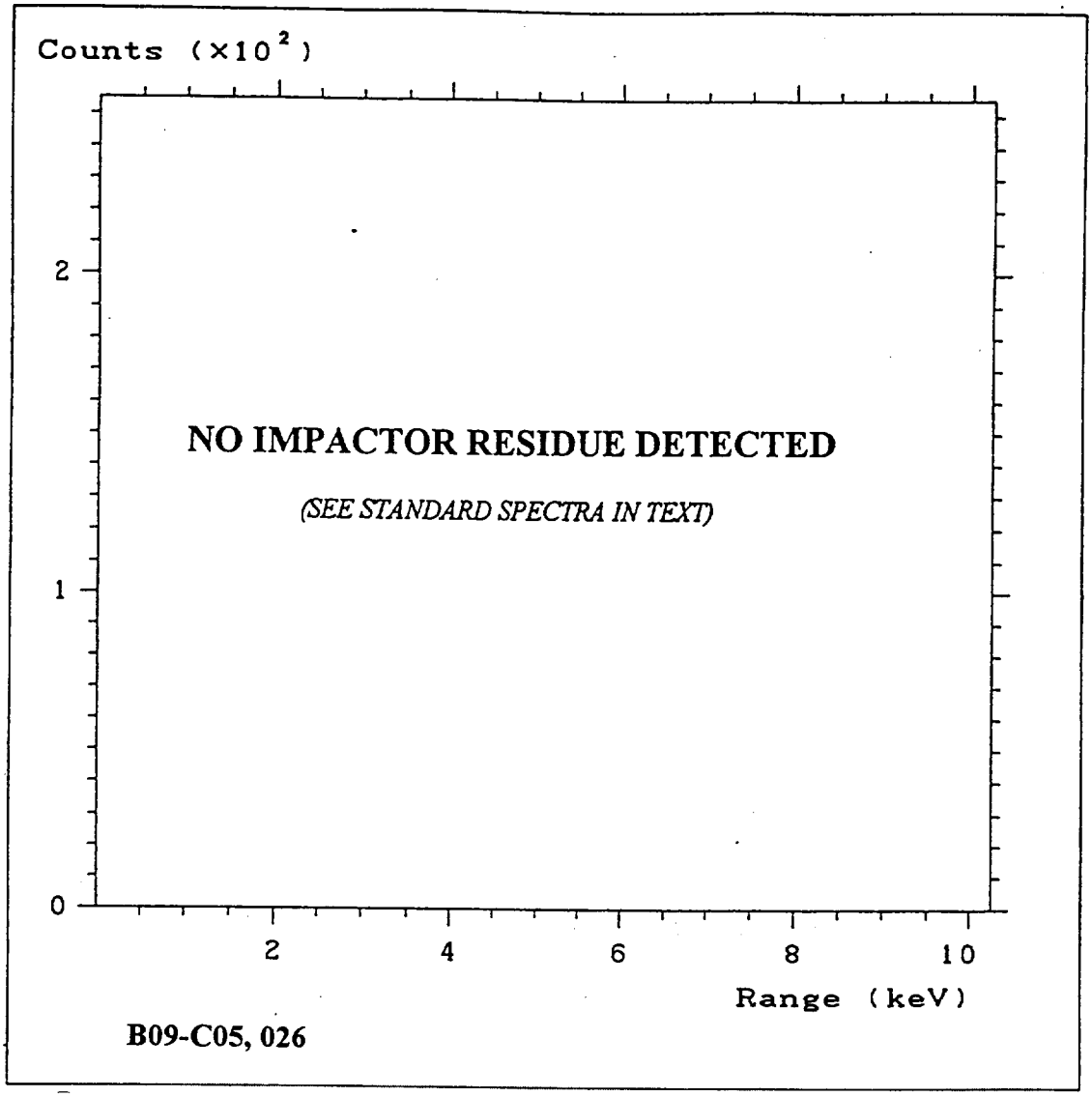


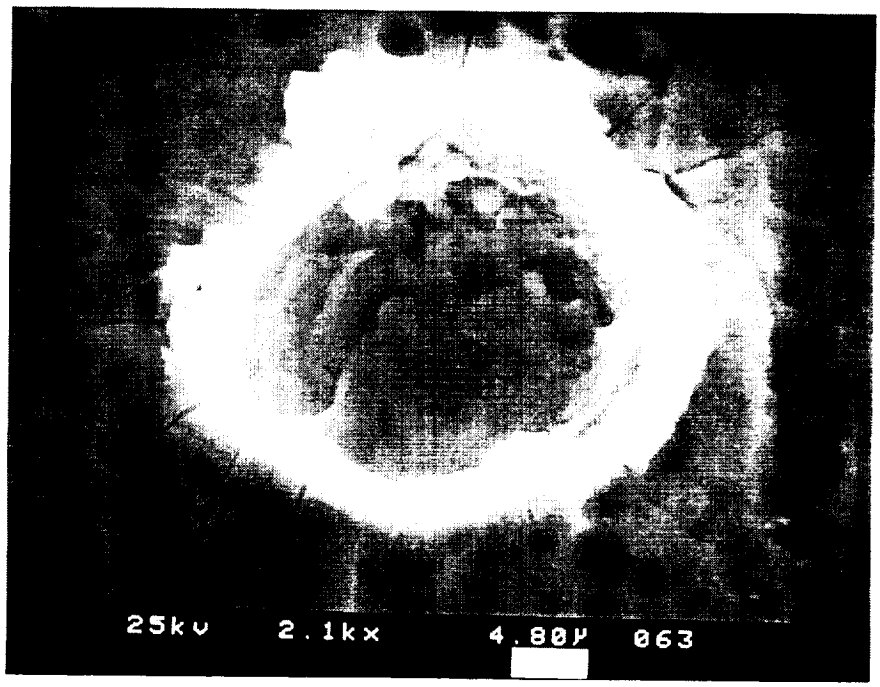
B09 C05 024 PAINT


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B09-C05, 025

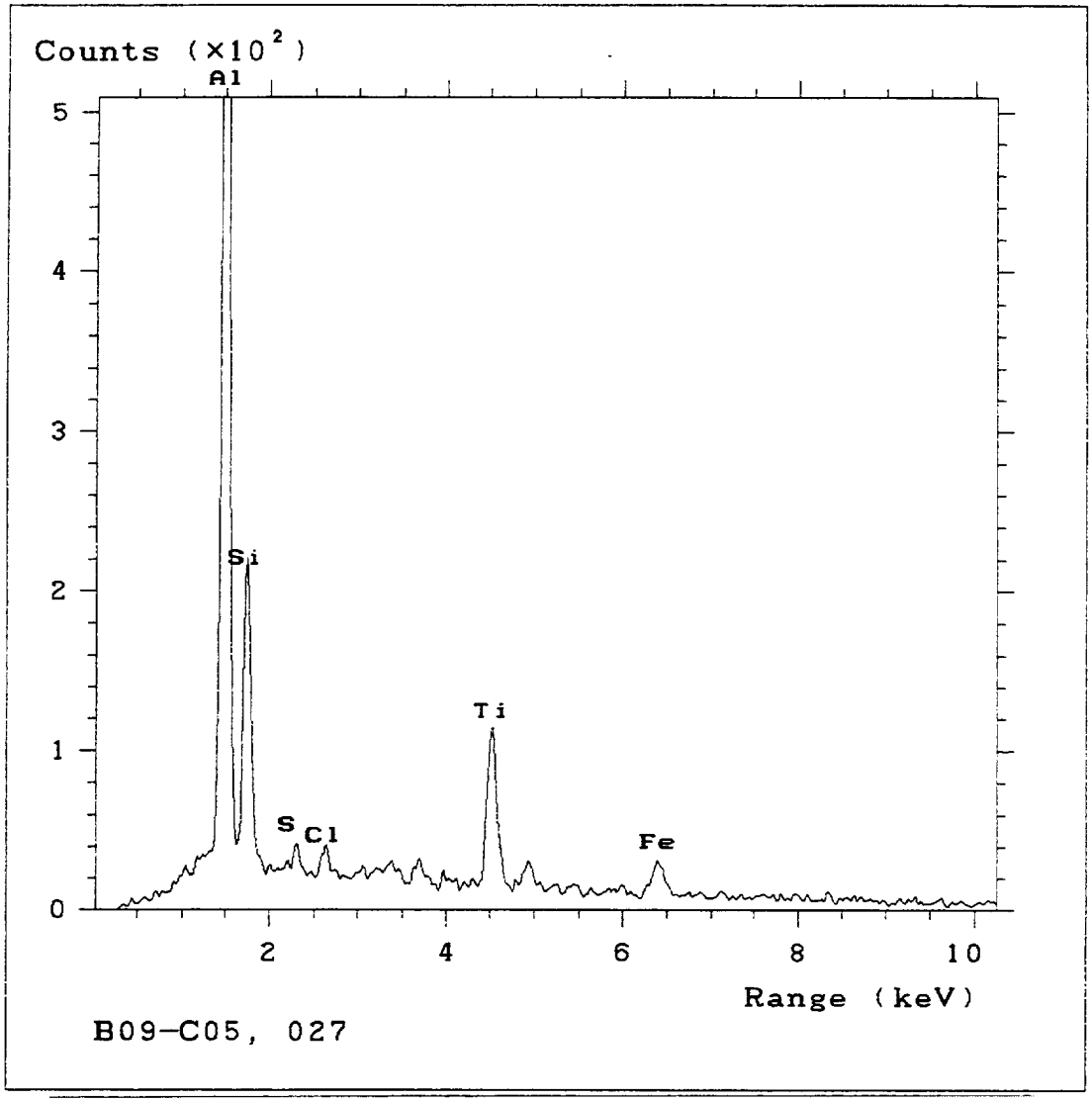

25kv 0.19kx 53.0µ 086

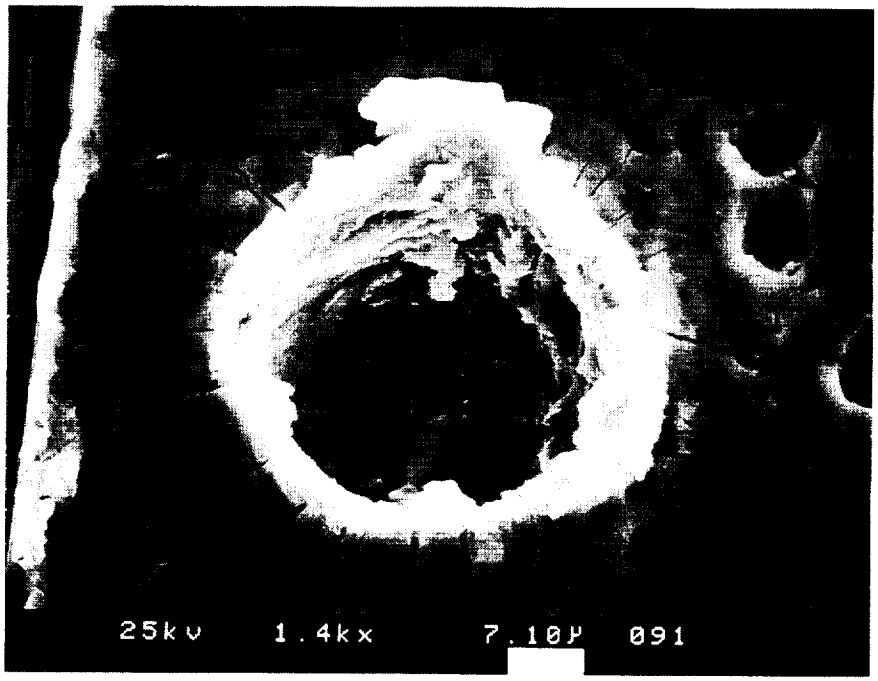
B09-C05 025


Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B09-C05, 026

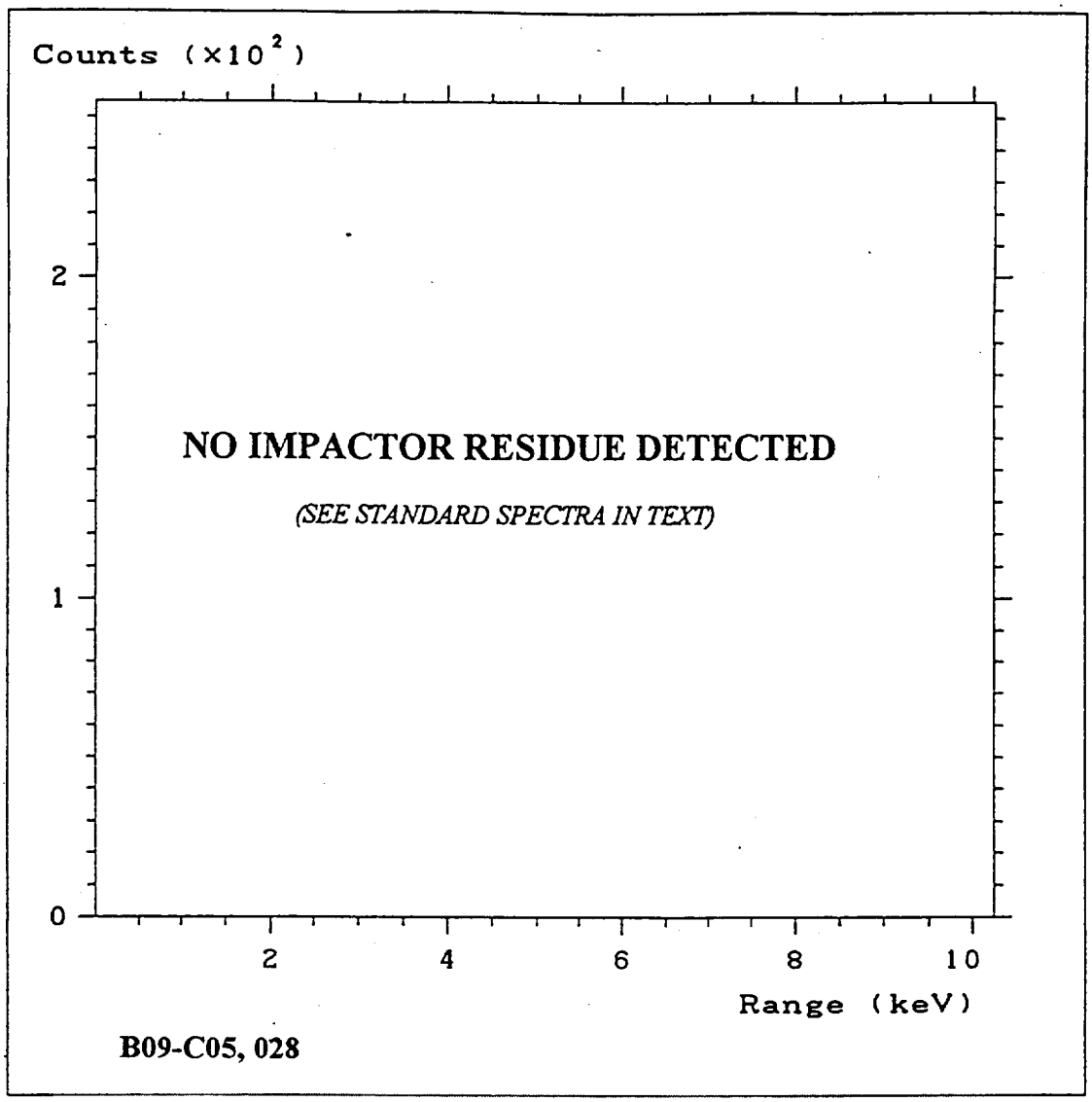

25kv 2.1kx 4.80μ 063

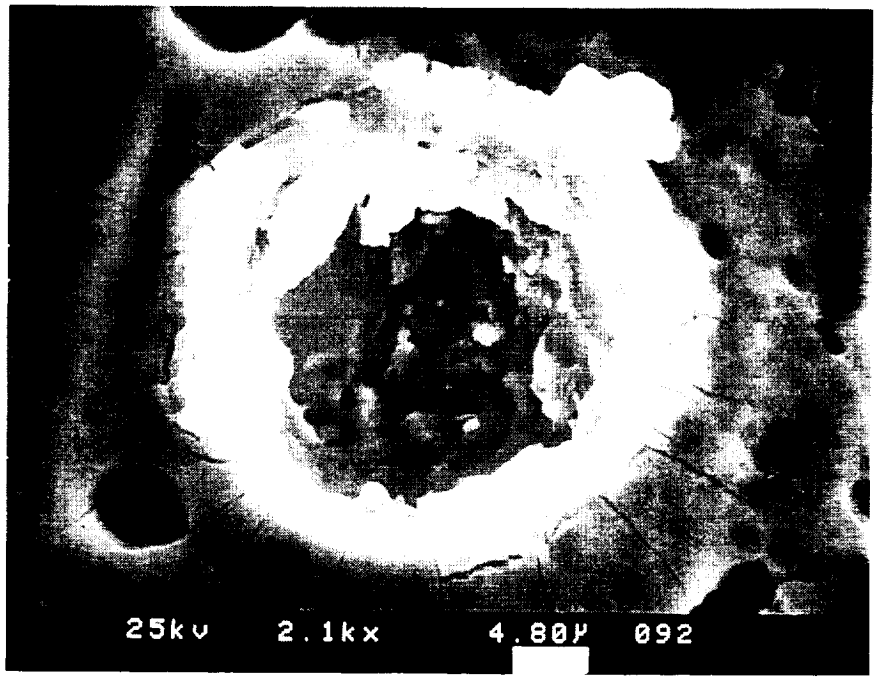
B09 - C05 026





B09-C05 027 PAINT

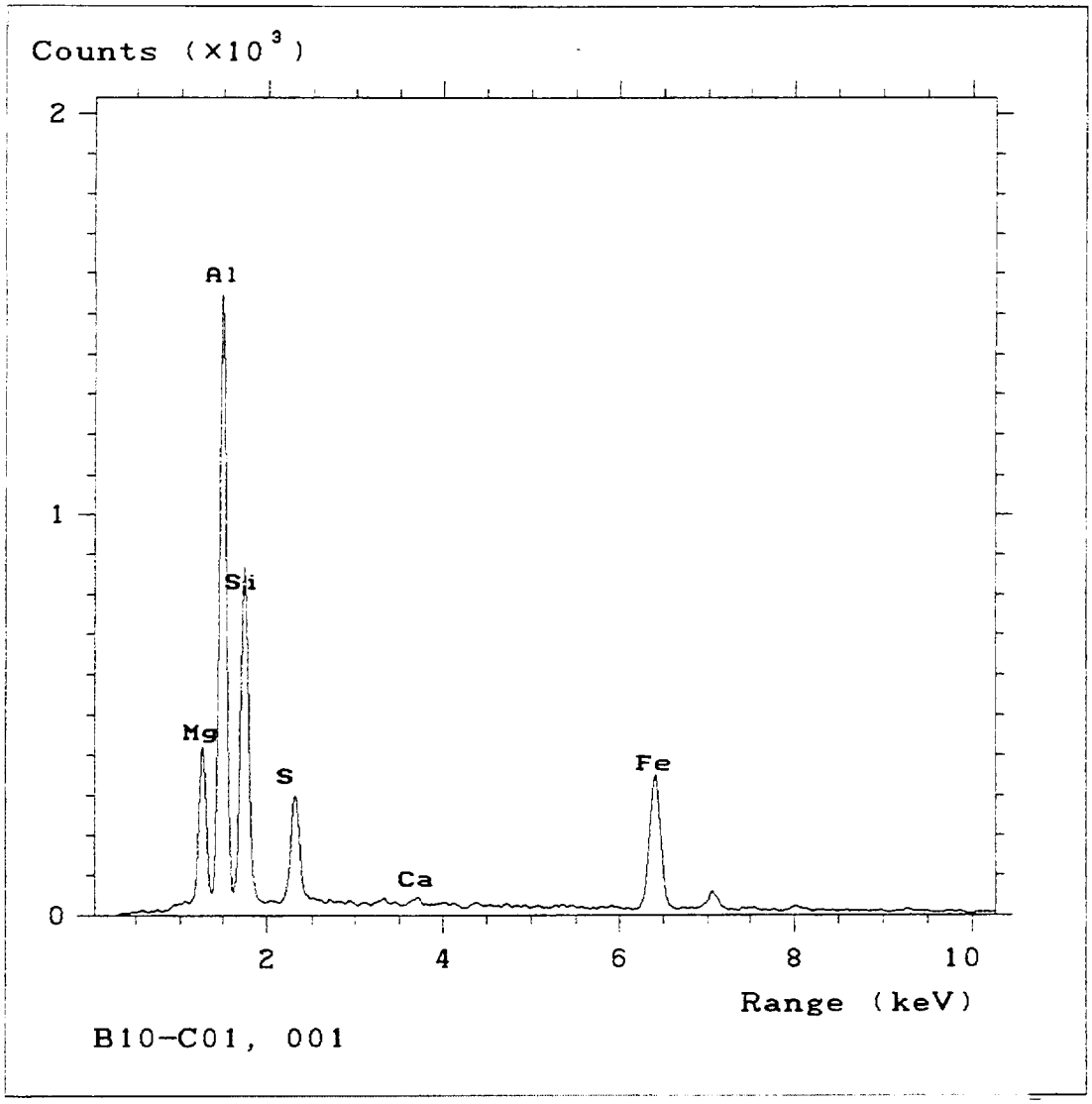


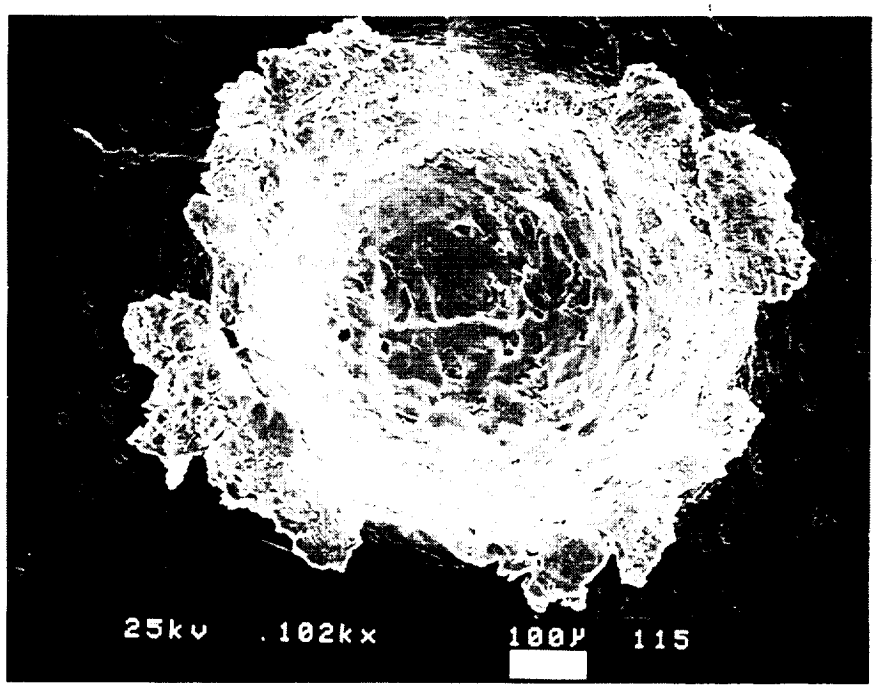


B09- C05 028 PRINT

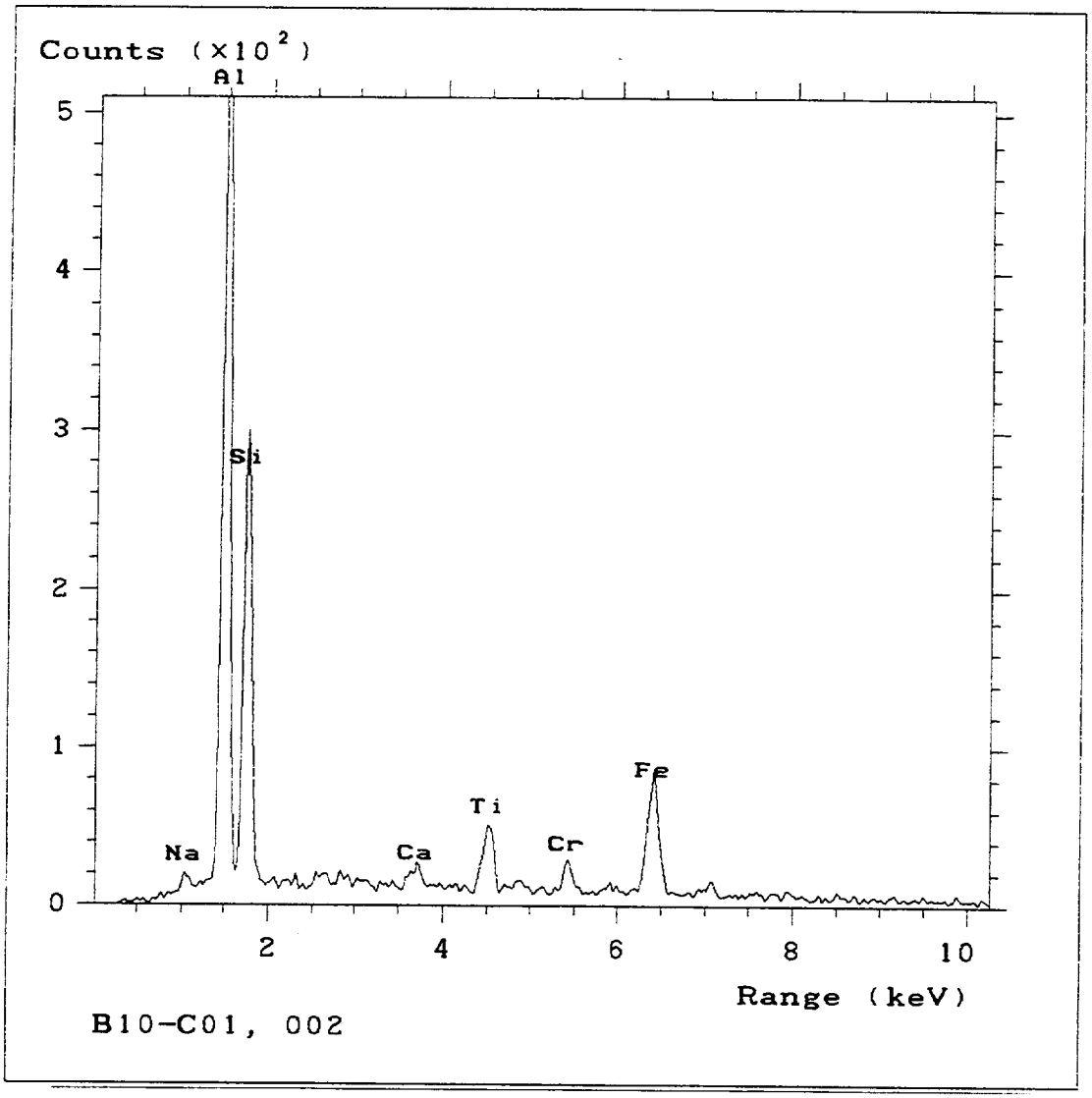
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B10-C01	001	4	46	700	MICROMETEORITIC
	002	4	2	10	PAINT
	003	77	1	130	UNKNOWN
	004	91	3	40	UNKNOWN
	005	70	10	50	UNKNOWN
	006	52	17	12	UNKNOWN
	007	86	12	80	UNKNOWN
	008	75	17	110	UNKNOWN
	009	39	20	200	MICROMETEORITIC
	010	39	19	30	MICROMETEORITIC
	011	112	23	30	NOT AN IMPACT
	012	123	25	60	MICROMETEORITIC
	013	119	32	50	UNKNOWN
	014	34	34	70	MICROMETEORITIC
	015	20	39	40	ELECTRICAL
	016	71	40	110	MICROMETEORITIC
	017	73	39	50	MICROMETEORITIC
	018	91	36	230	UNKNOWN
	019	123	36	150	UNKNOWN
	020	111	46	50	STAINLESS STEEL
	021	114	46	30	NOT AN IMPACT
	022	1	43	130	UNKNOWN

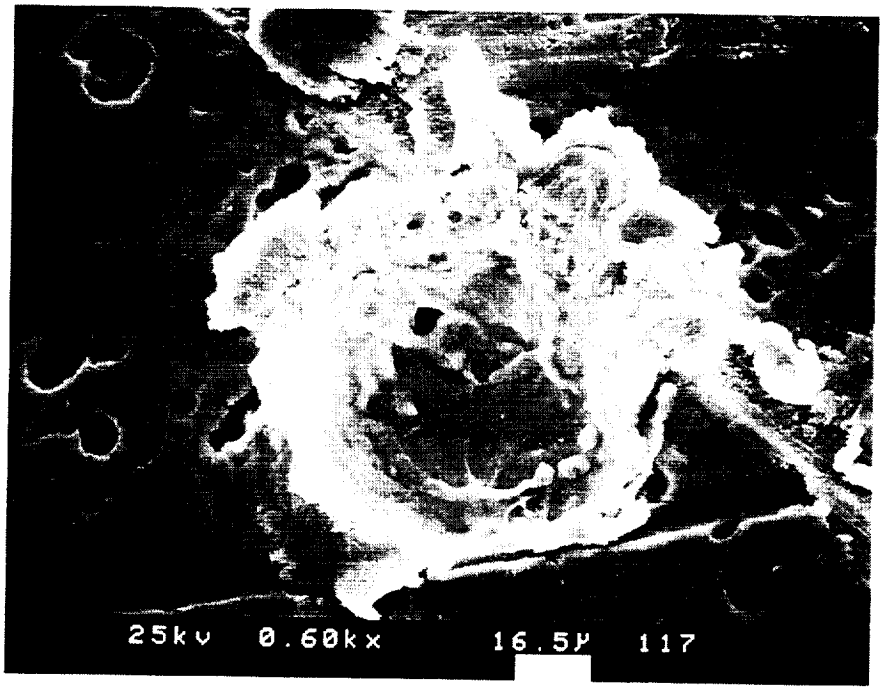
B10 - C01



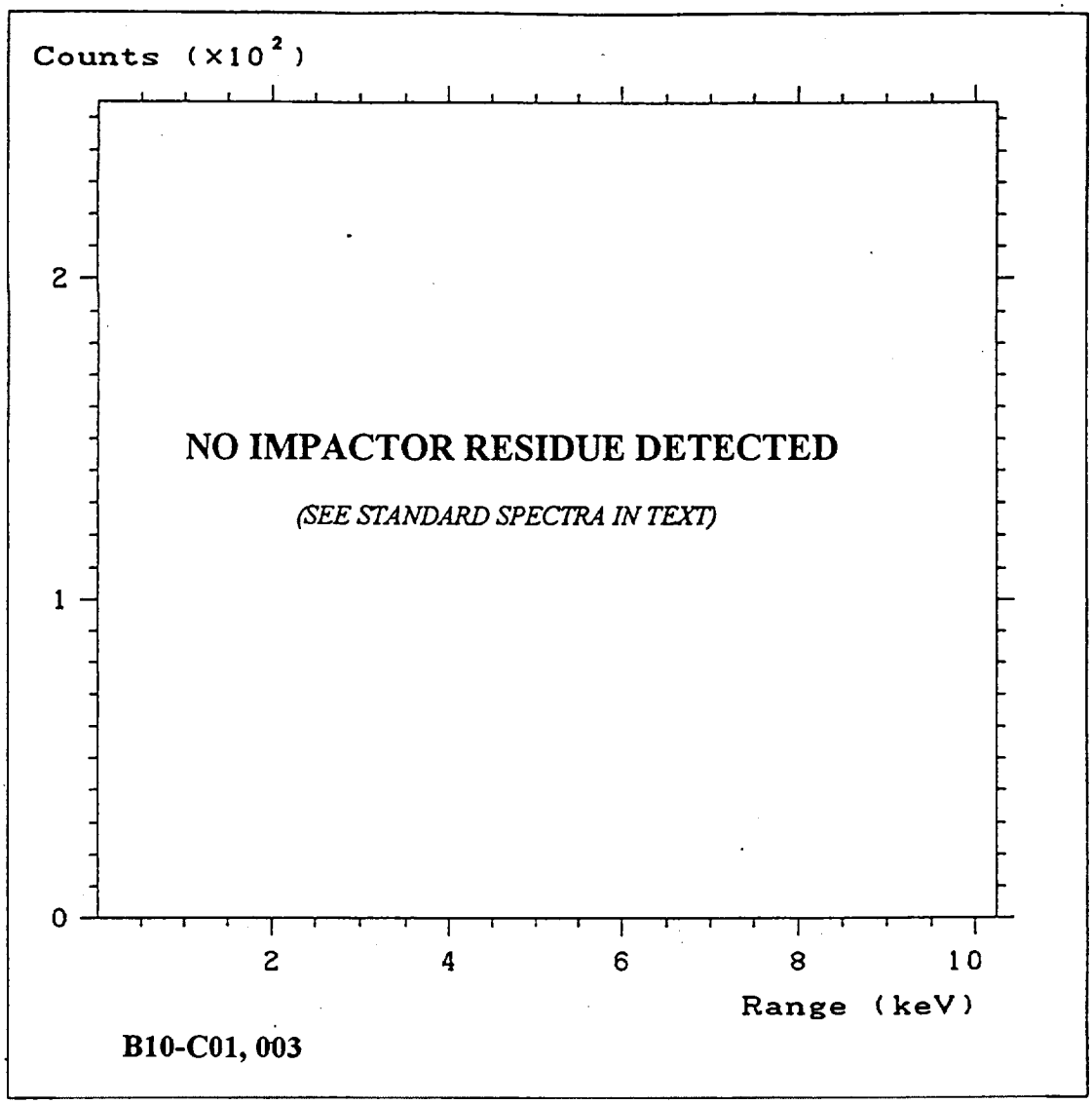


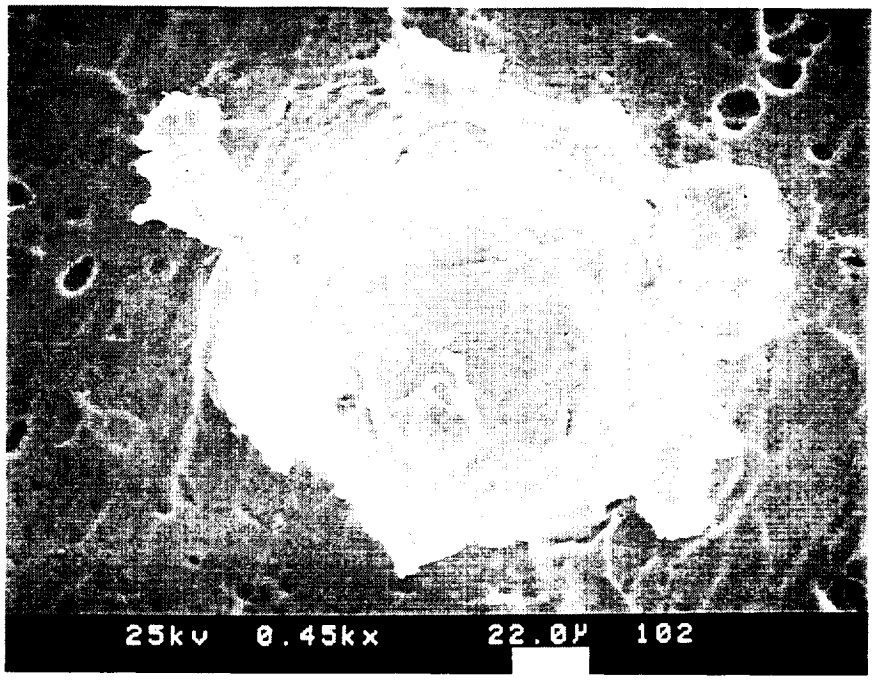
B10 - C01 C01 mm



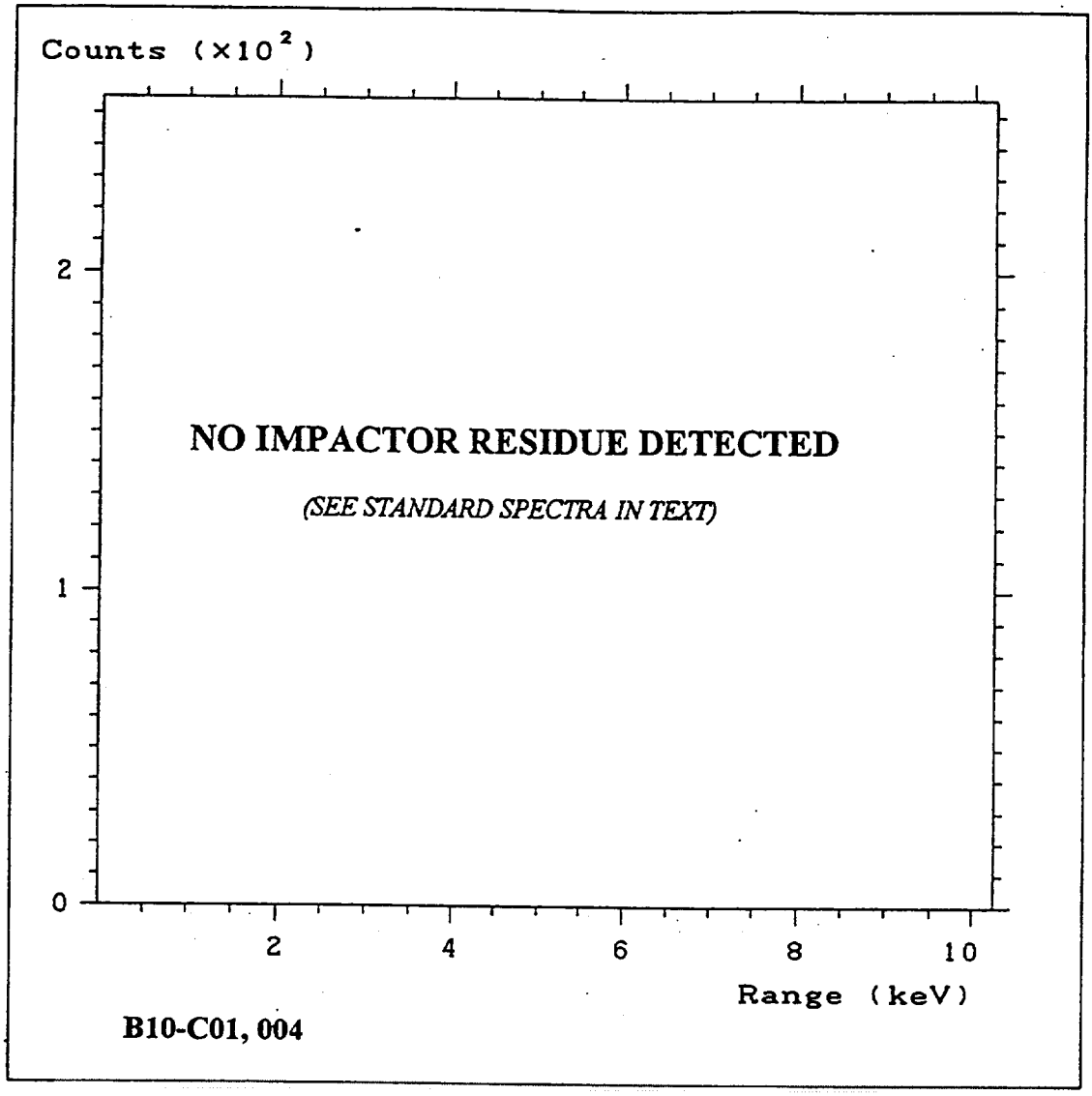


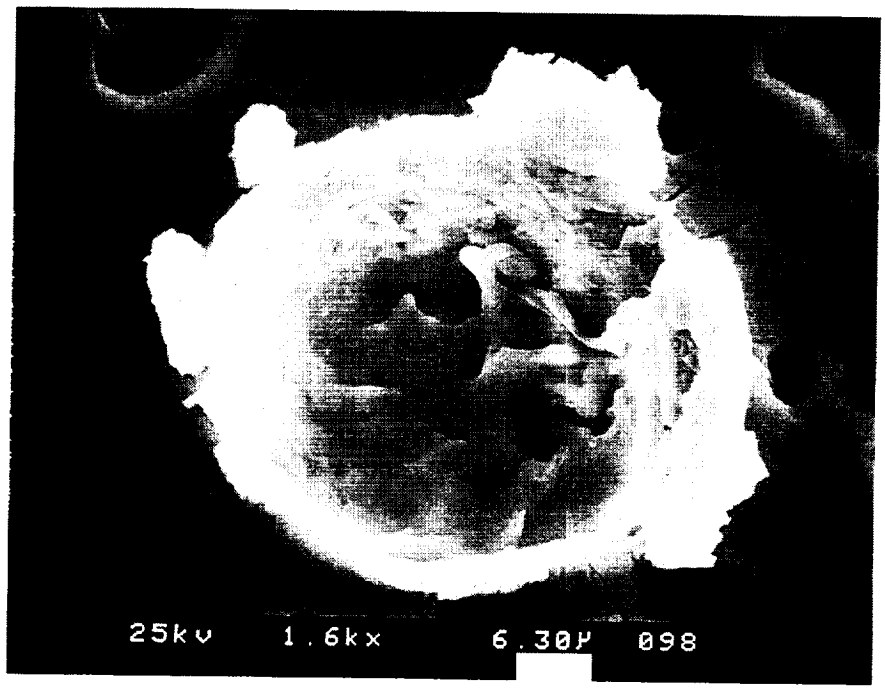
B10-C01 002 PAINT


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C01, 003

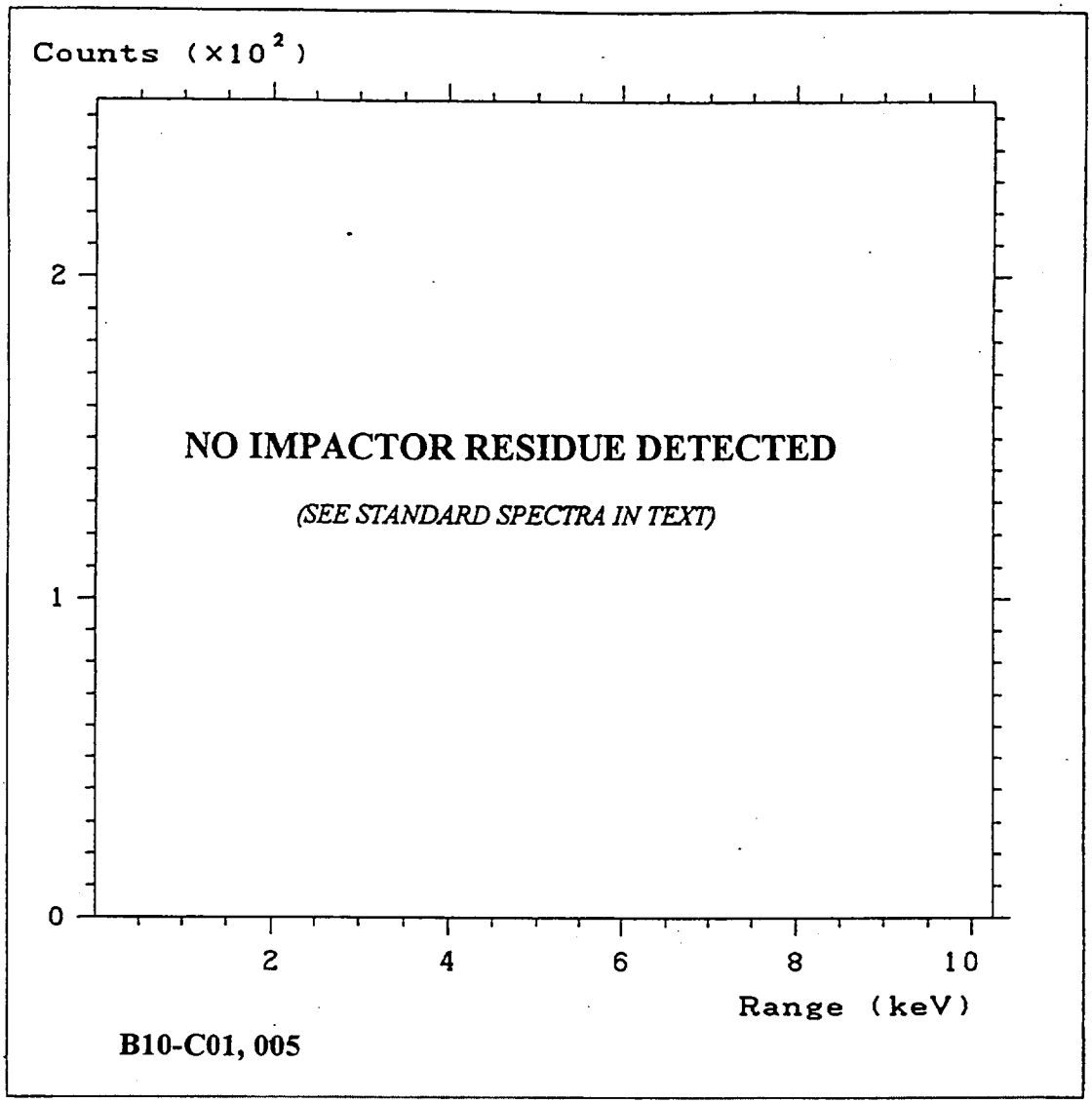

25kv 0.45kx 22.0µ 102

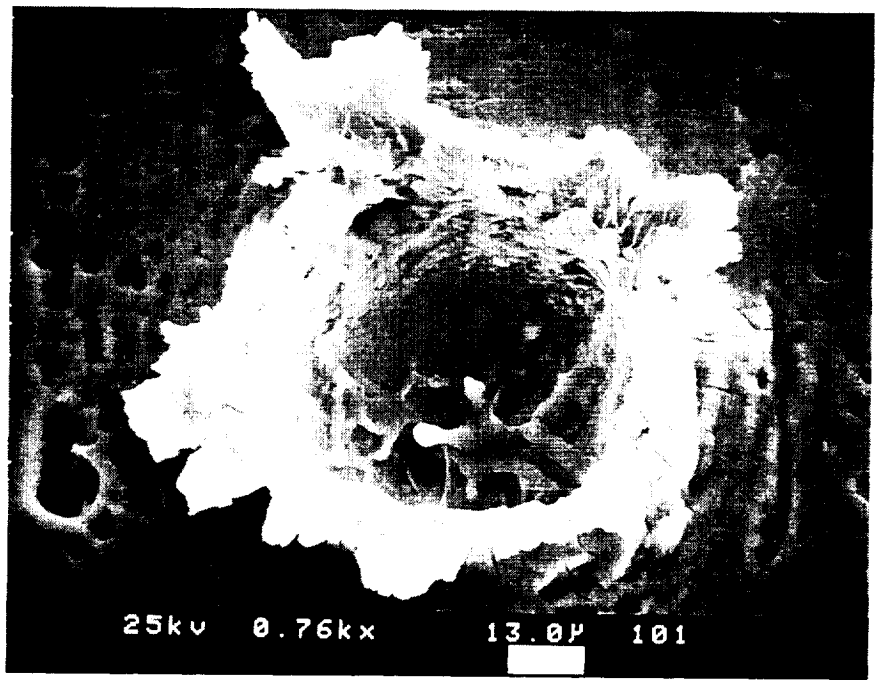
B10 - C01 003



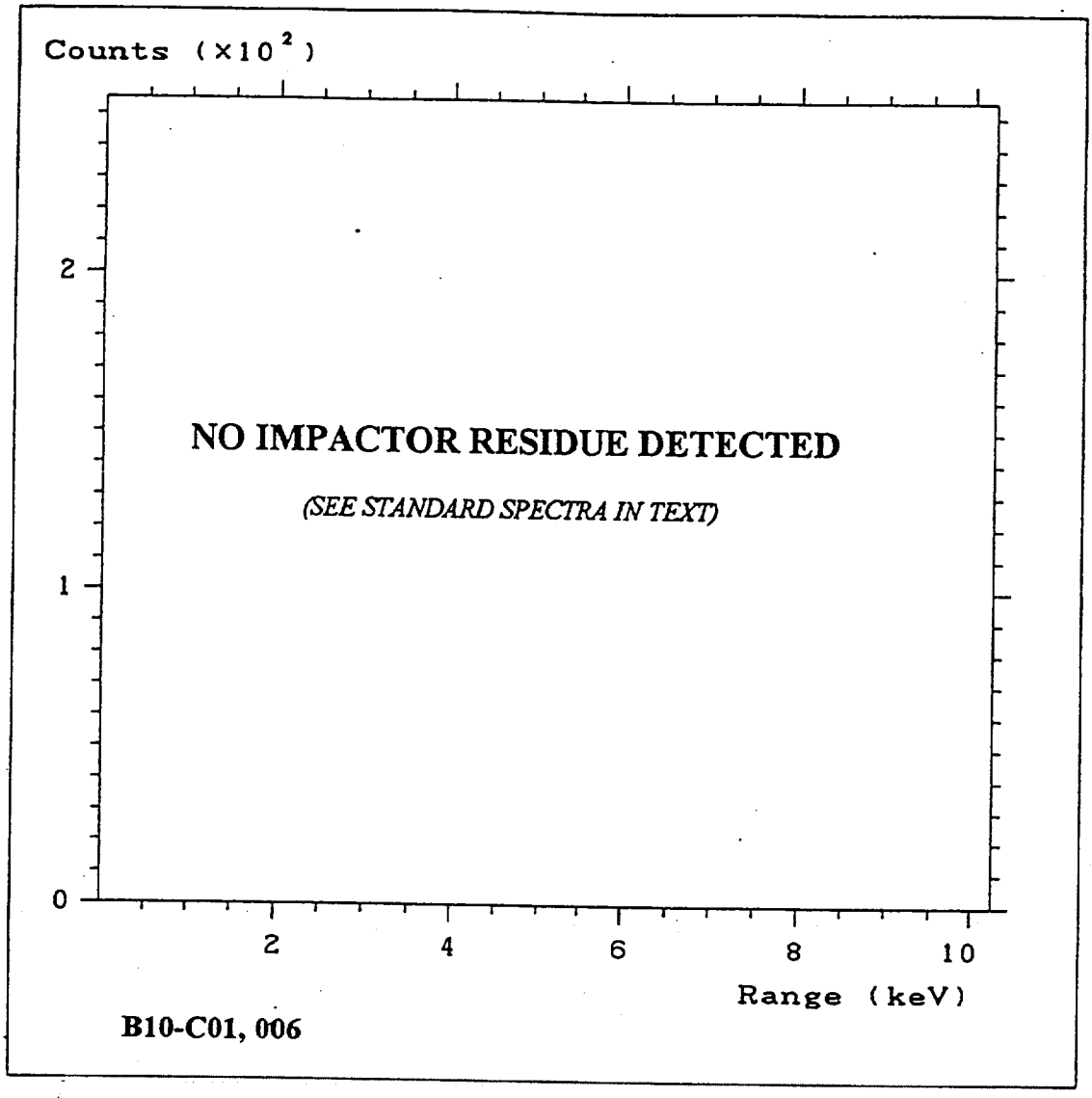


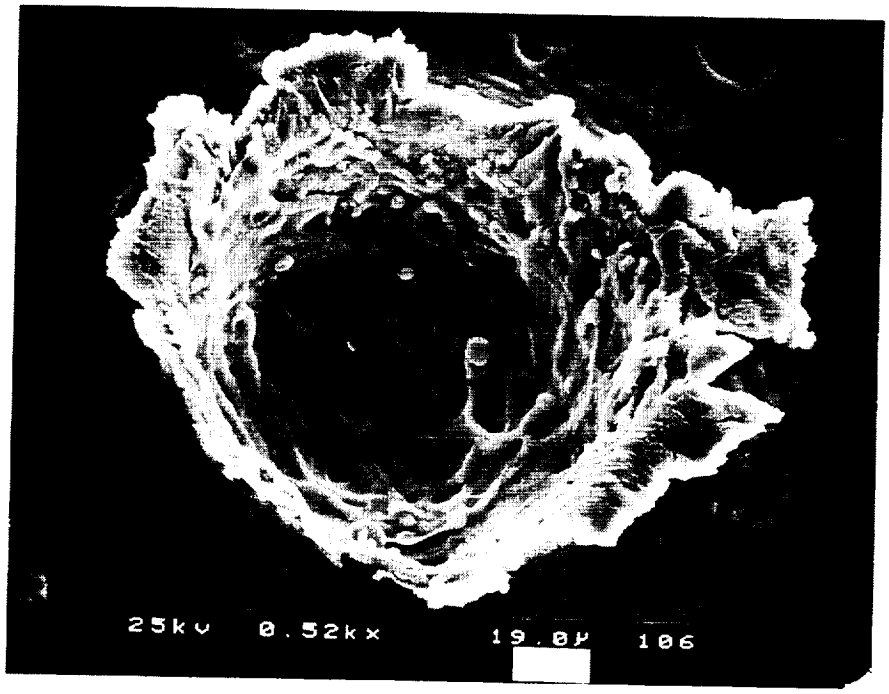
B10-C01 ~~023~~ ~~022~~ 004


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C01, 005

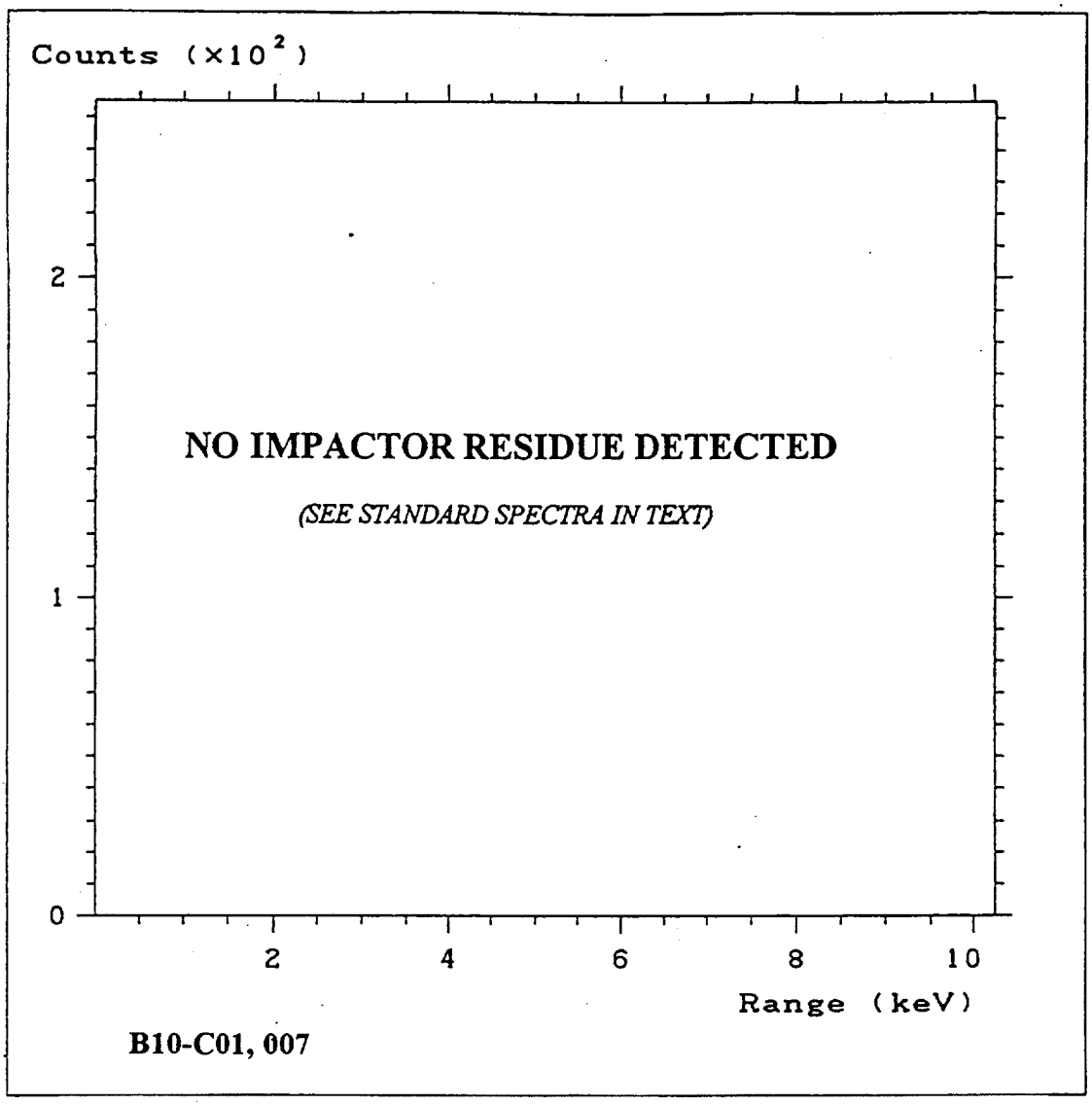

25kv 0.76kx 13.0µ 101

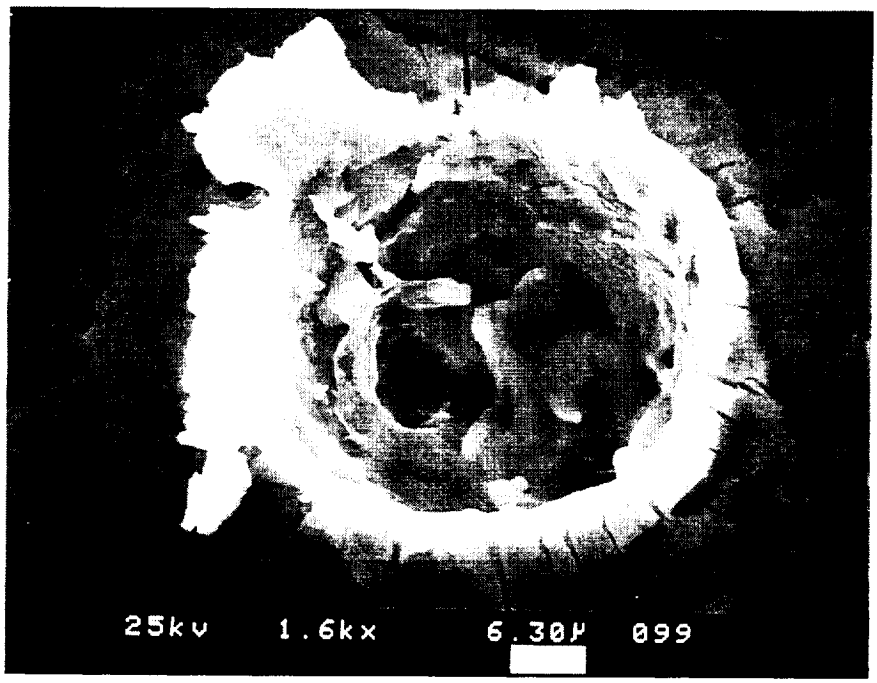
B10- C01 005


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B10-C01, 006

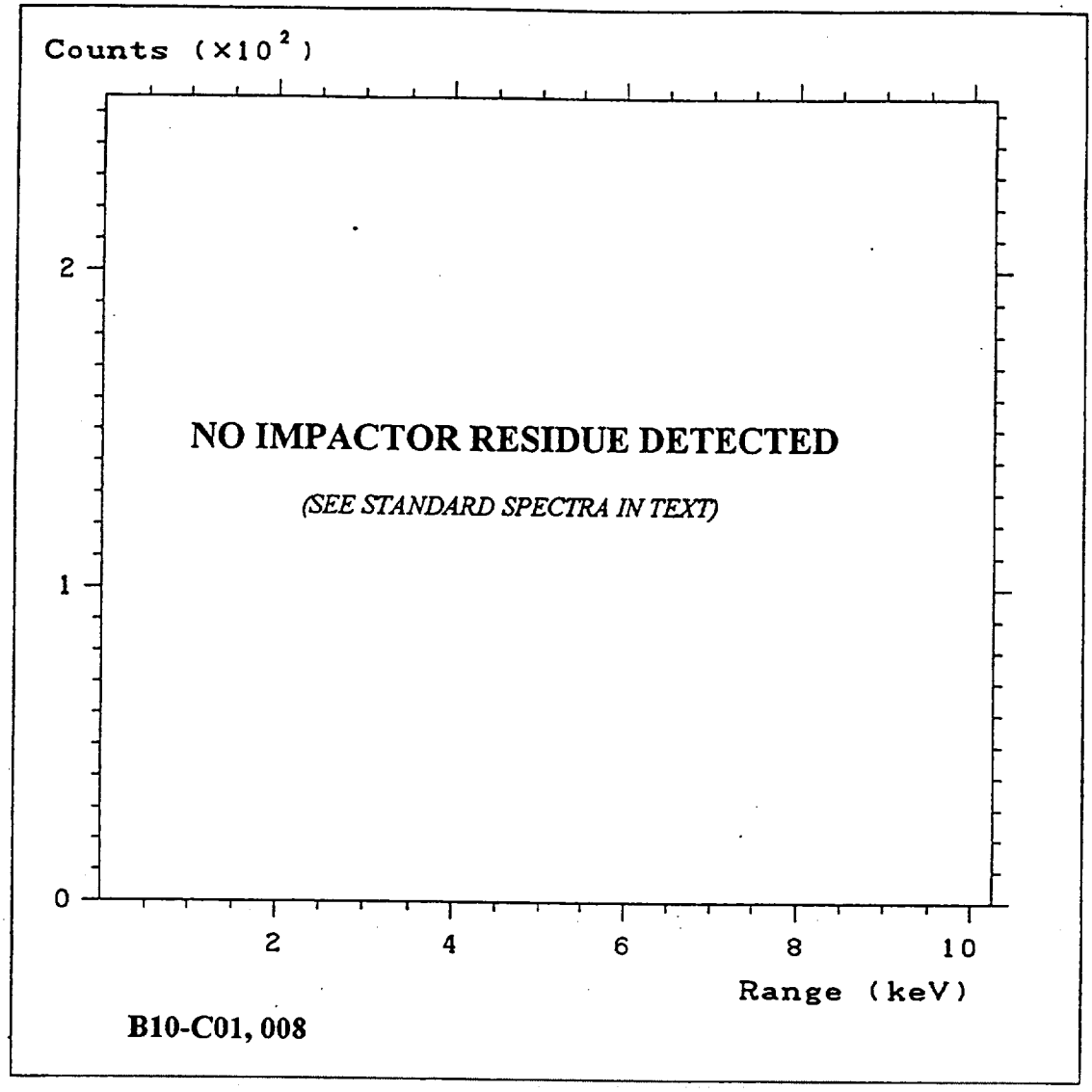

25kv 0.52kx 19.0µ 106

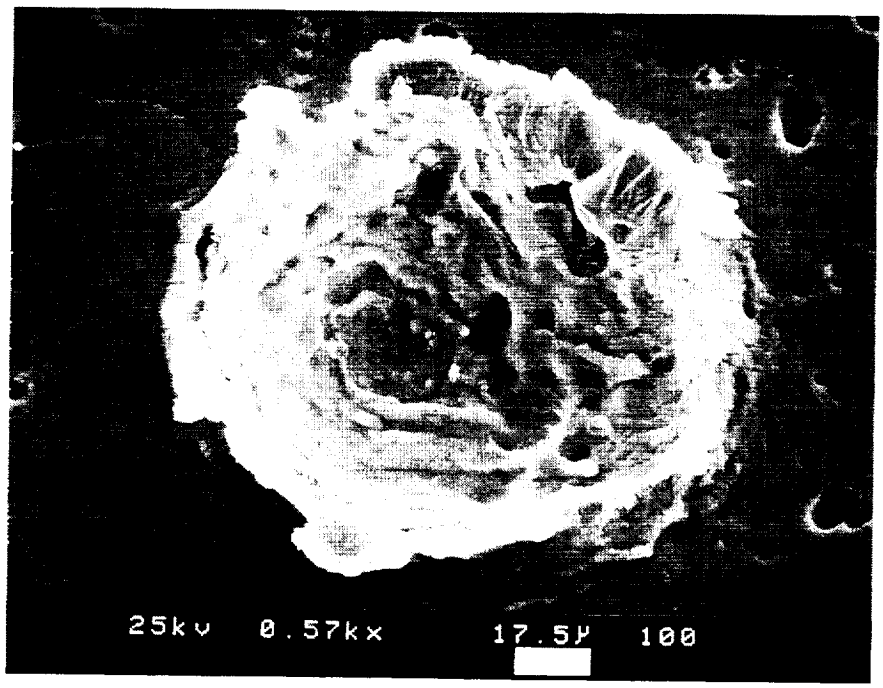
B10 - C01 006


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C01, 007

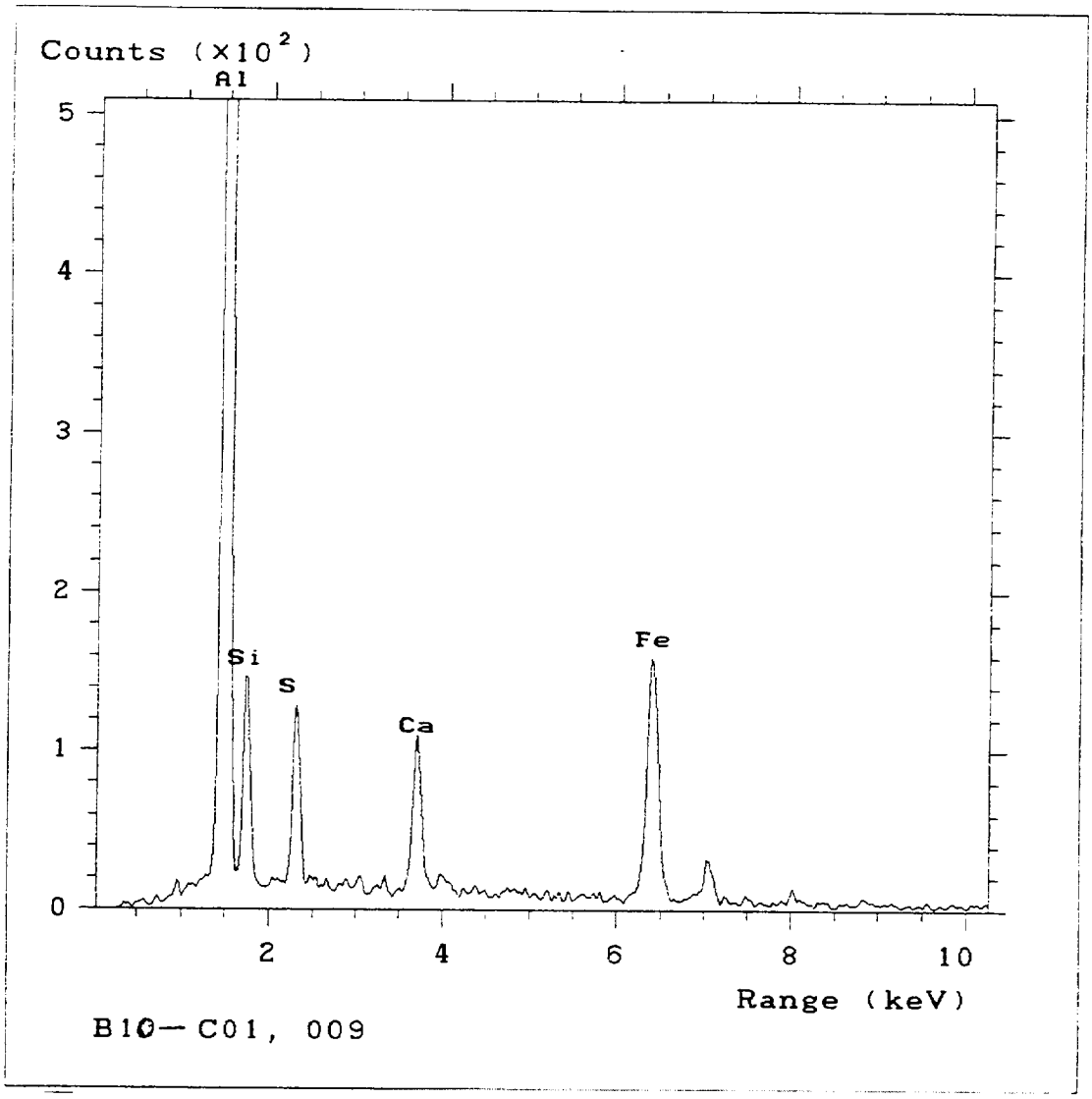

25kv 1.6kx 6.30µ 099

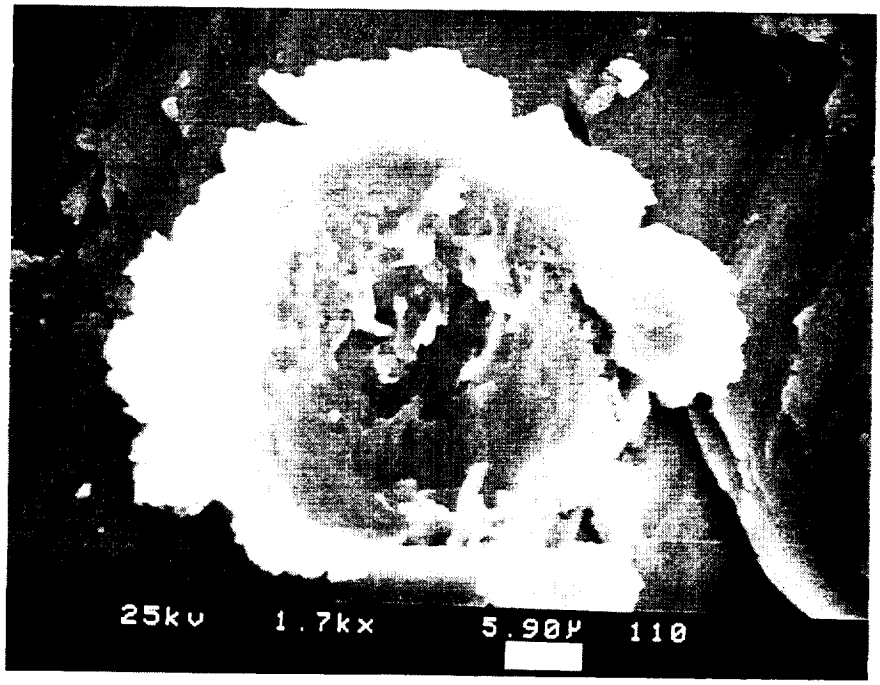
B10- C01 007


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B10-C01, 008

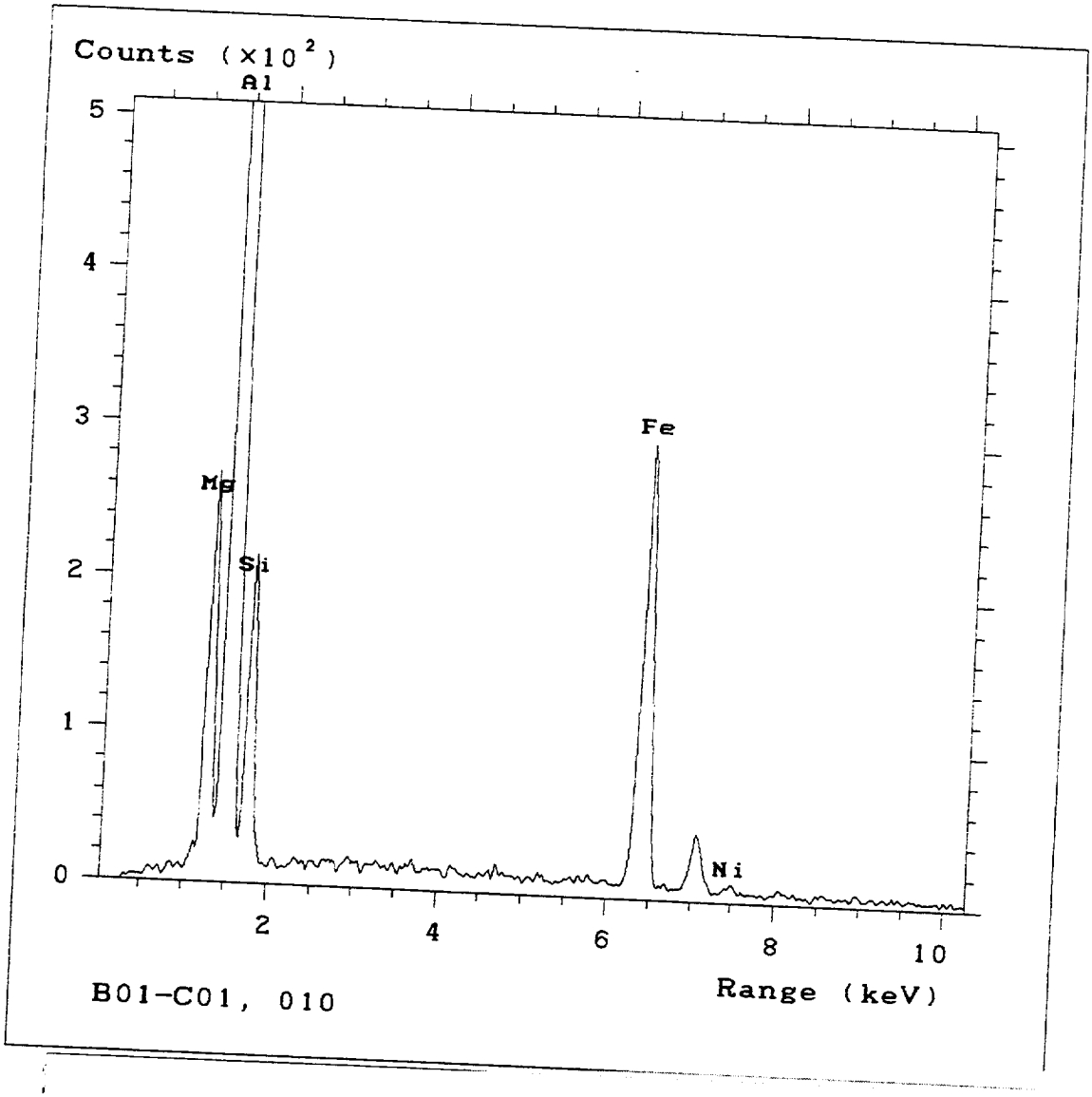

25kv 0.57kx 17.5μ 100

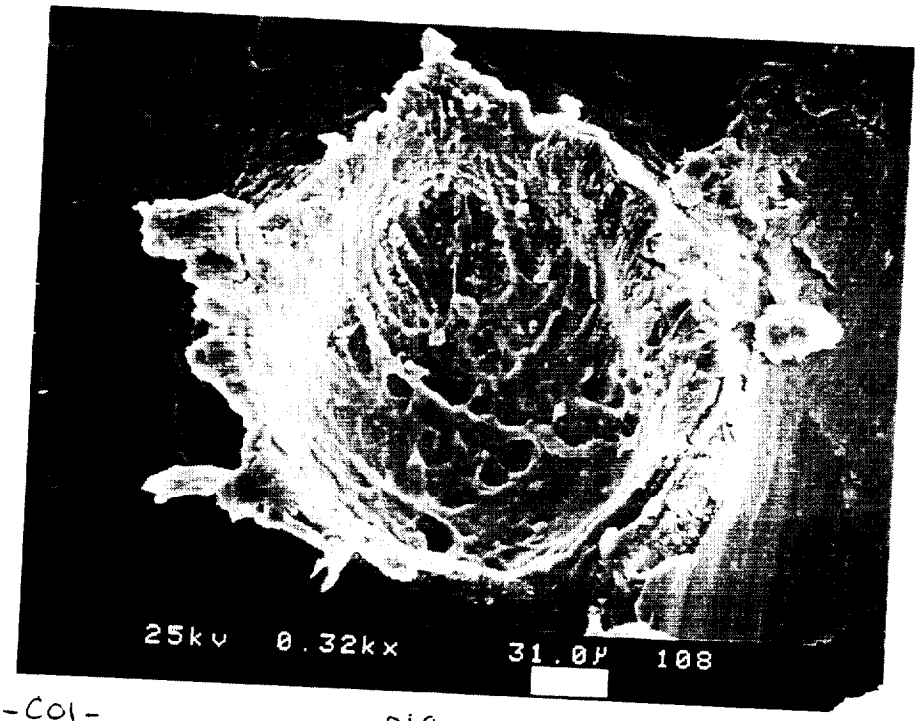
B10 - C01 008





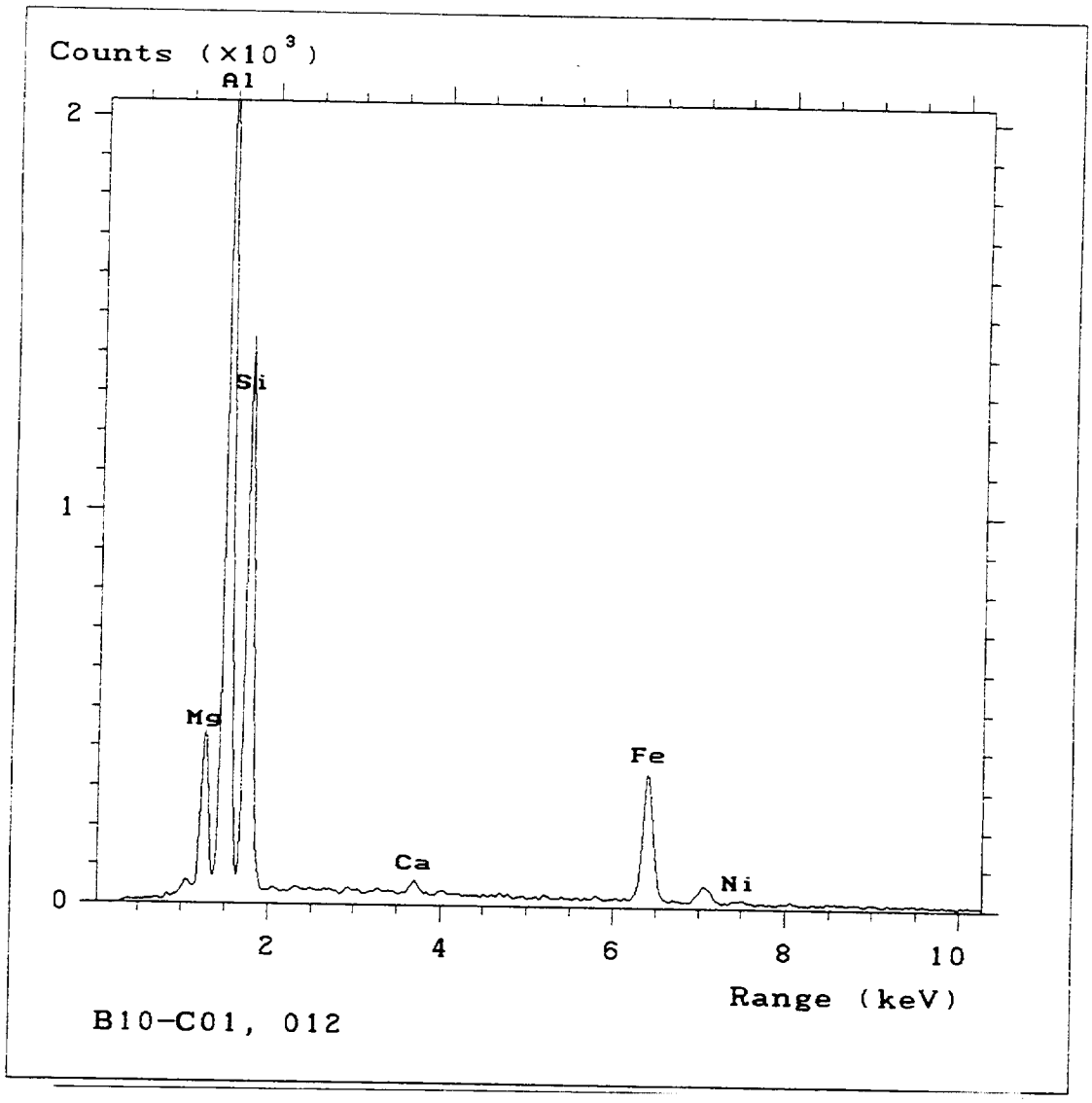
B10-C01 009 MM

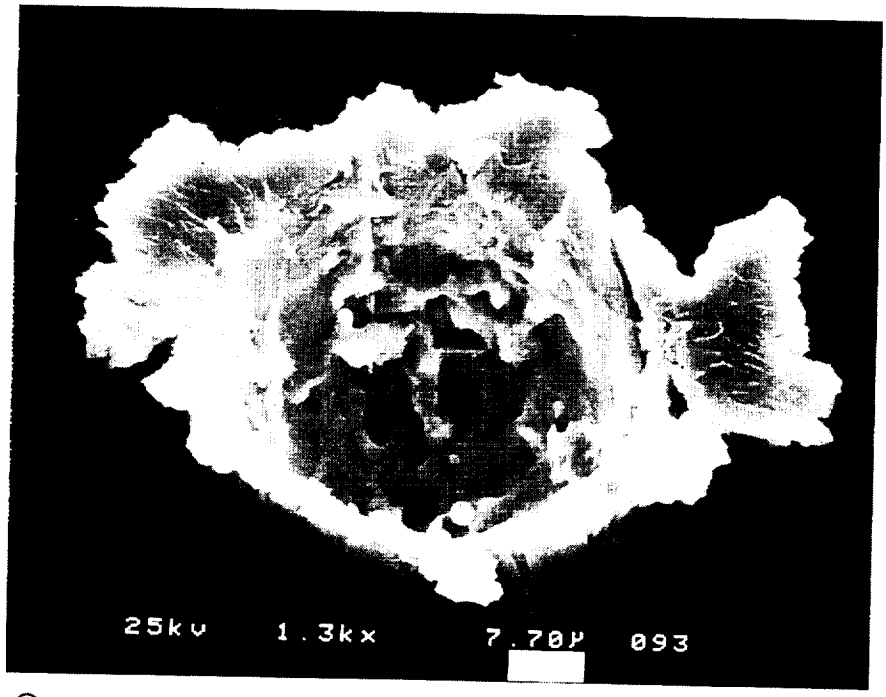




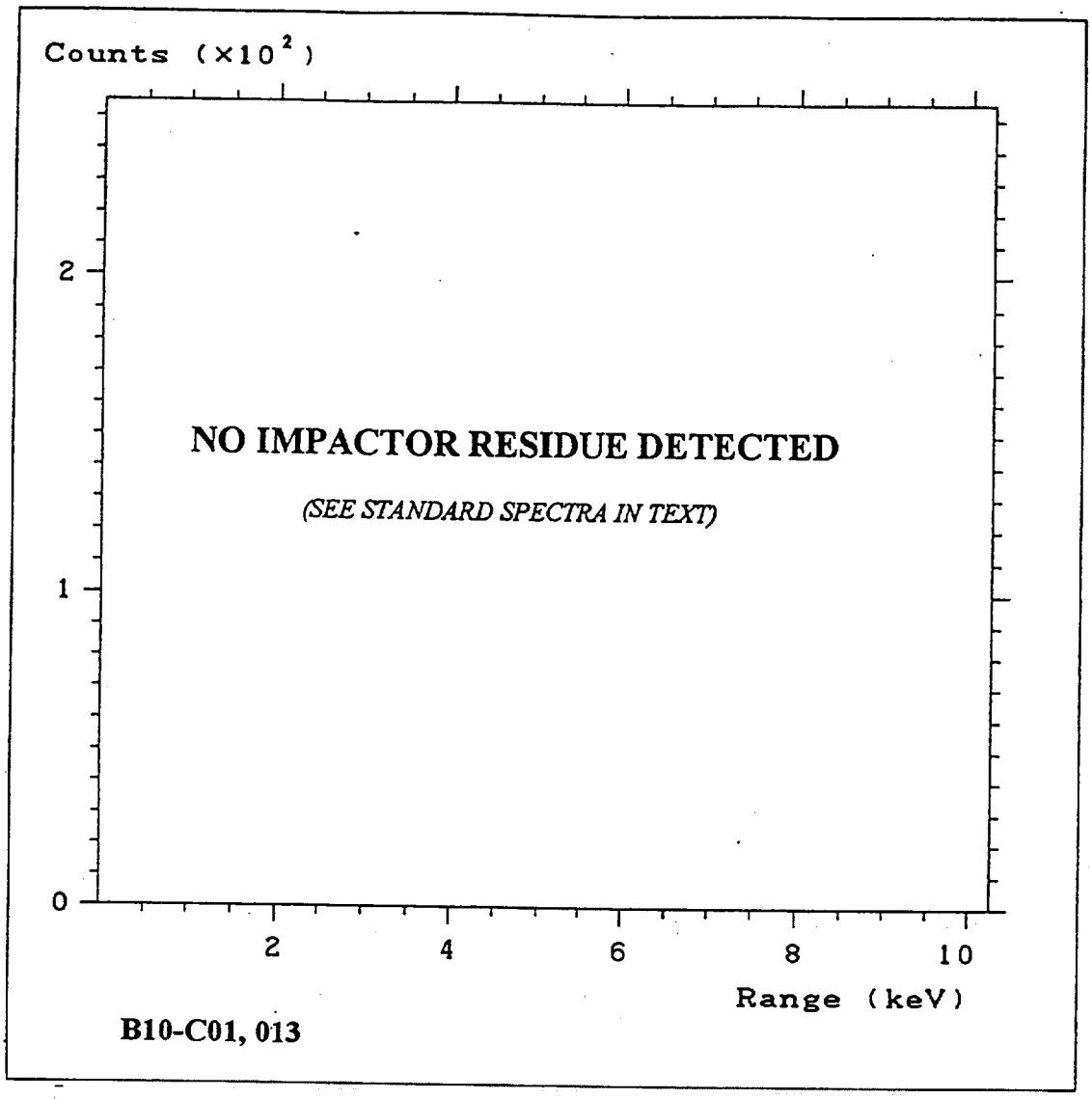
B10-C01-010

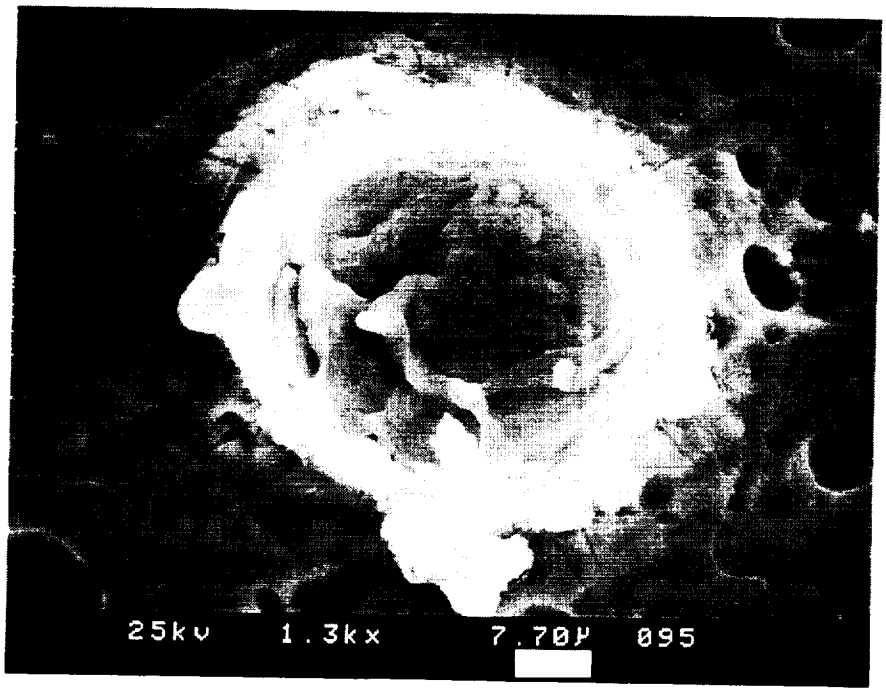
mm



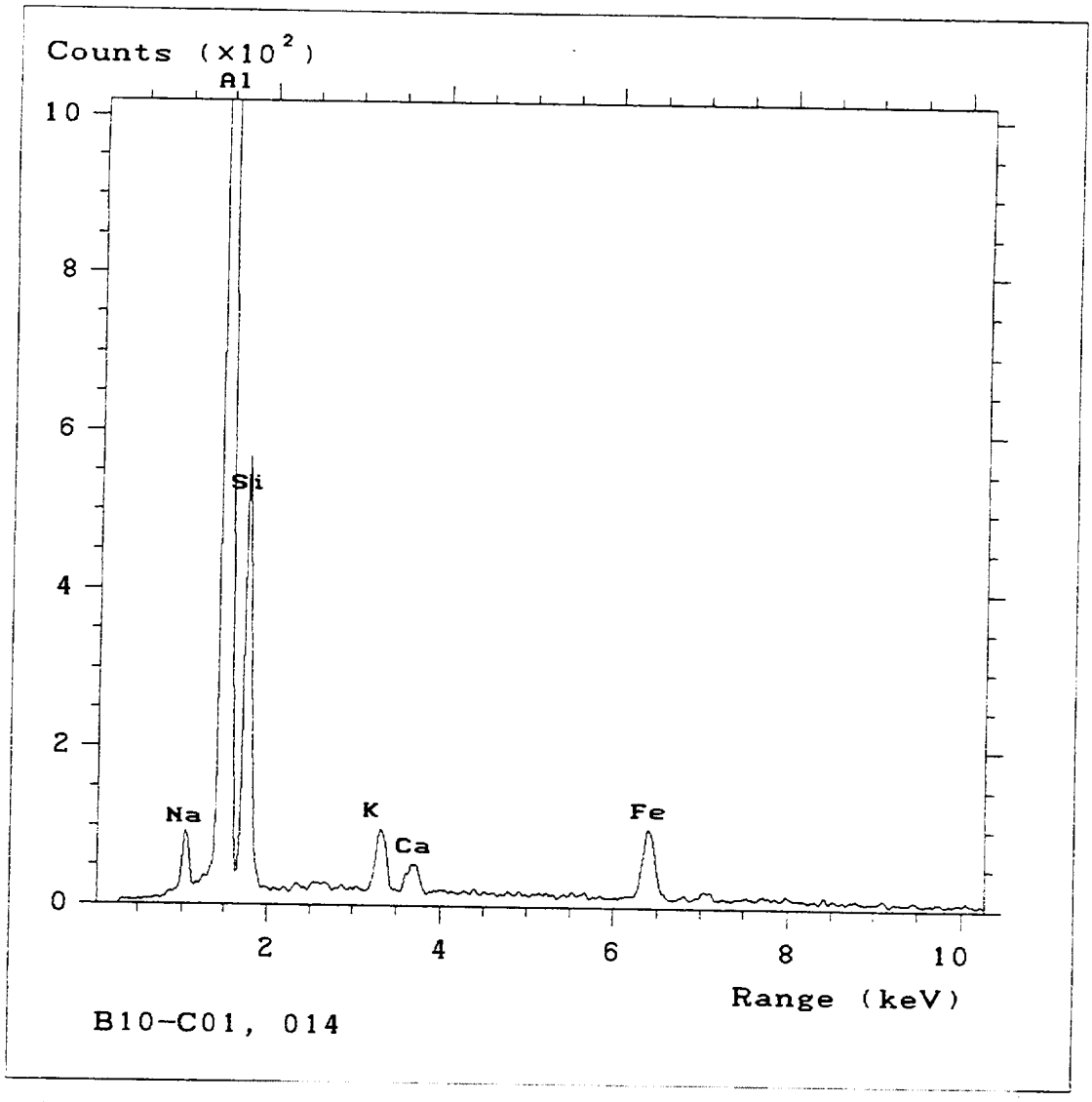


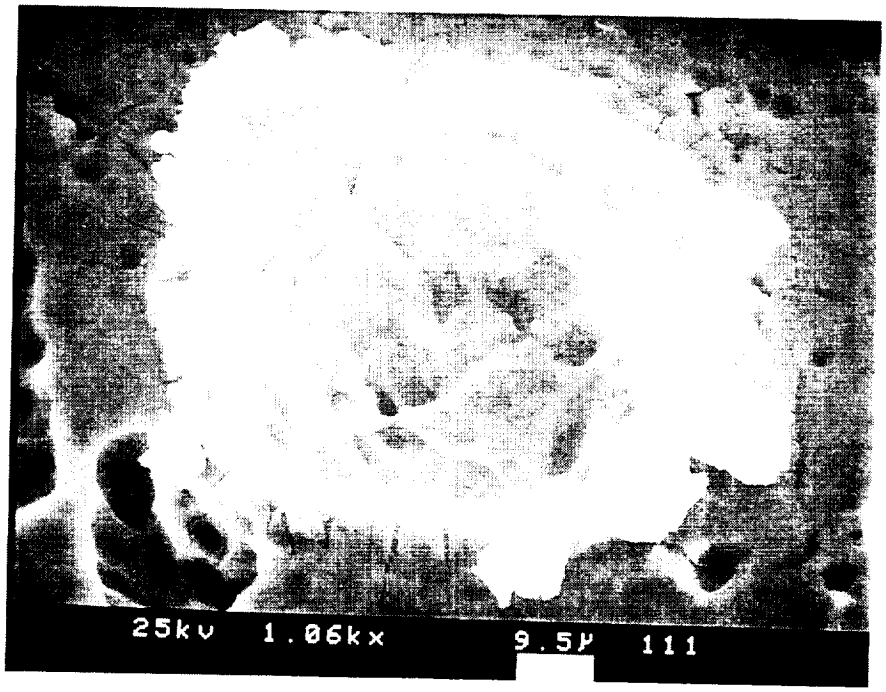
B10-C01 012 mm


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B10-C01, 013

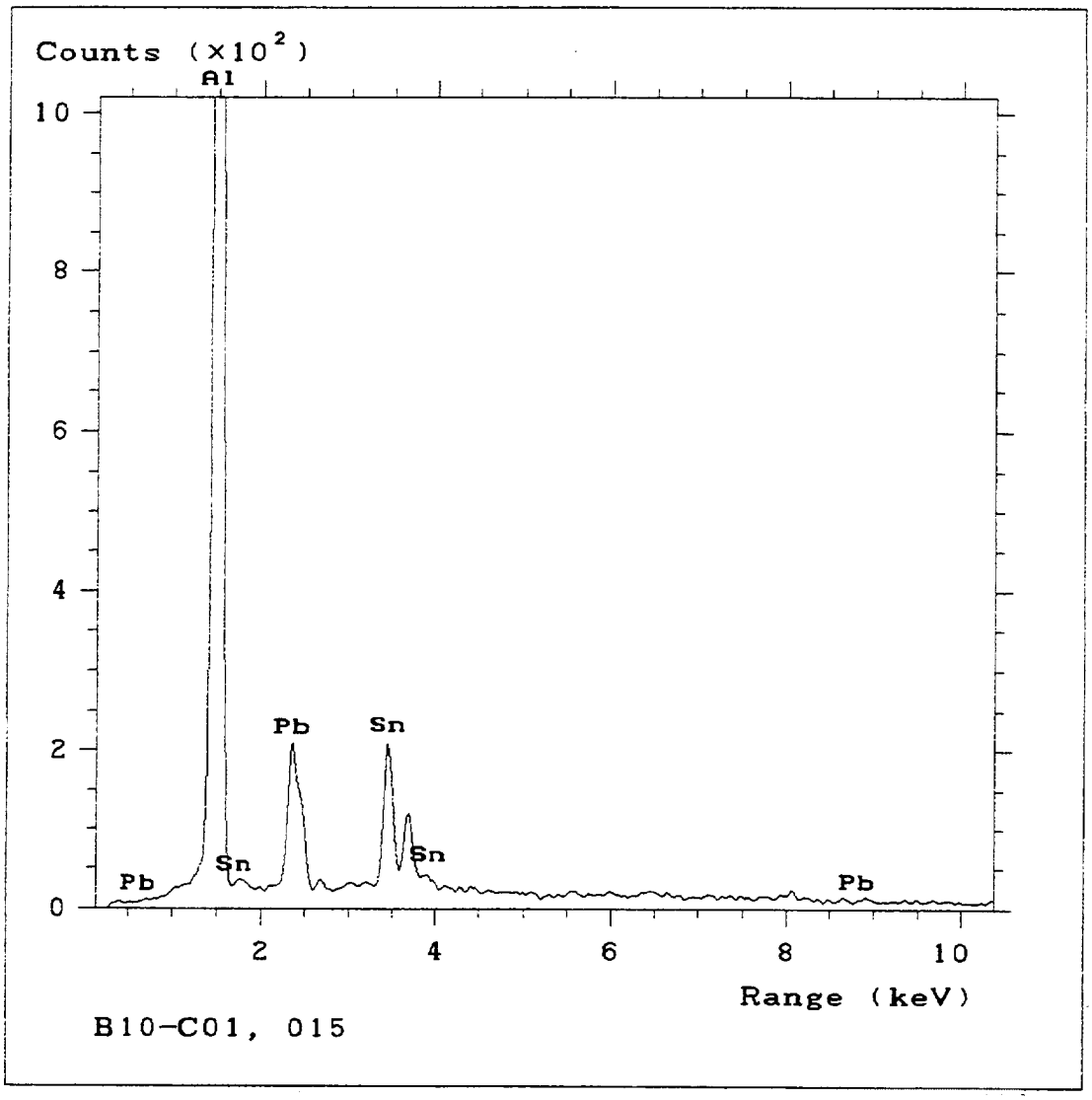

25kv 1.3kx 7.70µ 095

B10-C01 013


Counts (x10²)
Al
Si
Na
K
Ca
Fe
10
8
6
4
2
0
2
4
6
8
10
Range (keV)
B10-C01, 014

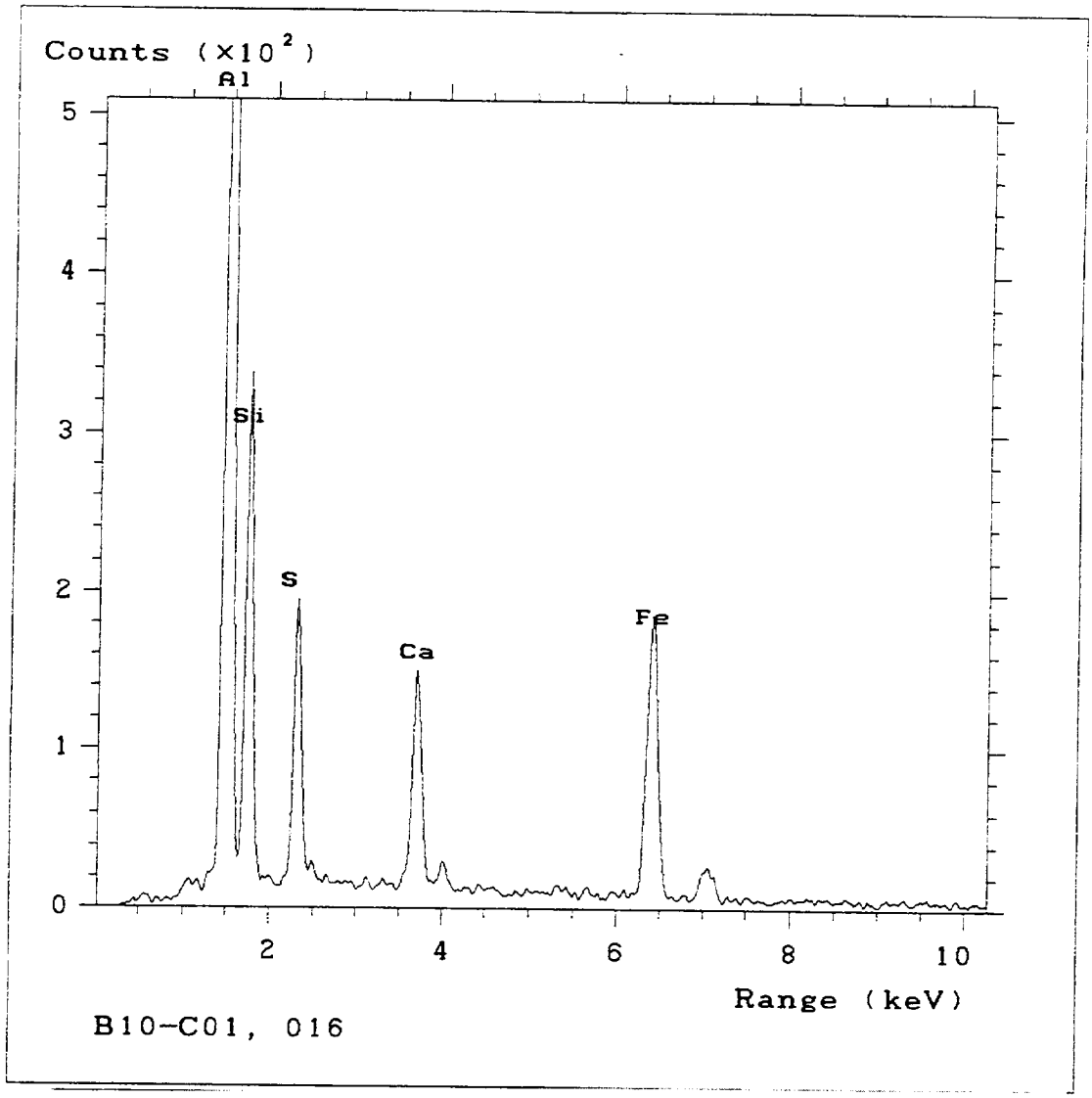

25kv 1.06kx 9.5µ 111

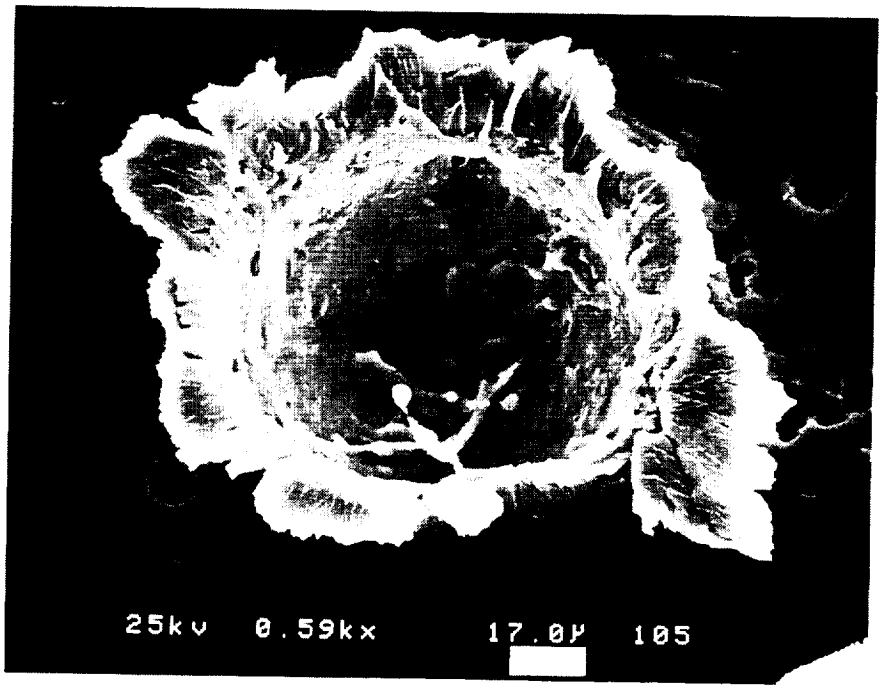
B10-C01 014


Counts (x10²)
Al
10
8
6
4
2
0
Pb
Sn
Pb
Sn
Sn
Pb
2
4
6
8
10
Range (keV)
B10-C01, 015

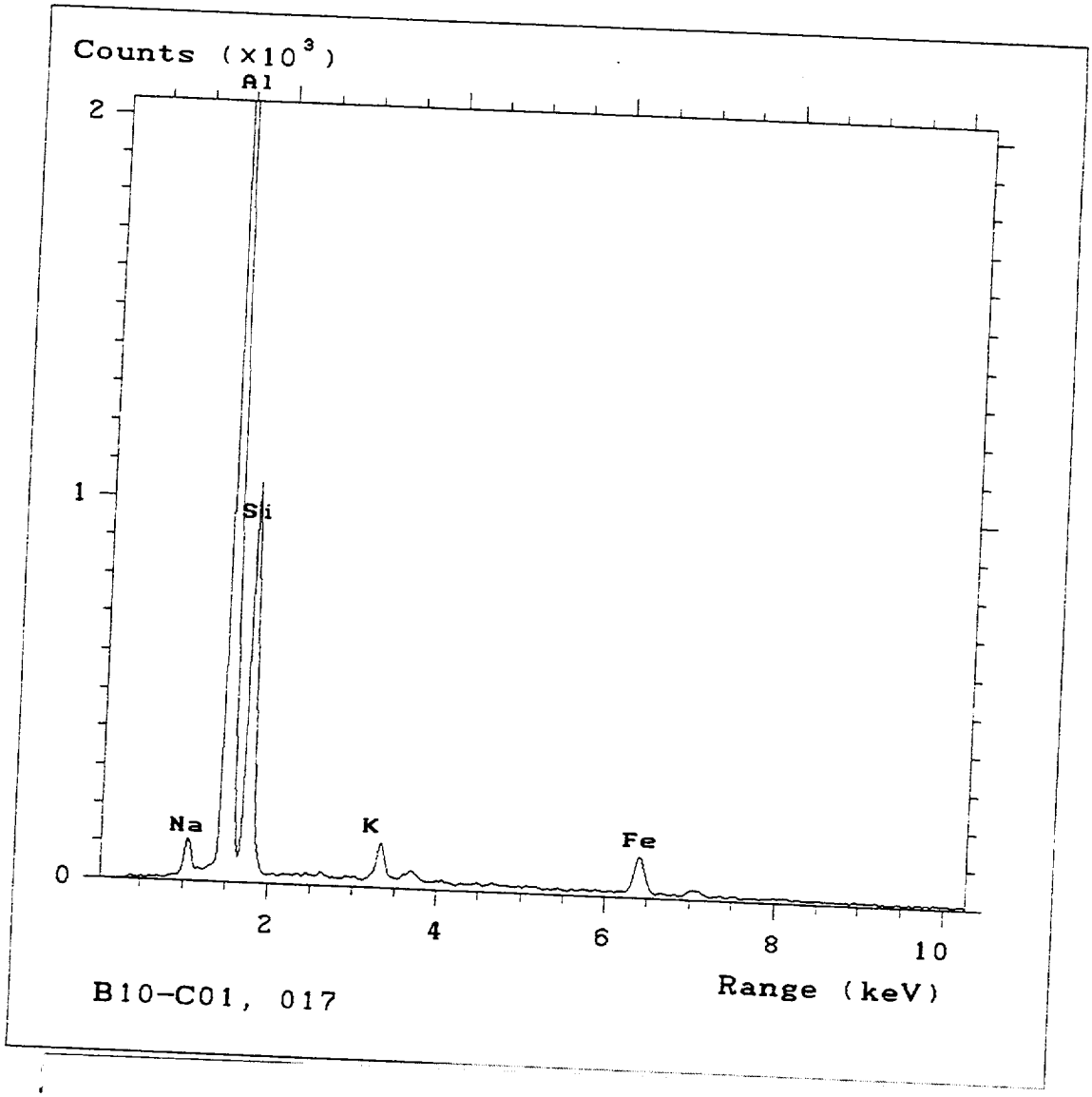
25kv 1.8kx 5.60µ 112

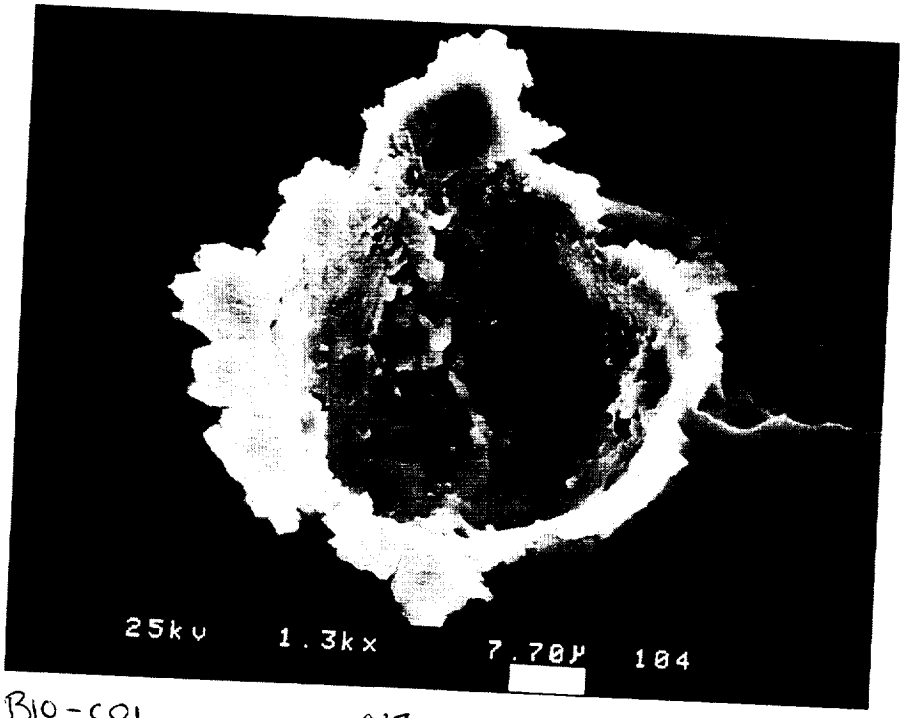
B10-C01 015



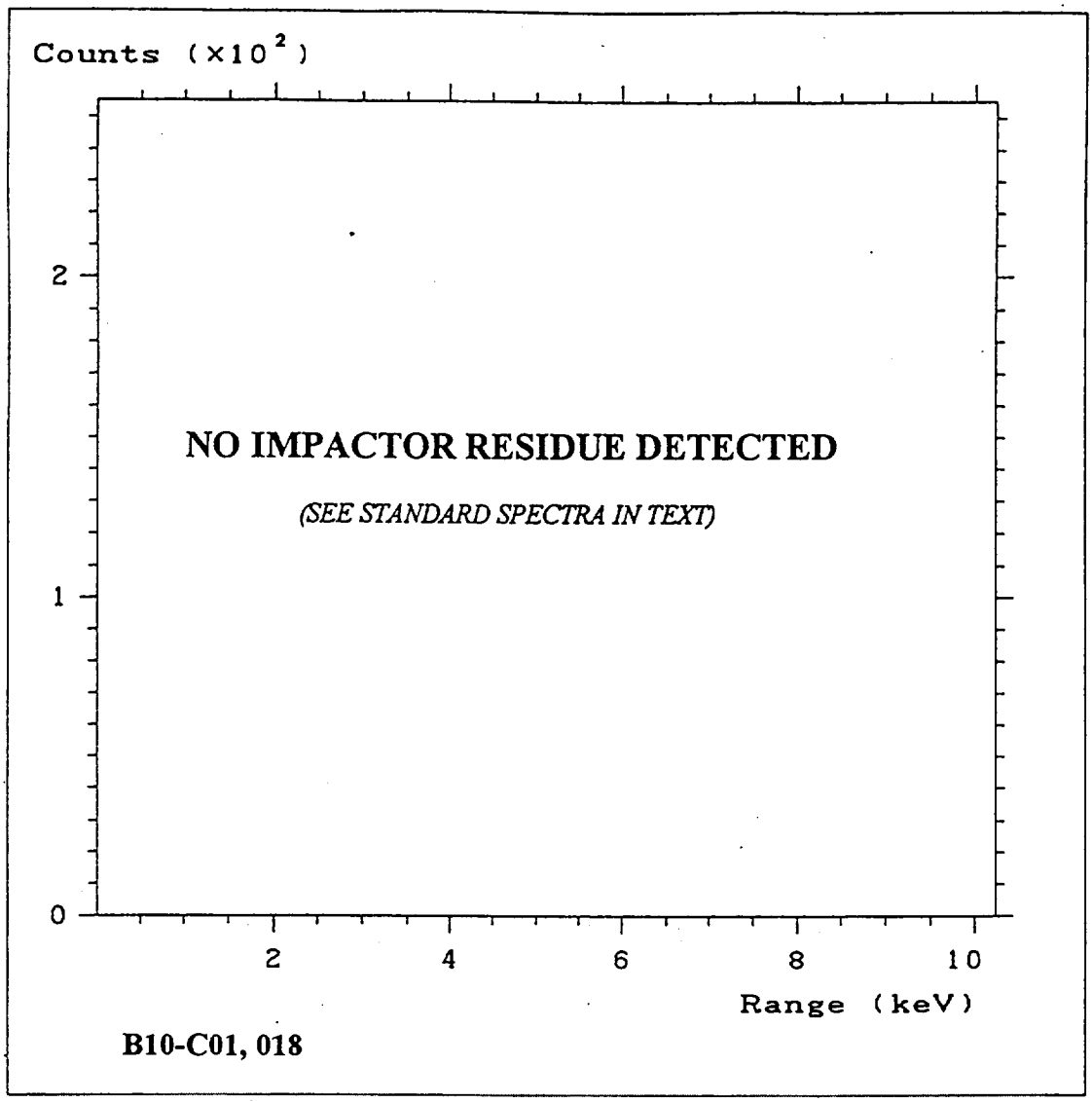


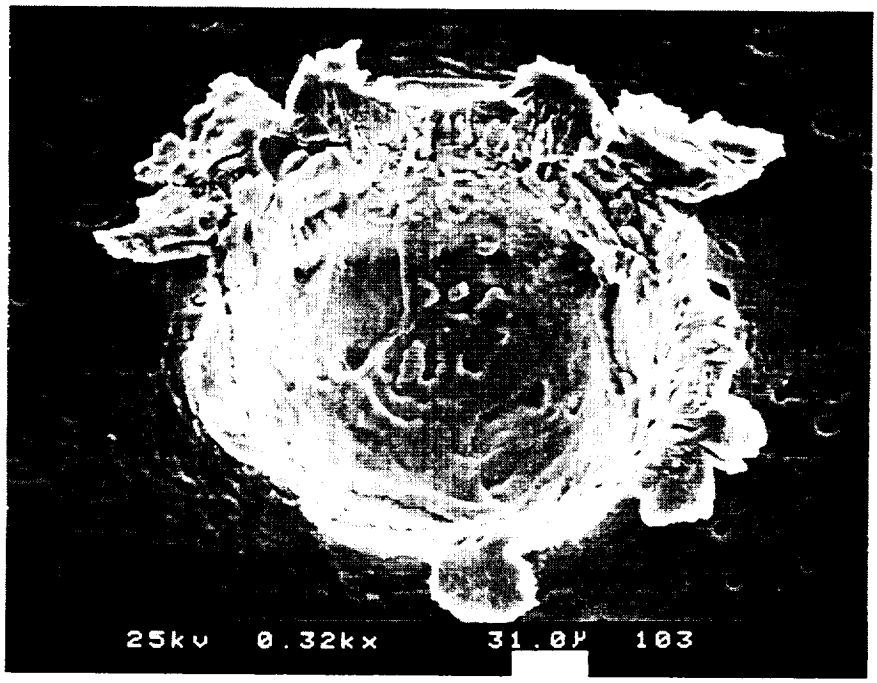
B10 - C01 016 mm



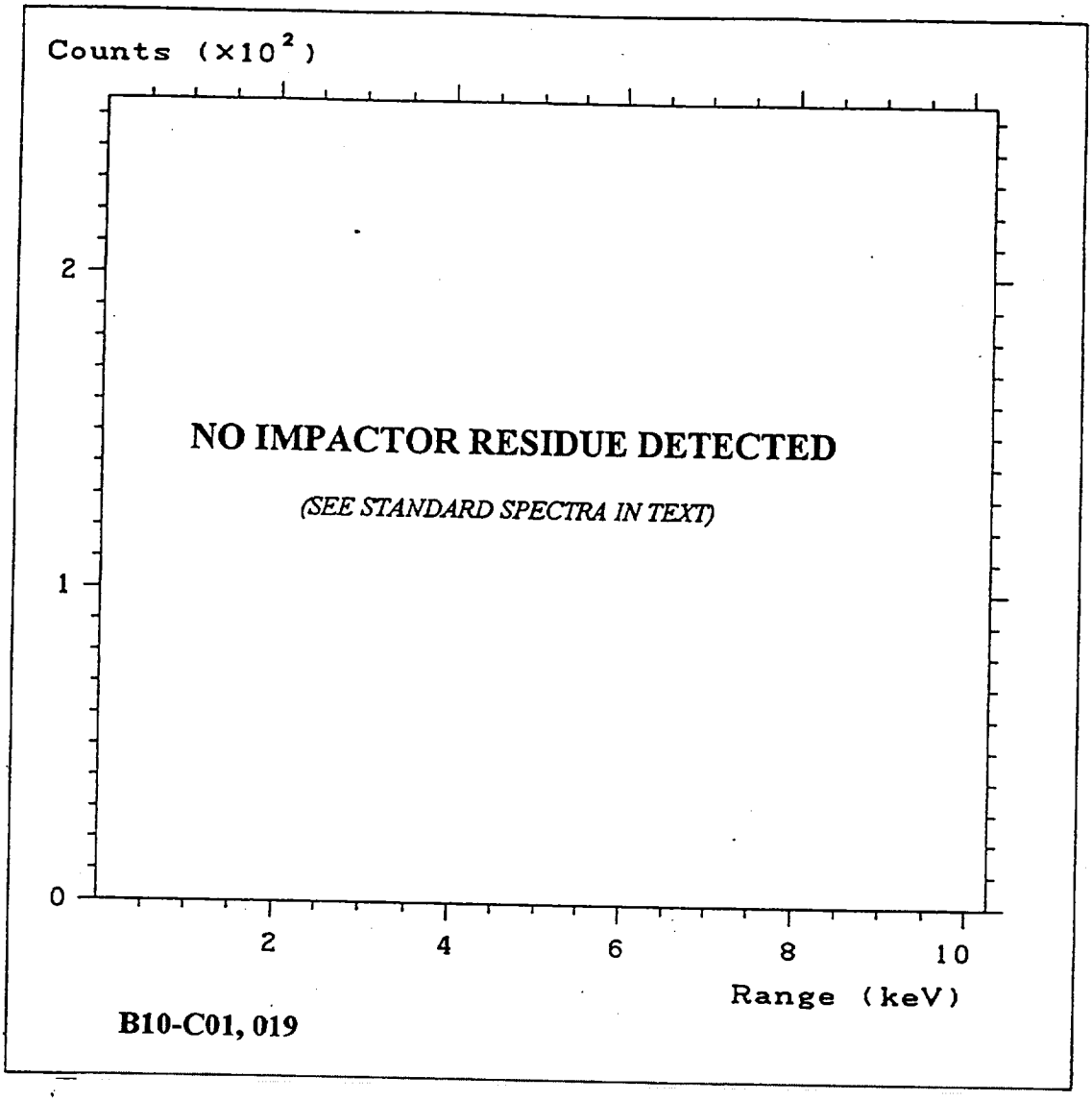


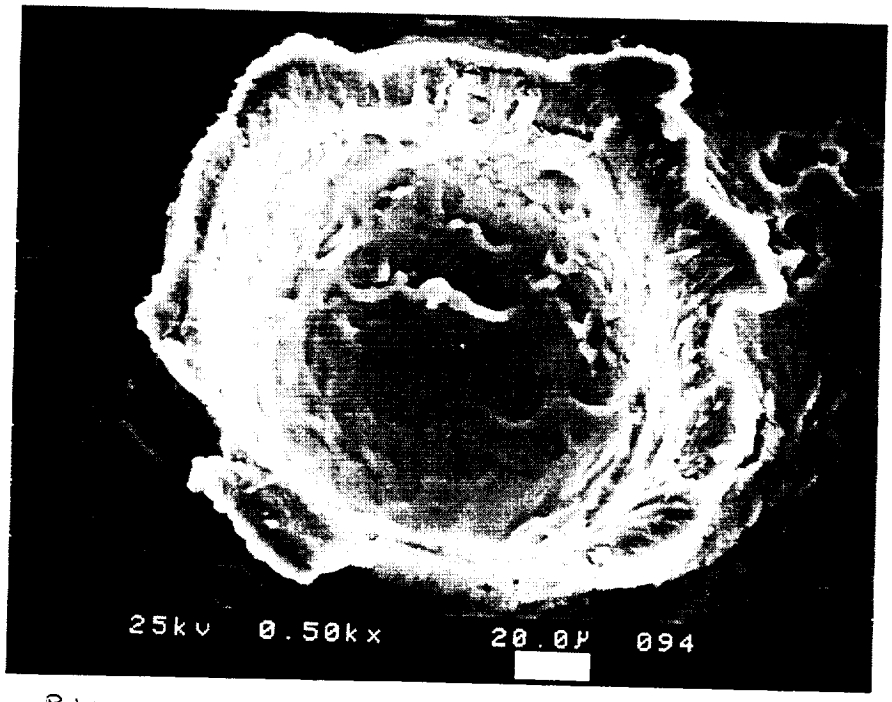
B10-C01 017 mm


Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C01, 018

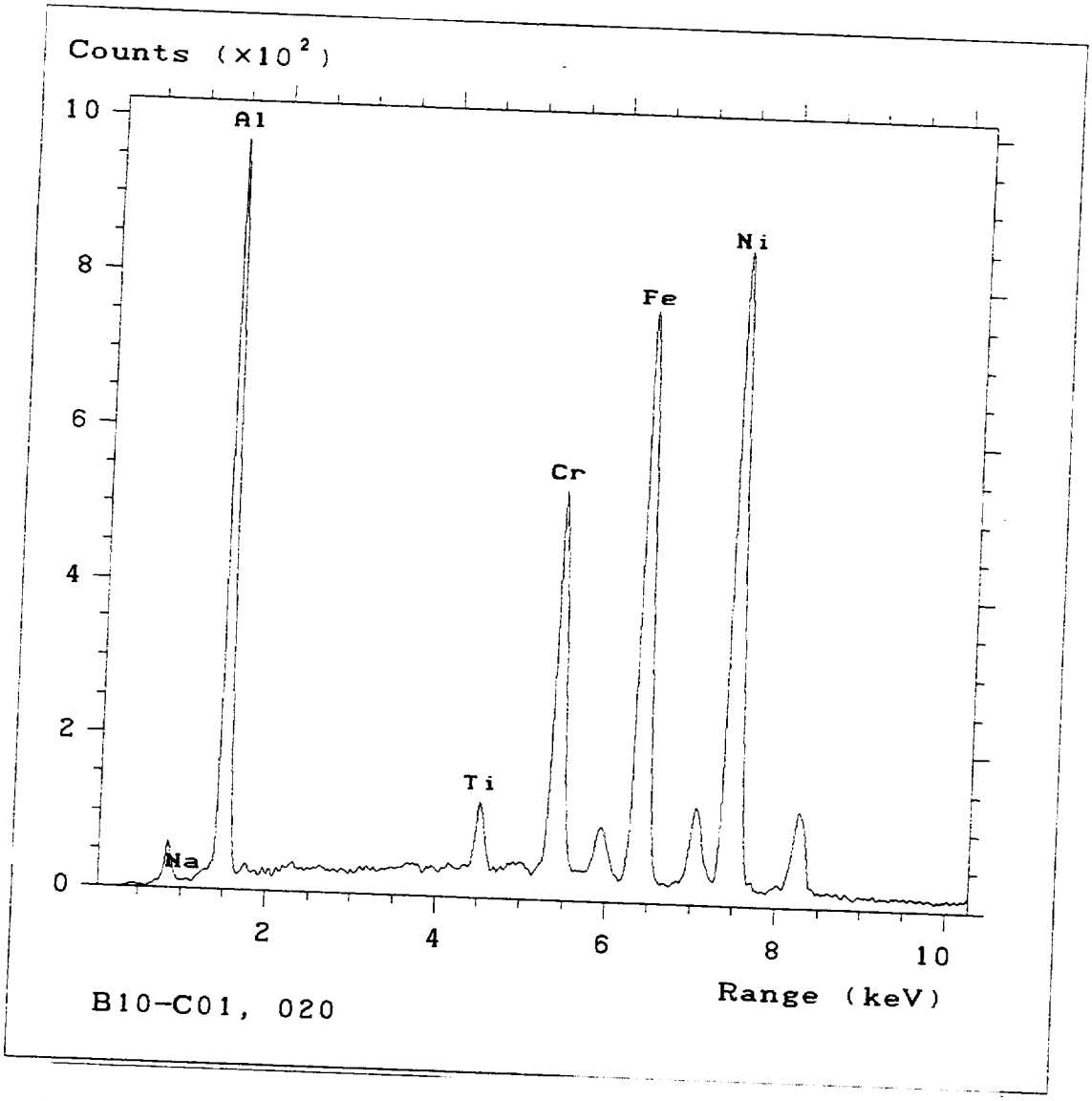

25kv 0.32kx 31.0µ 103

B10-CC1 018

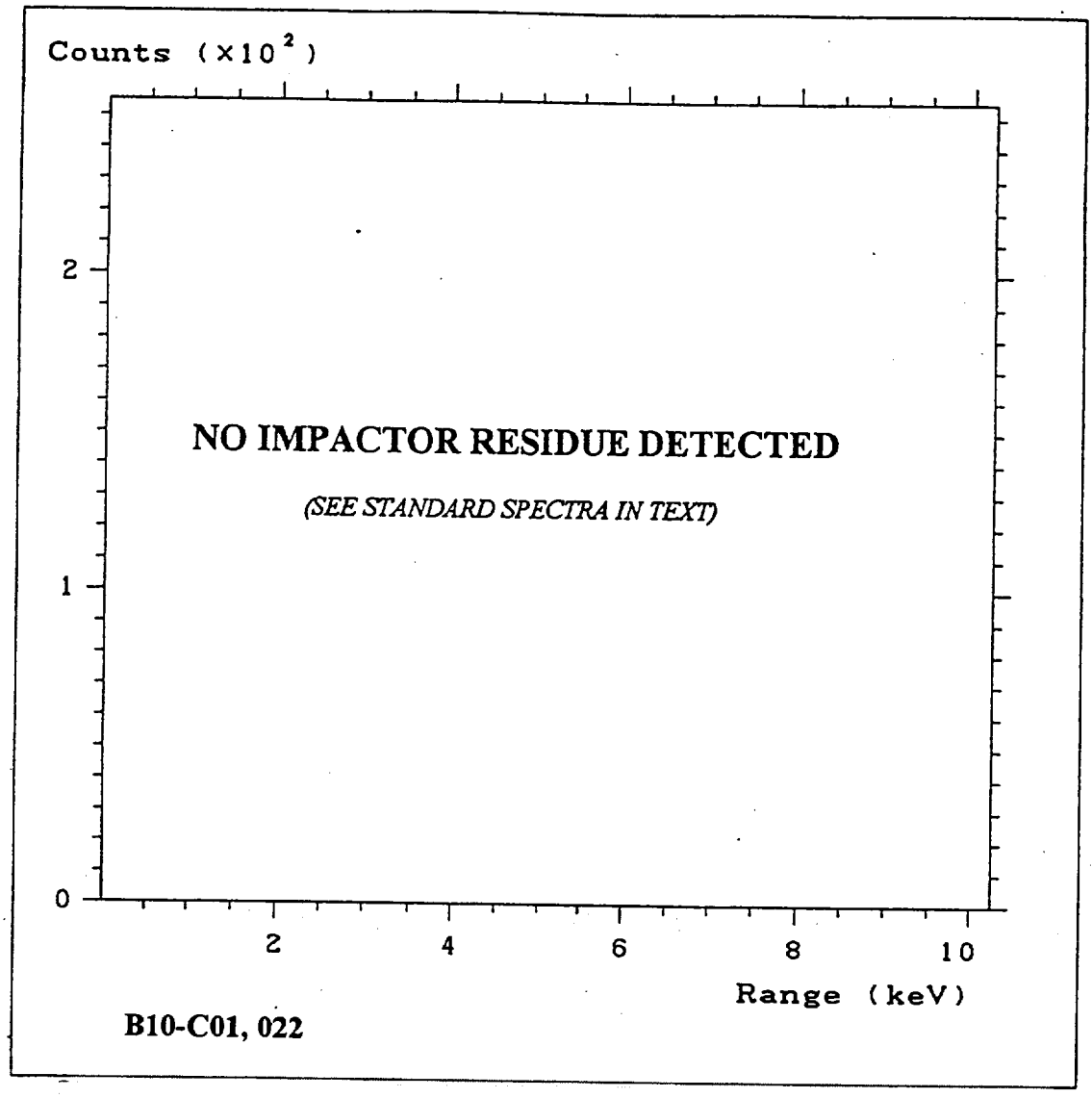

Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C01, 019

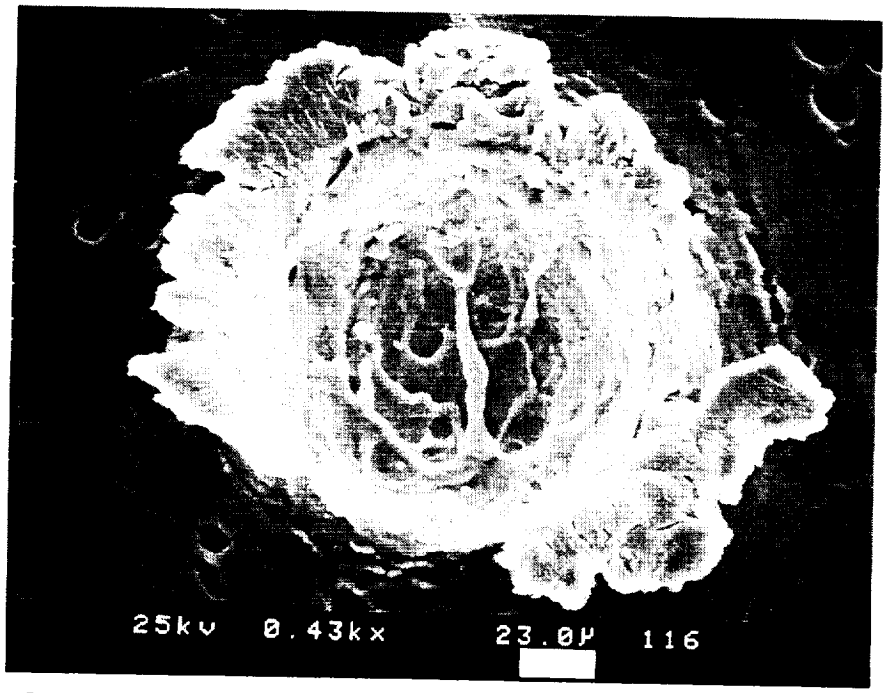

25kv 0.50kx 20.0μ 094

B10 - C01 019



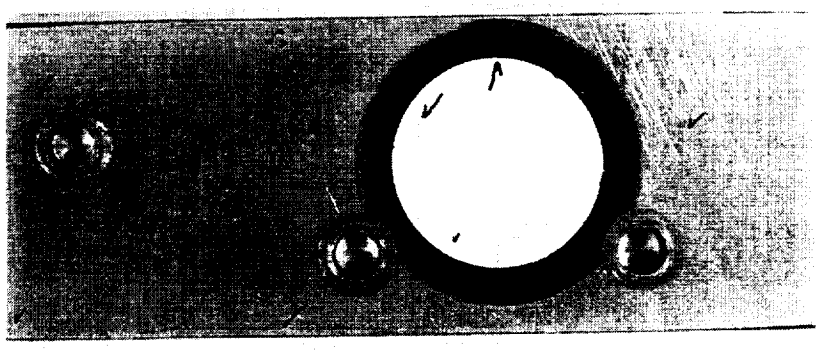
B10-C01 020 SS


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B10-C01, 022

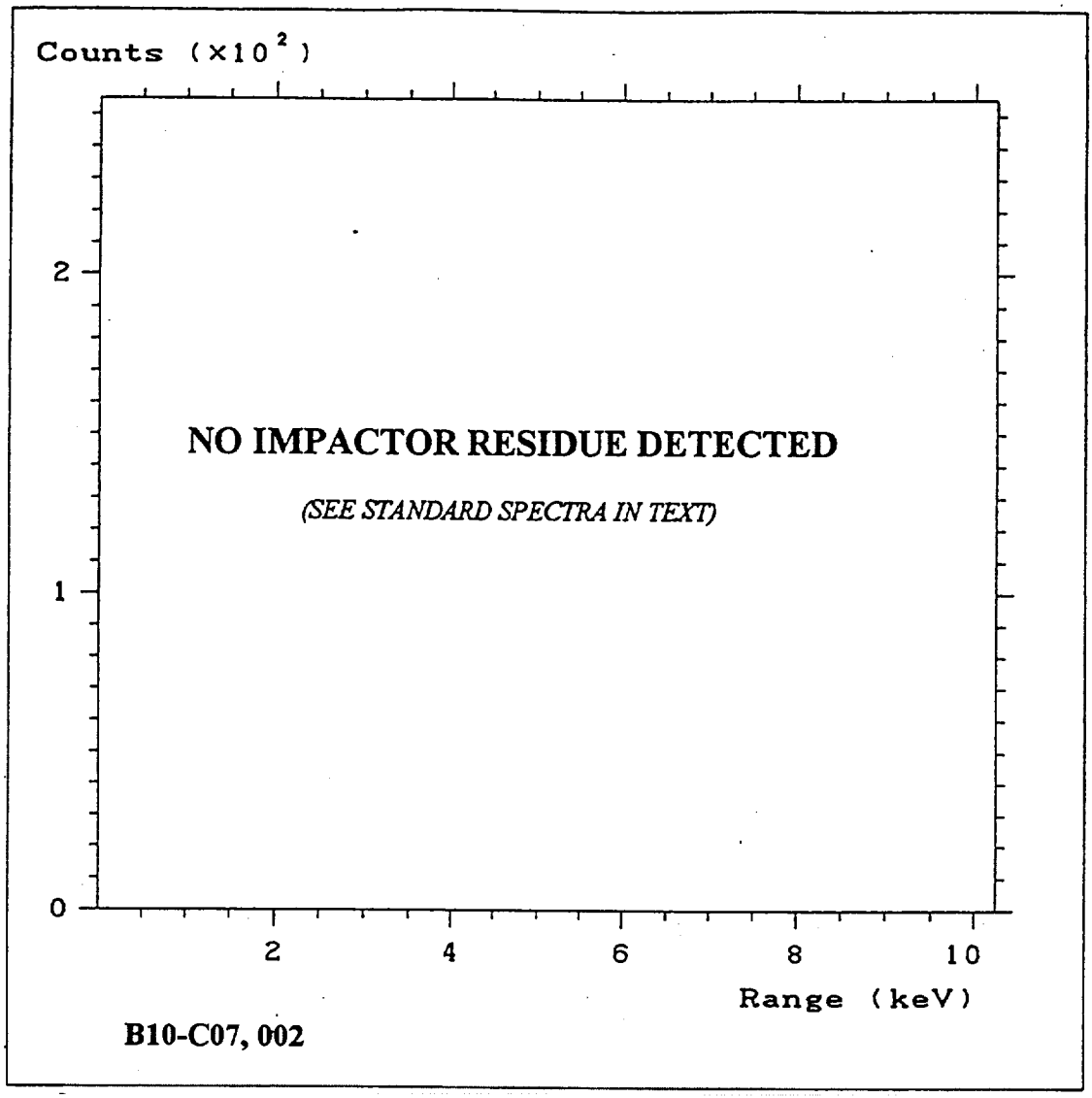

25kv 0.43kx 23.0μ 116

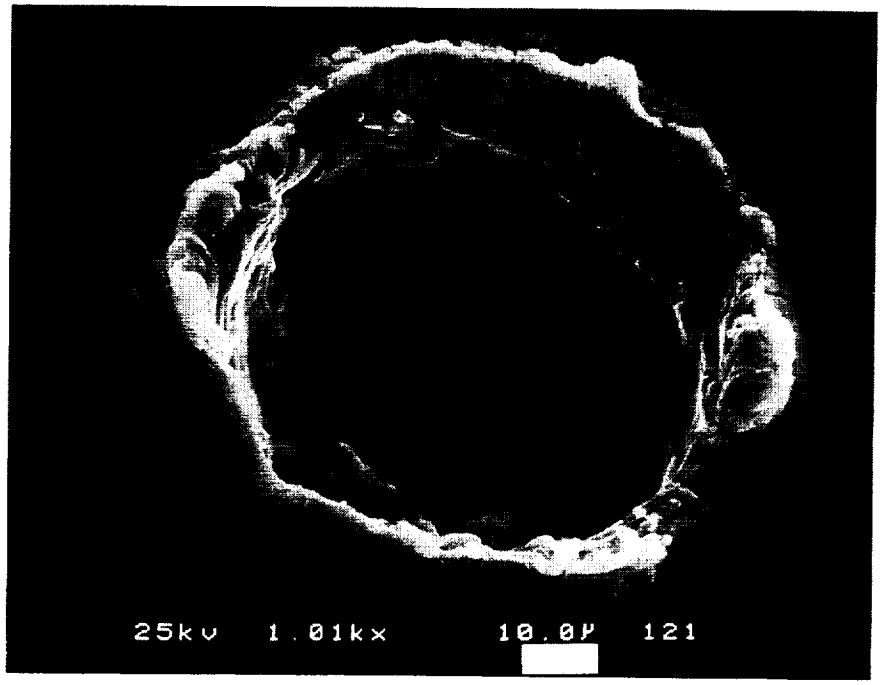
B10-C01 022

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B10-C07	001	2	2	3	NOT AN IMPACT
	002	38	6	80	UNKNOWN
	003	43	1	140	PAINT
	004	31	22	150	MICROMETEORITIC
	005	106	30	160	UNKNOWN
	006	70	12	130	PAINT PATCH
	007	65	31	260	PAINT PATCH
	008	27	27	140	MICROMETEORITIC
	009	9	40	120	MICROMETEORITIC
	010	77	38	200	PAINT PATCH
	011	46	46	150	UNKNOWN

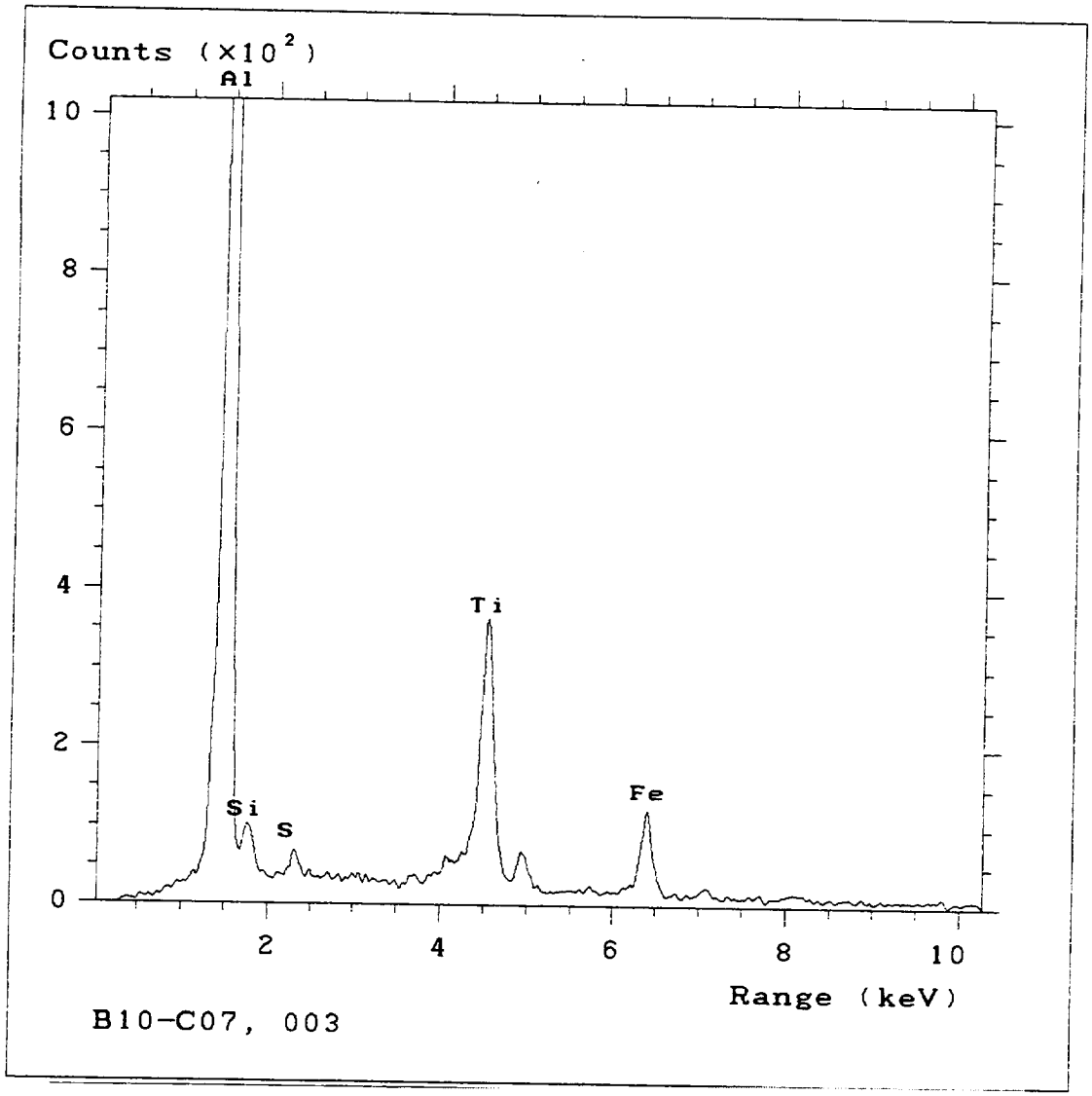


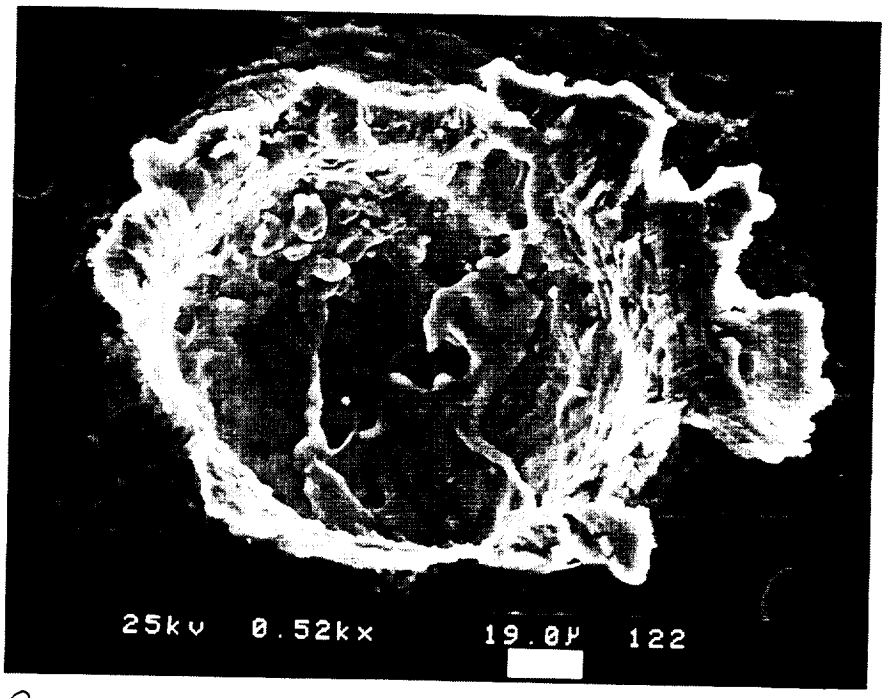
B10 - C07


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B10-C07, 002

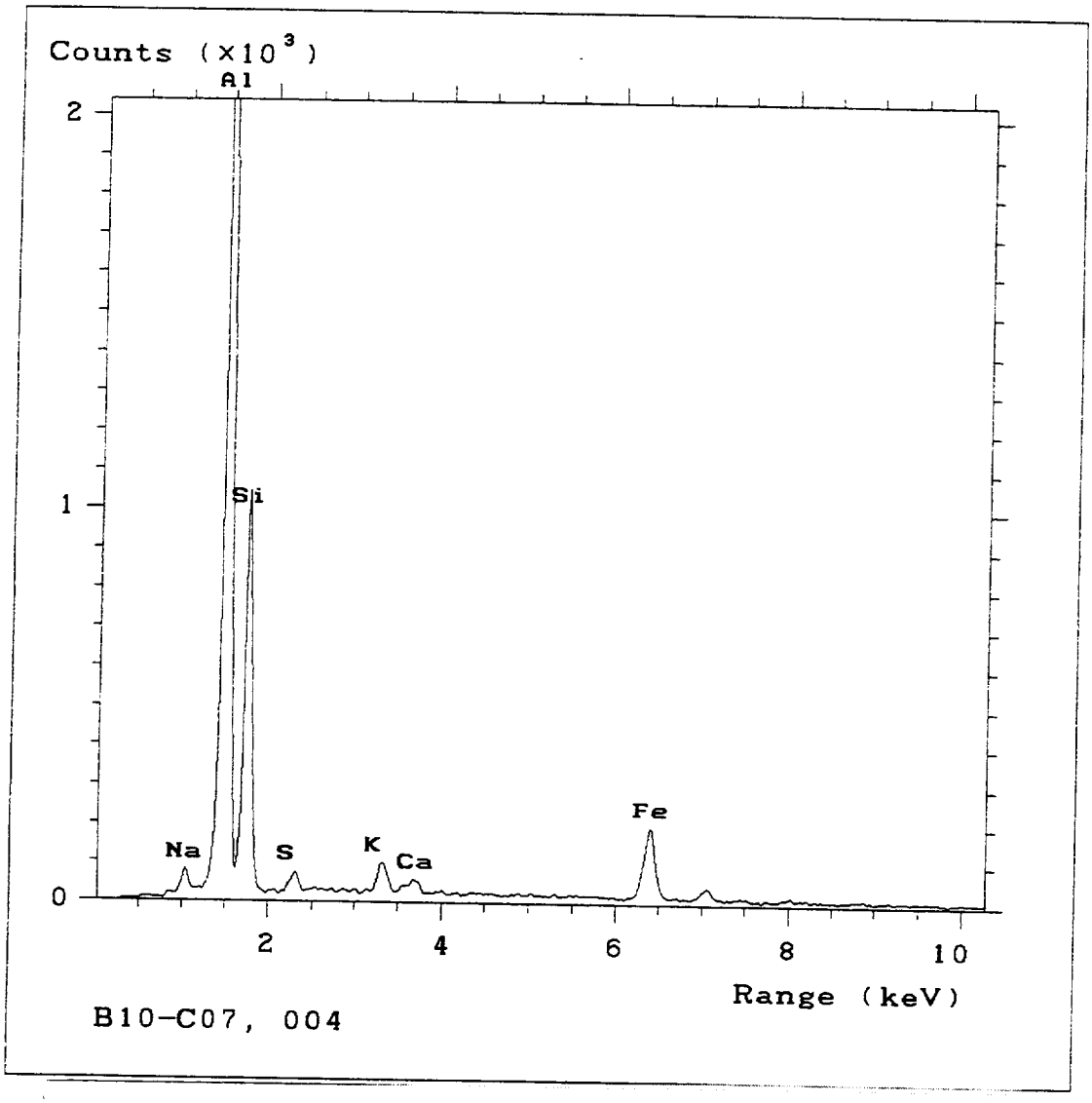

25kv 1.01kx 10.0µ 121

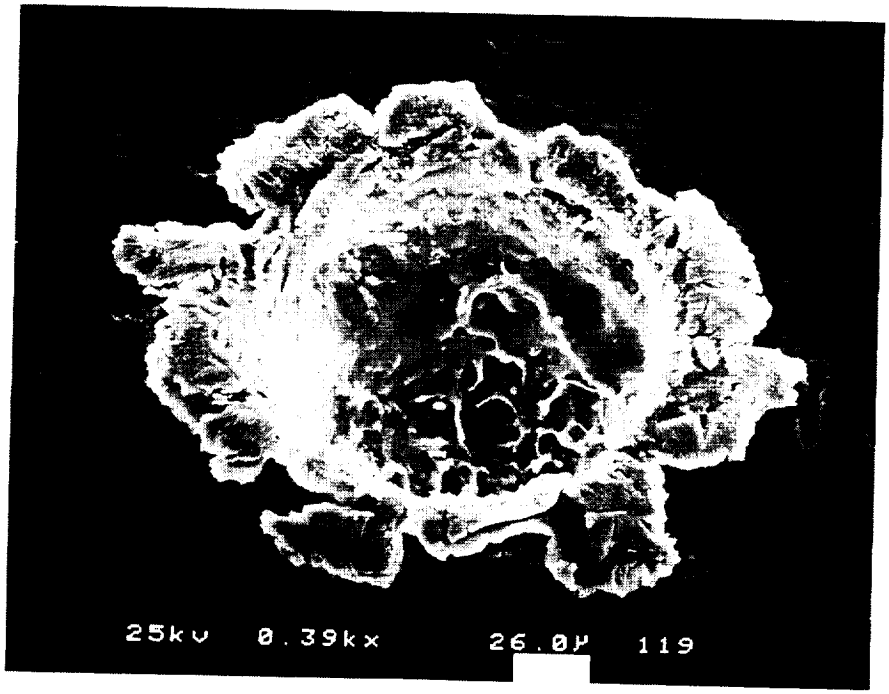
B10-C07 002



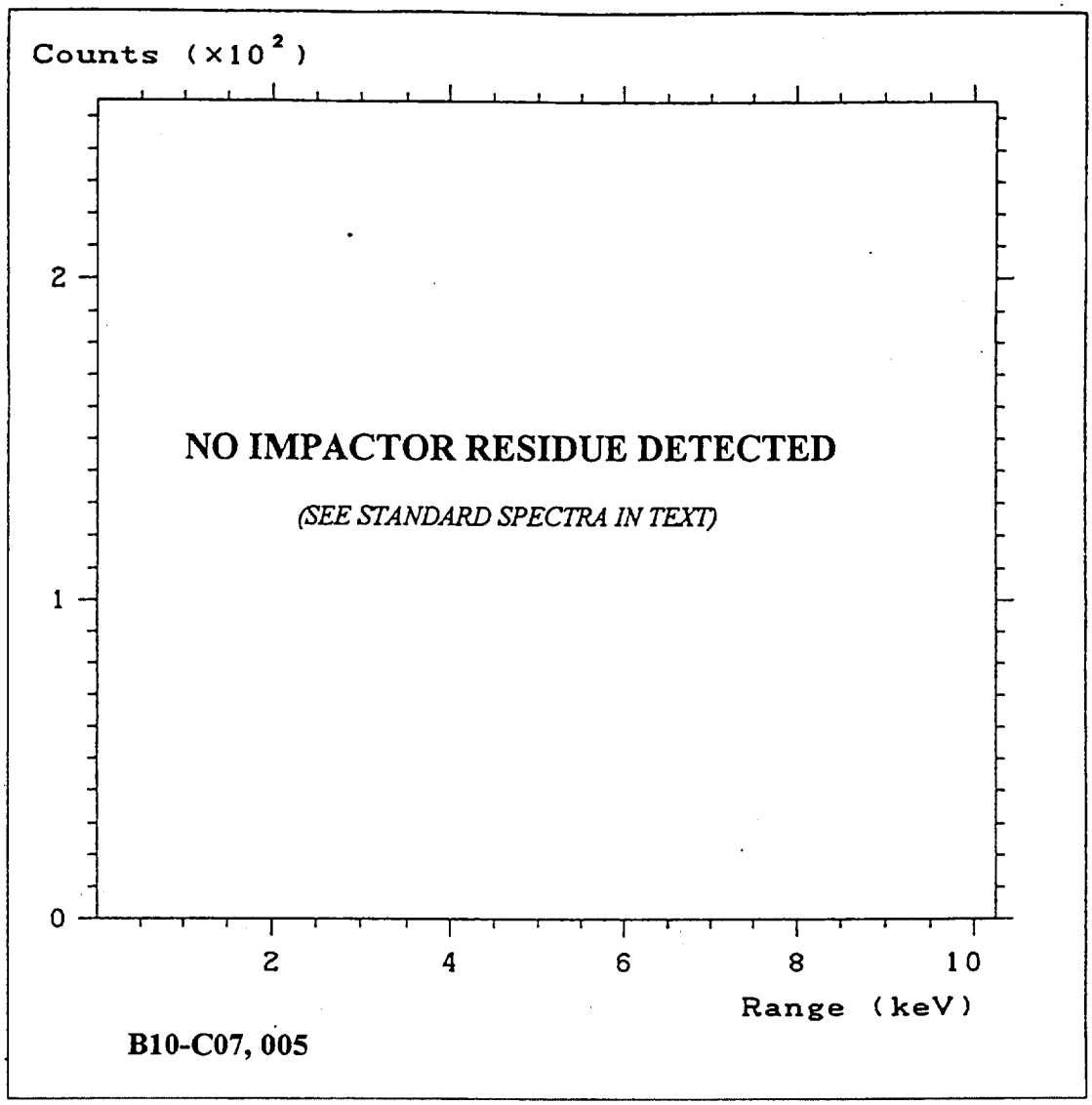


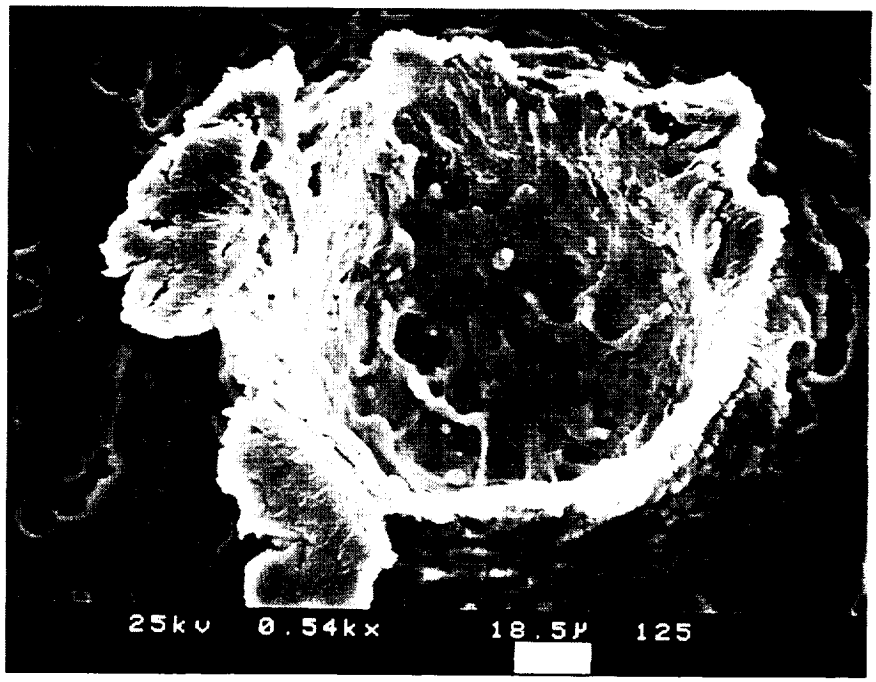
B10-C07 003 PRINT



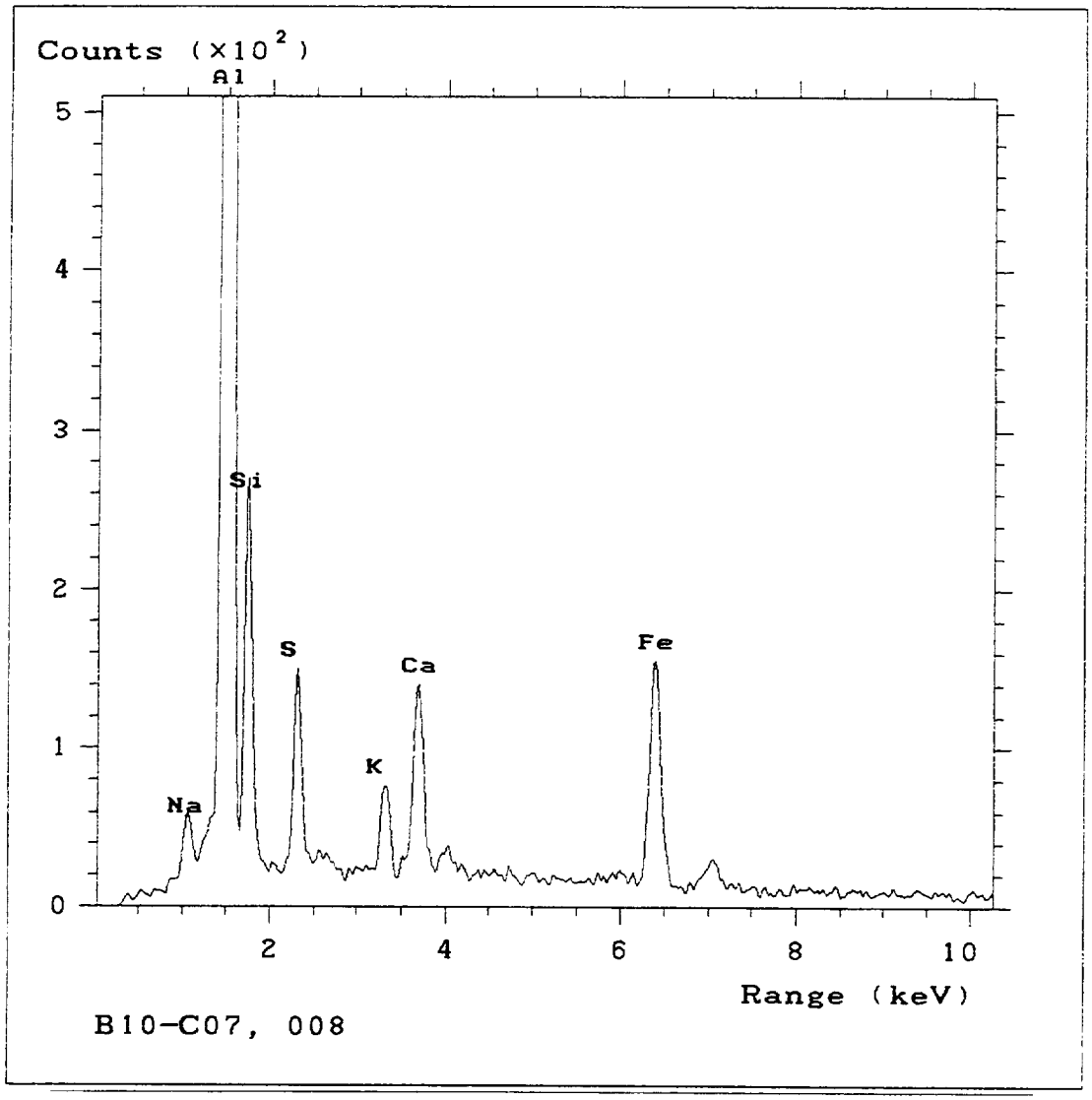


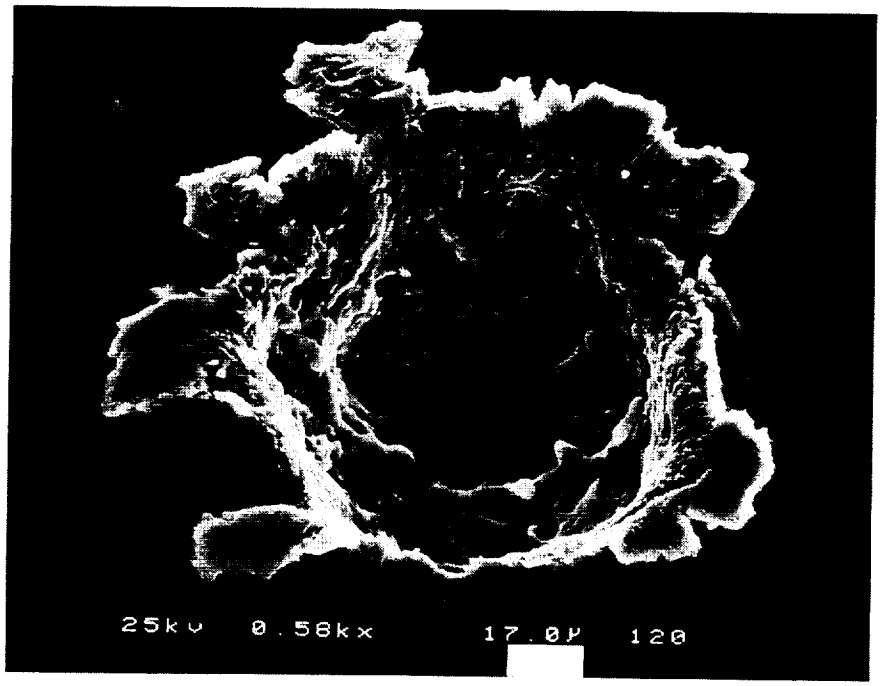
B10-C07 004 mm


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C07, 005

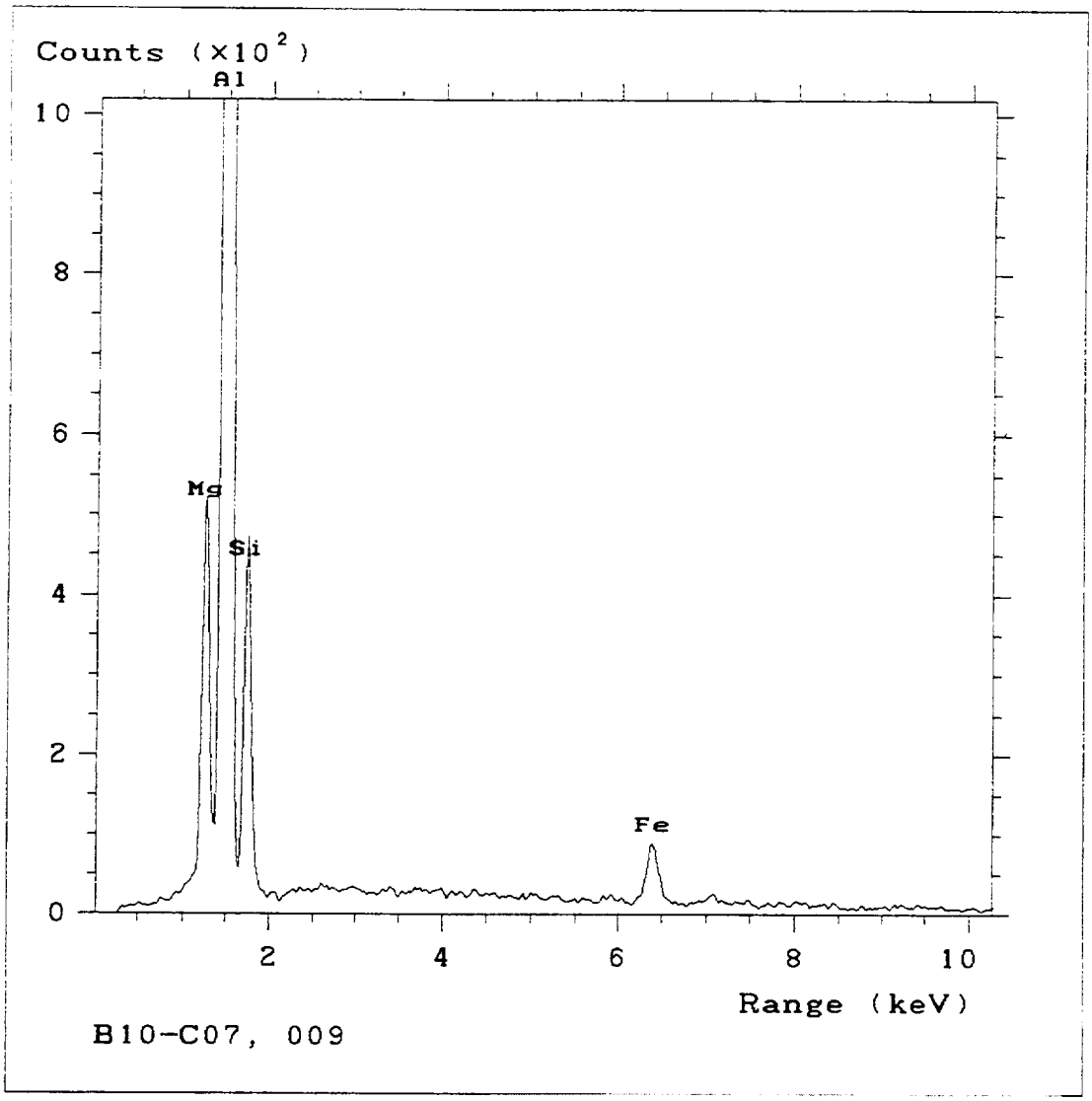

25kv 0.54kx 18.5μ 125

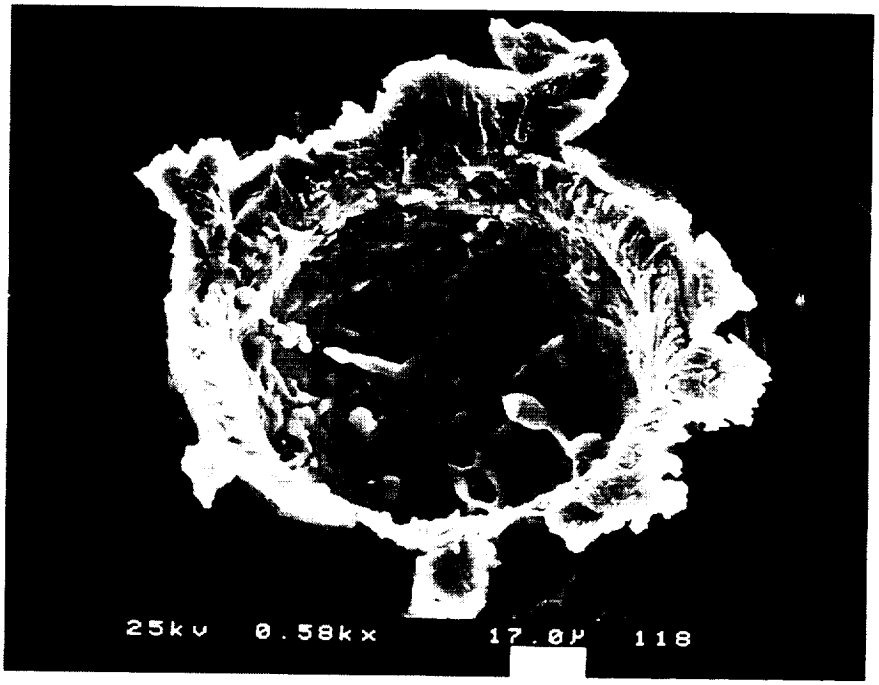
B10 - C07 005



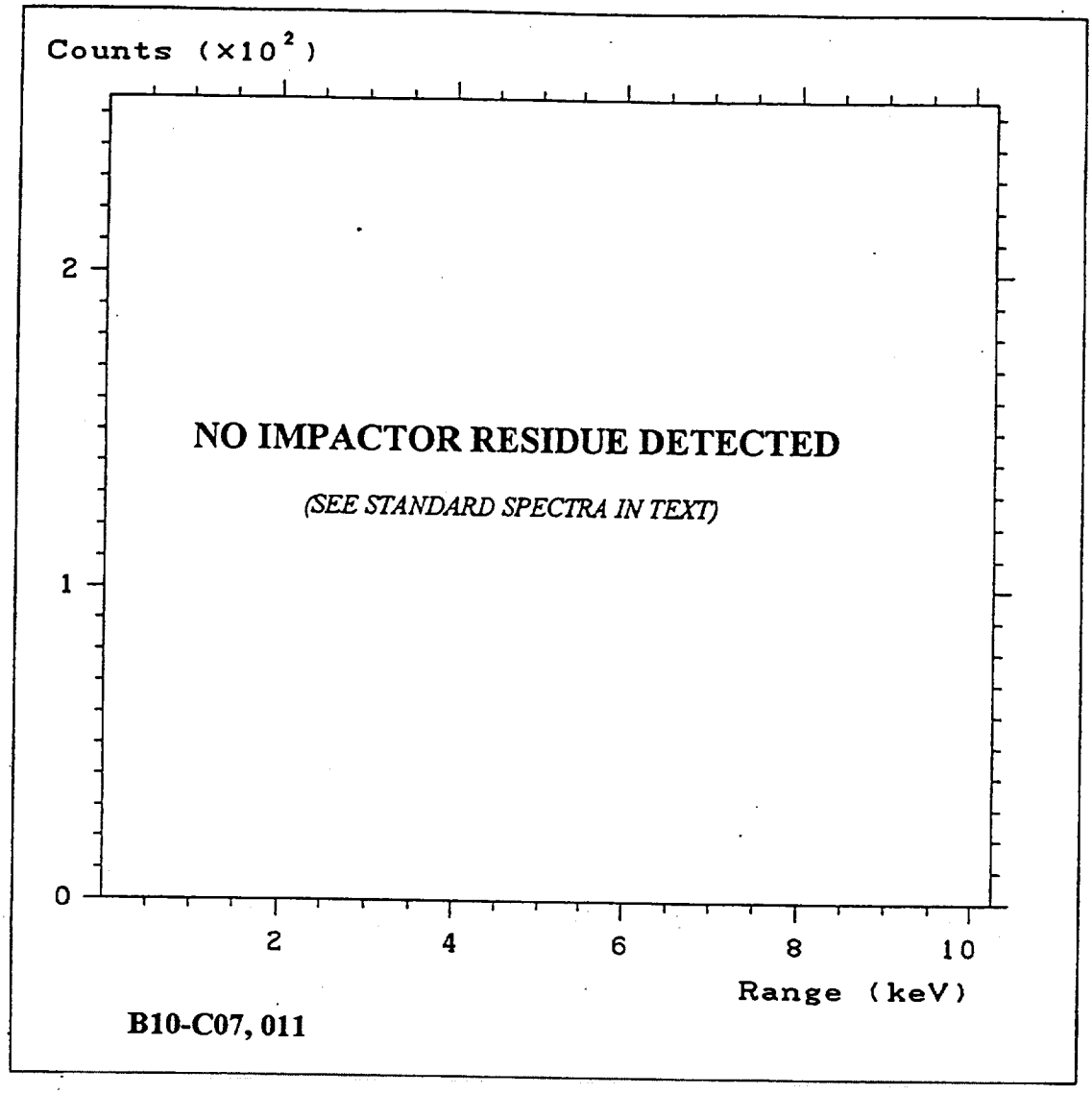


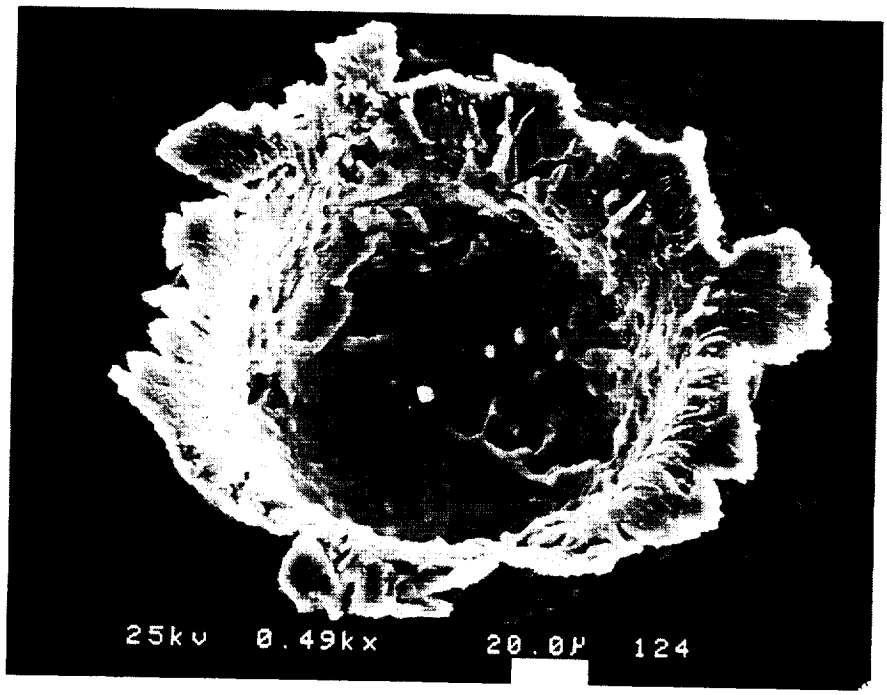
B10 - C07 008 mm





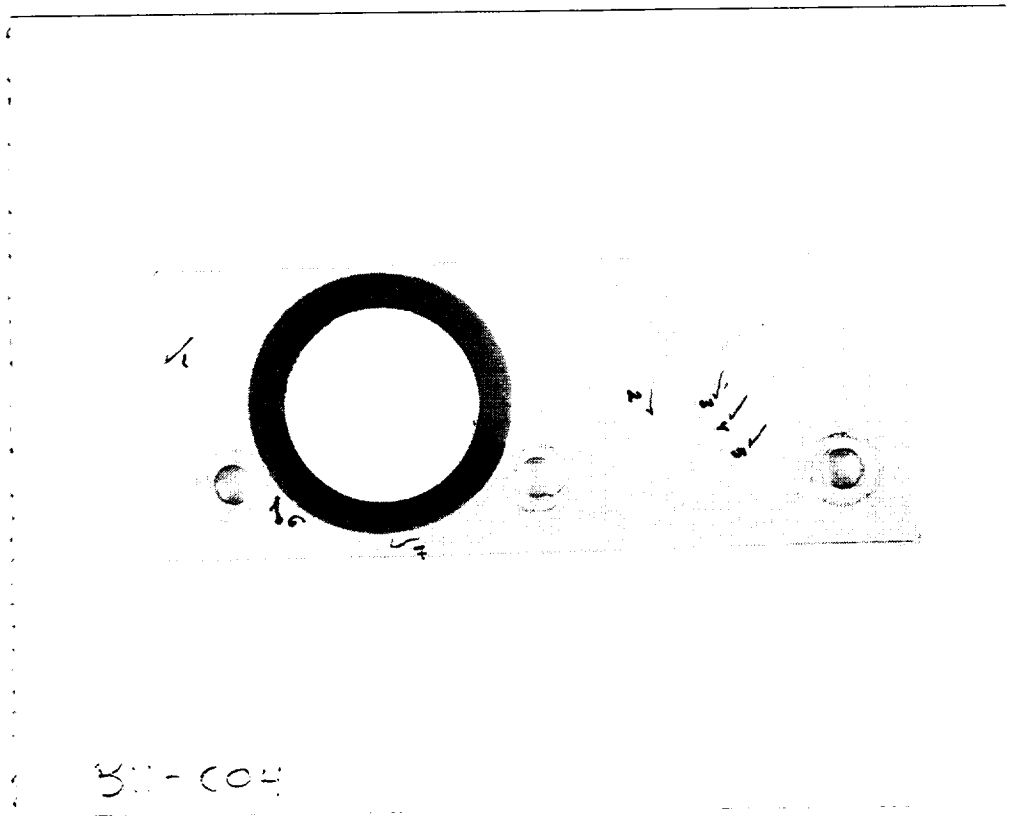
B10-C07 009 MA

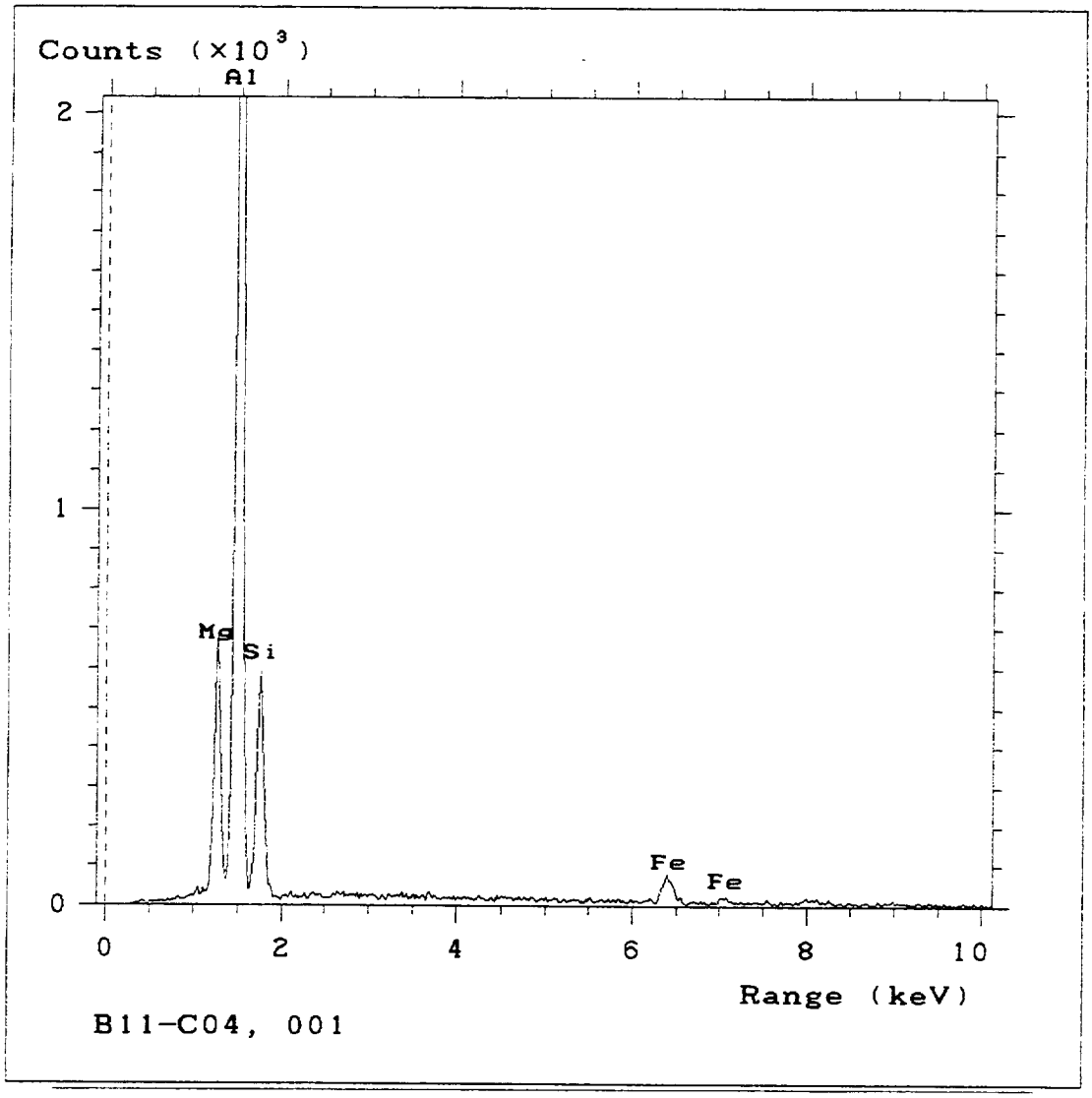

Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B10-C07, 011

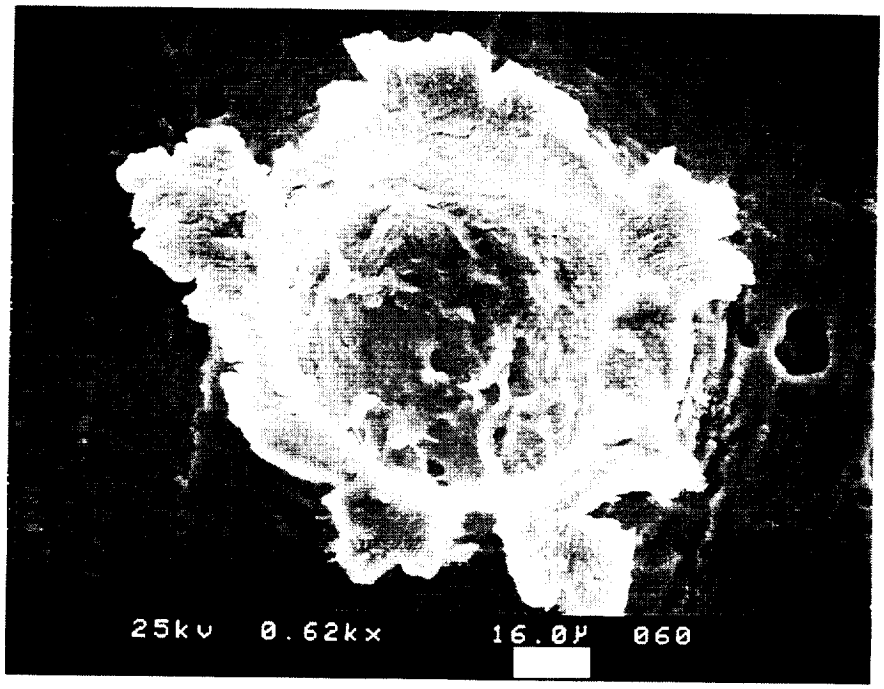

25kv 0.49kx 20.0µ 124

B10-C07 011

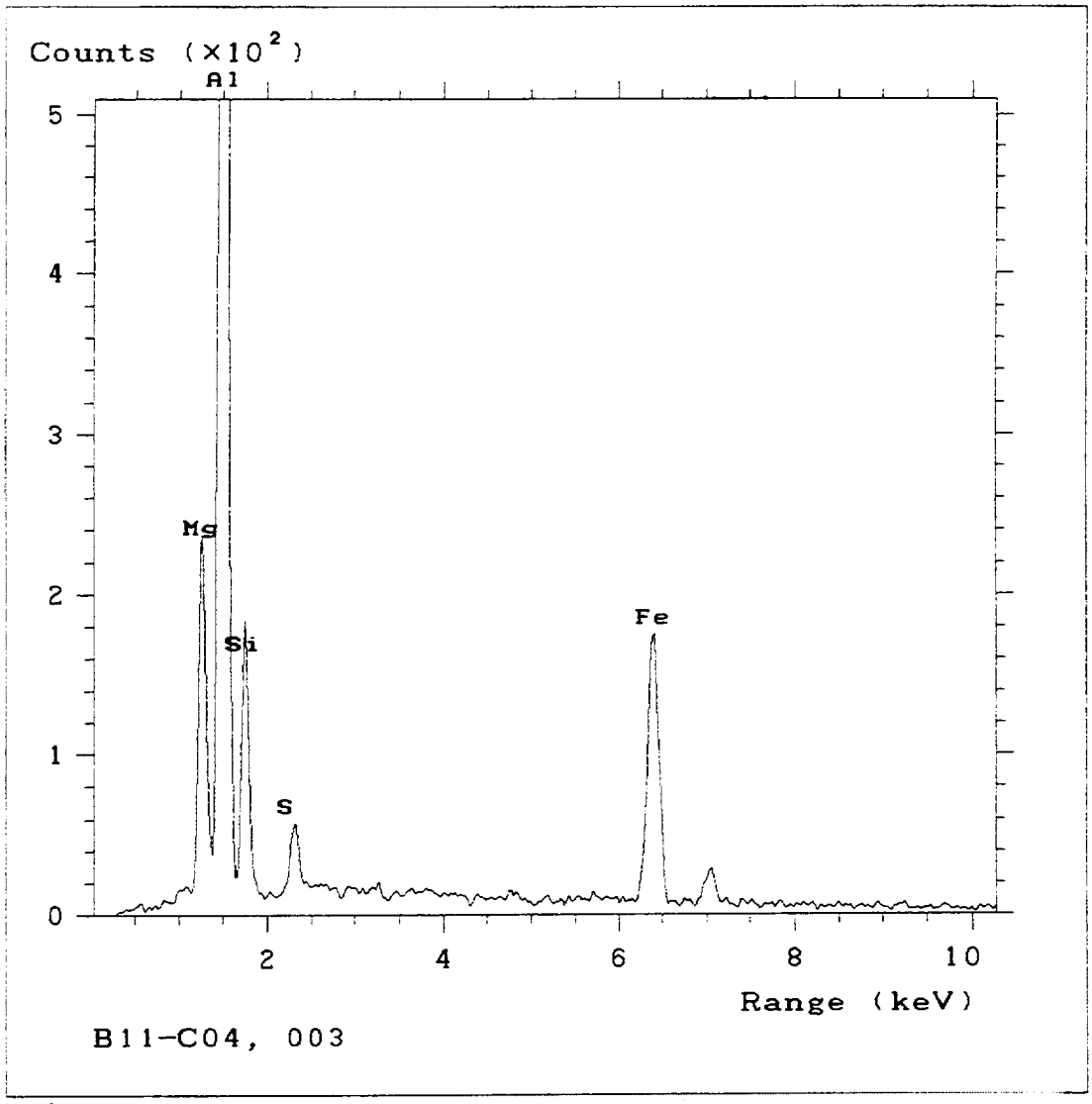
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B11-C04	001	15	1	100	MICROMETEORITIC
	002	27	82	30	NOT AN IMPACT
	003	24	93	180	MICROMETEORITIC
	004	28	95	35	MICROMETEORITIC
	005	32	98	100	UNKNOWN
	006	38	20	90	UNKNOWN
	007	47	39	150	STAINLESS STEEL

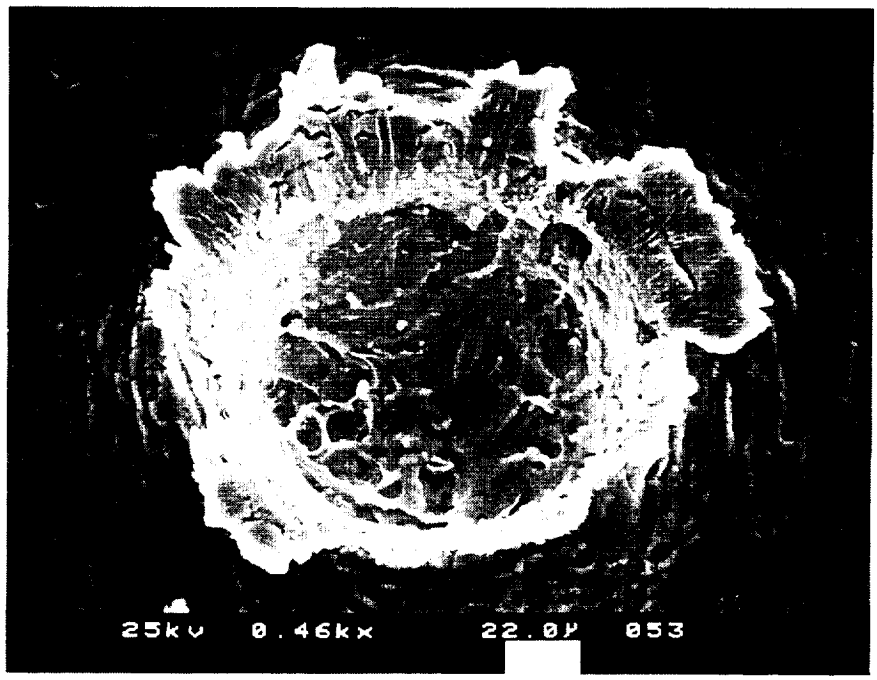




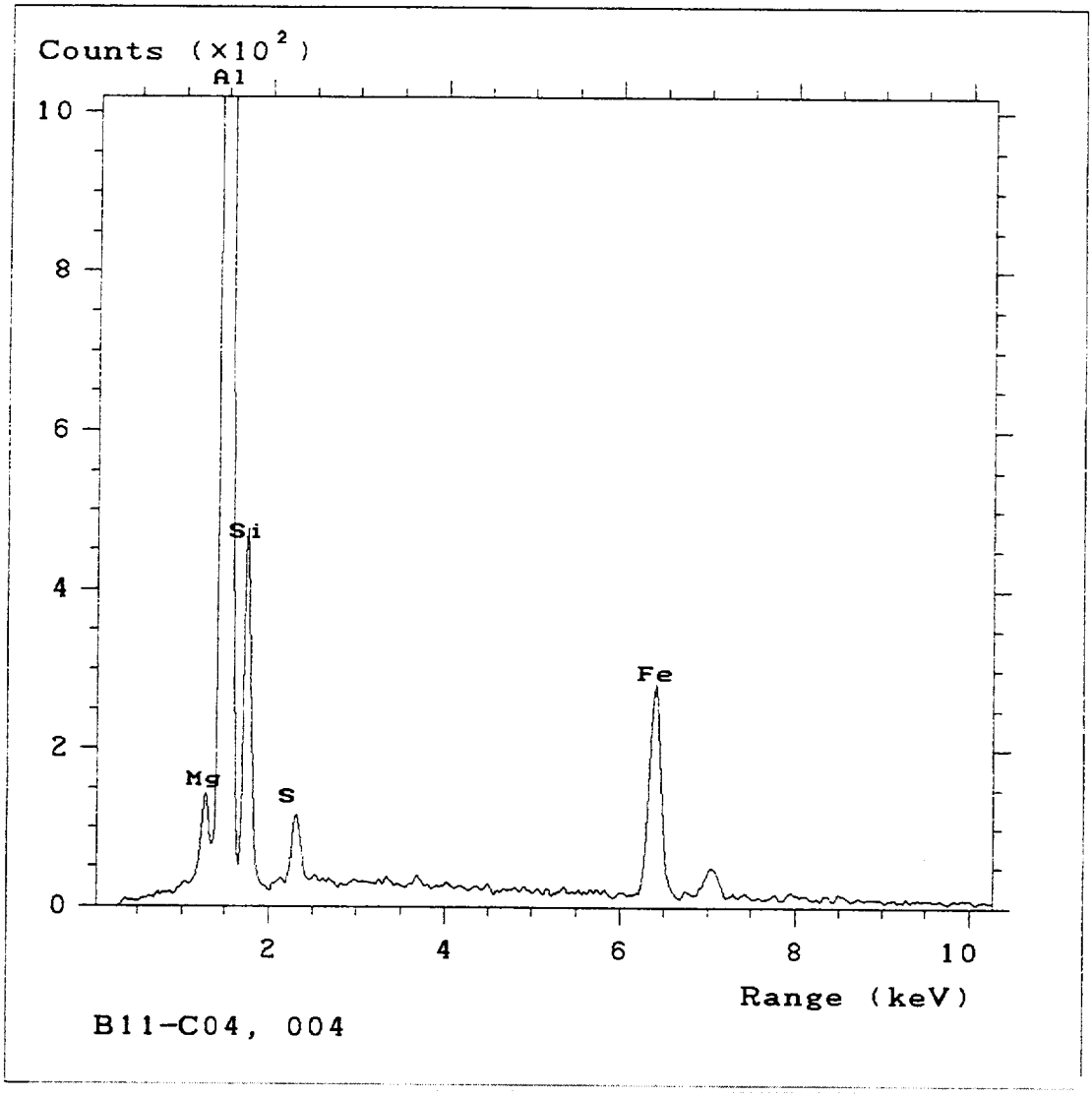


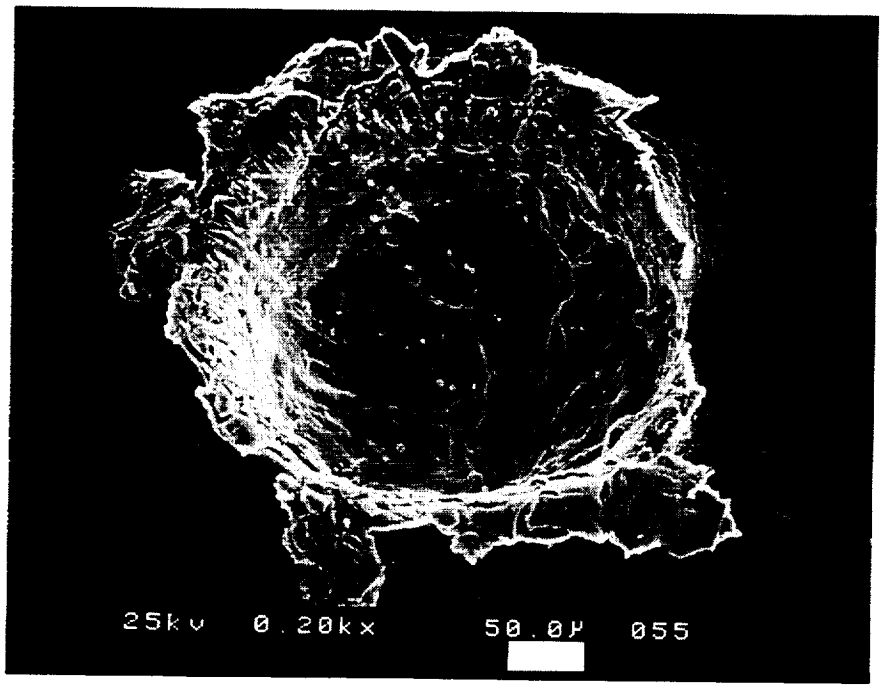
B11-C04 001 mm


Counts (×10²)
Al
Mg
Si
S
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B11-C04, 003

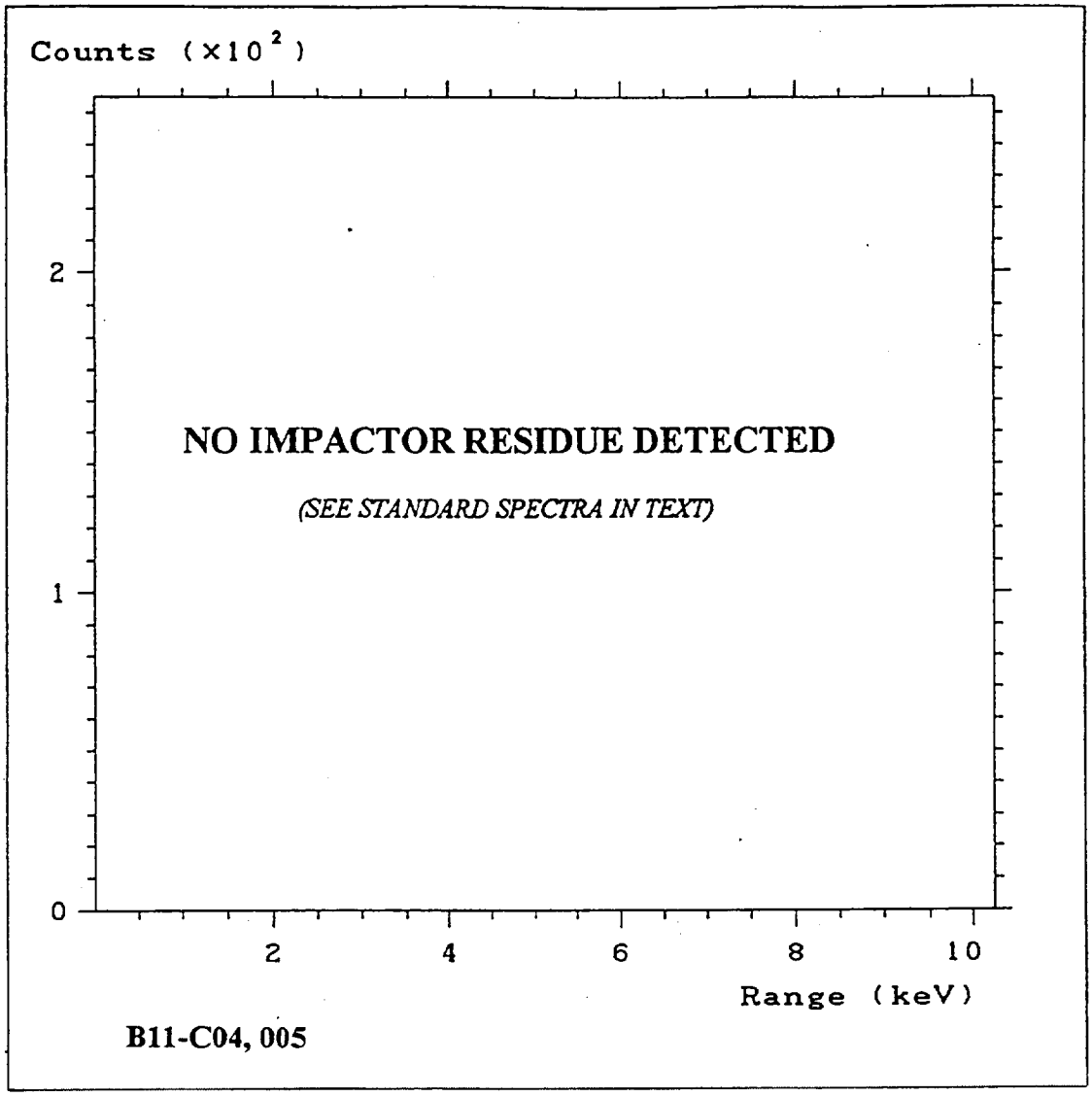

25kv 0.46kx 22.0µ 053

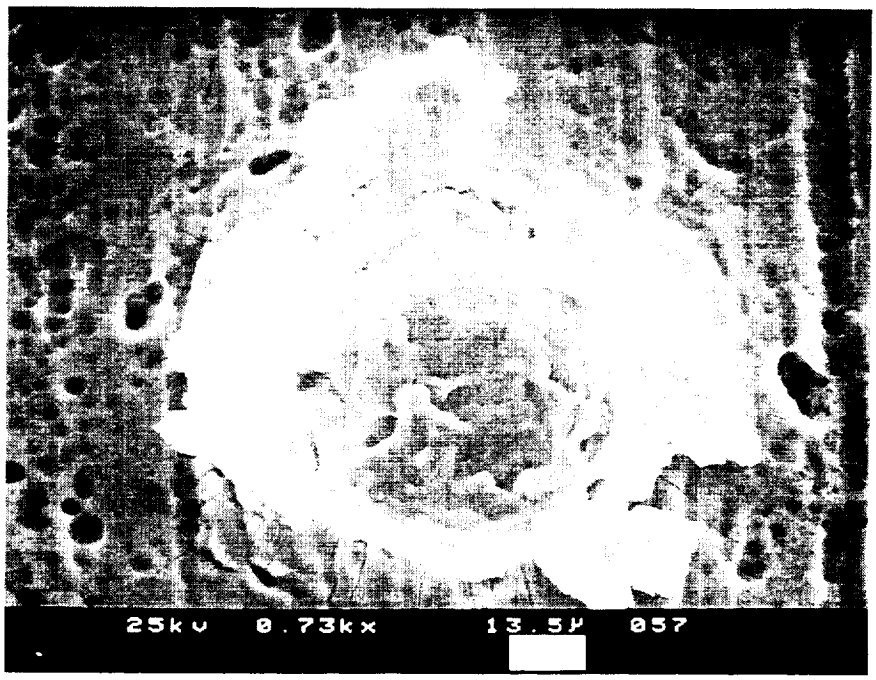
B11-C04 003



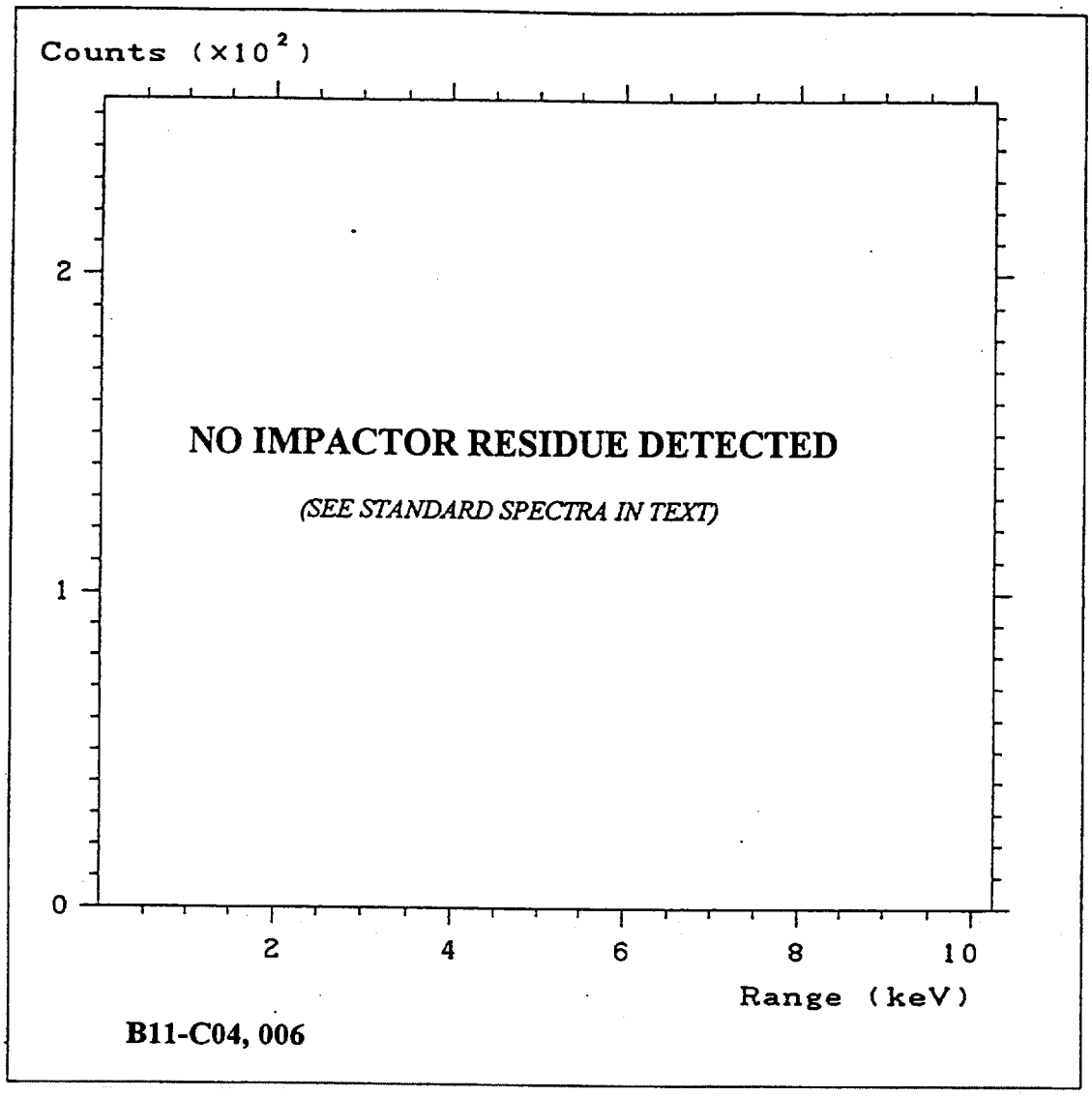


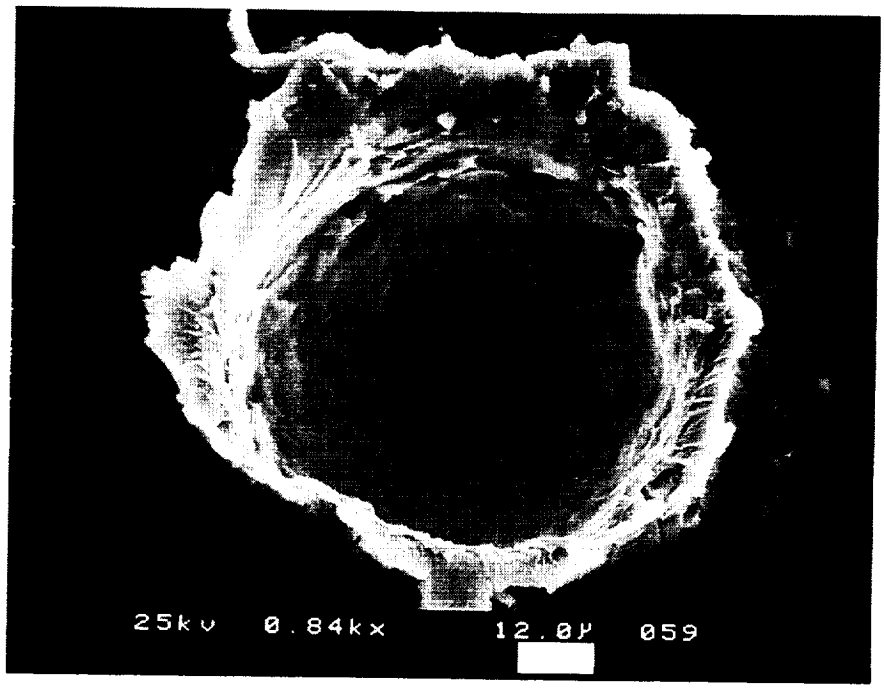
B11-C04 064 mm


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C04, 005

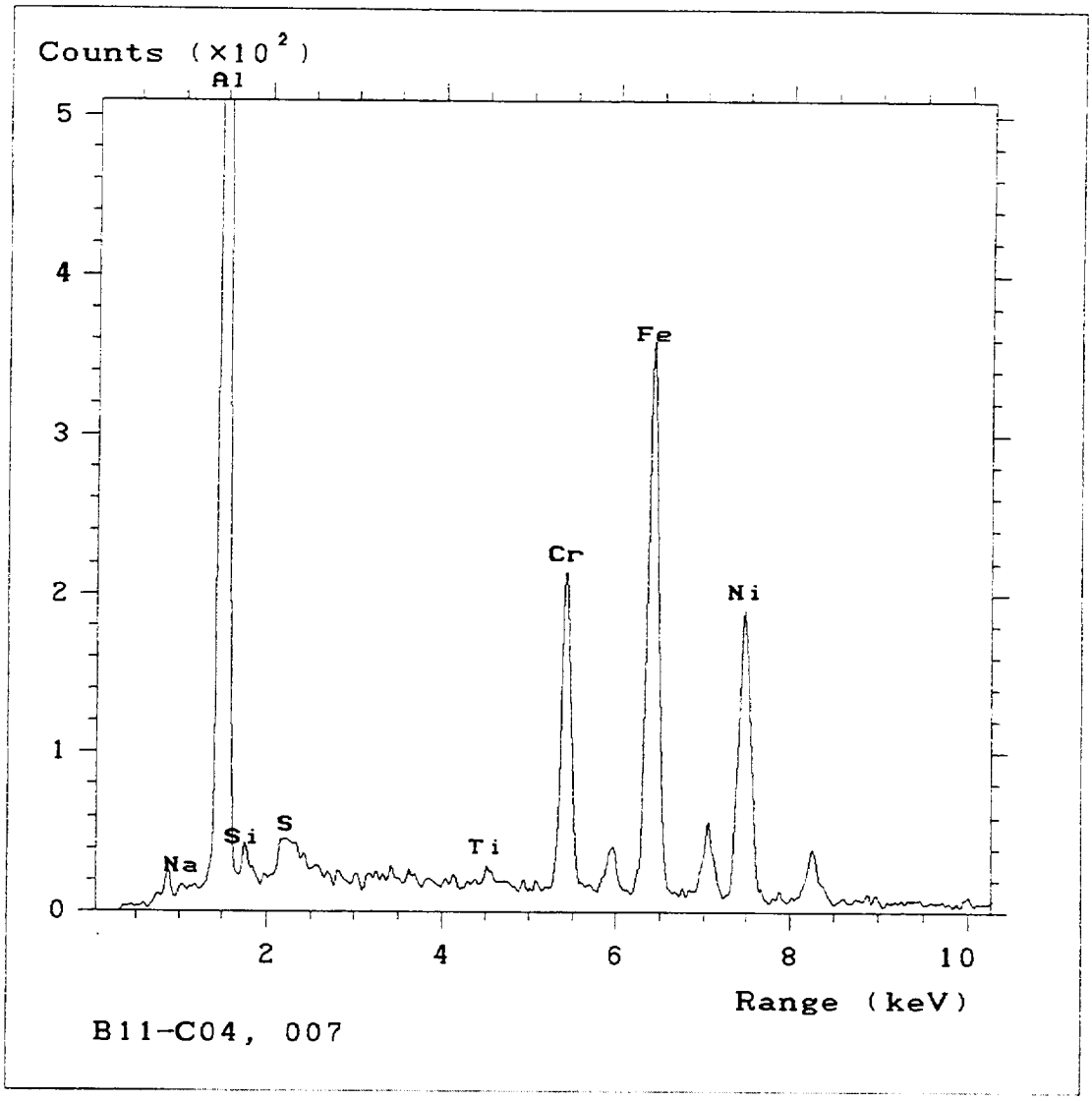

25kv 0.73kx 13.5µ 057

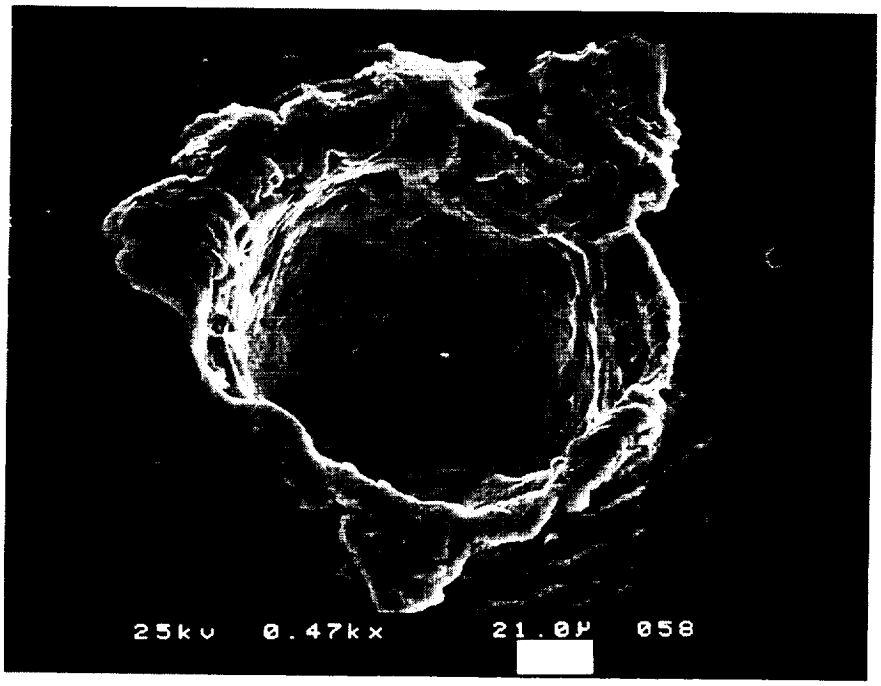
B11-C04 005


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C04, 006


25kv 0.84kx 12.0μ 059

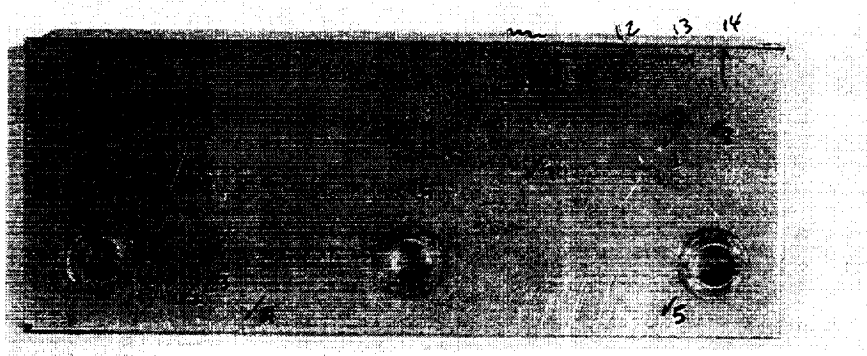
B11-C04 006



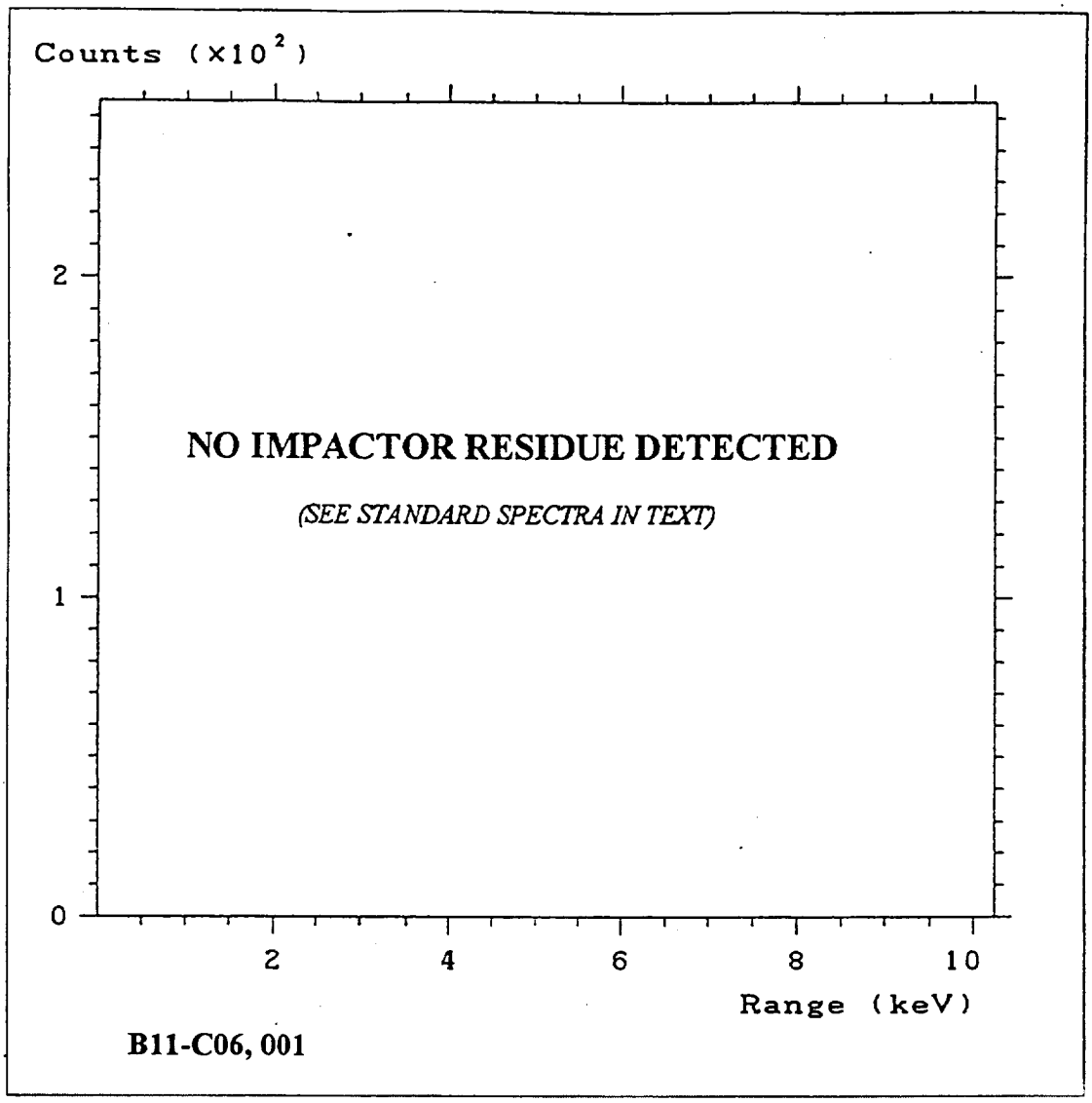


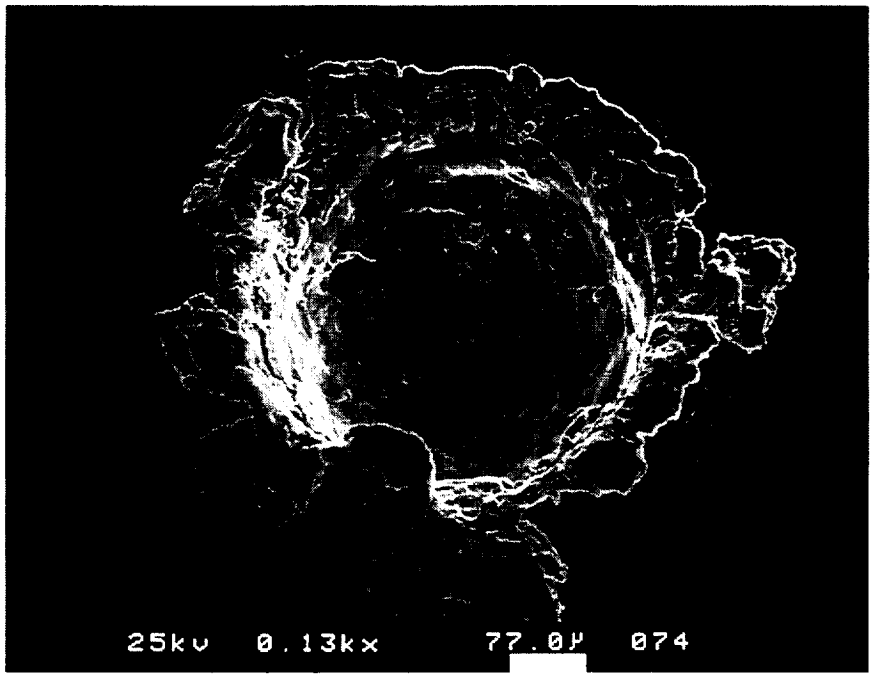
B11-C04 007 SS

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B11-C06	001	106	29	470	UNKNOWN
	002	25	3	140	UNKNOWN
	003	29	8	60	UNKNOWN
	004	36	1	220	UNKNOWN
	005	105	2	270	MICROMETEORITIC
	006	64	23	100	UNKNOWN
	007	83	24	180	MICROMETEORITIC
	008	114	32	80	MICROMETEORITIC
	009	110	32	50	PAINT
	010	10	42	80	MICROMETEORITIC
	011	32	48	120	PAINT
	012	102	39	140	MICROMETEORITIC
	013	114	46	90	PAINT
	014	119	48	220	EDGE
	015	88	47	60	MICROMETEORITIC

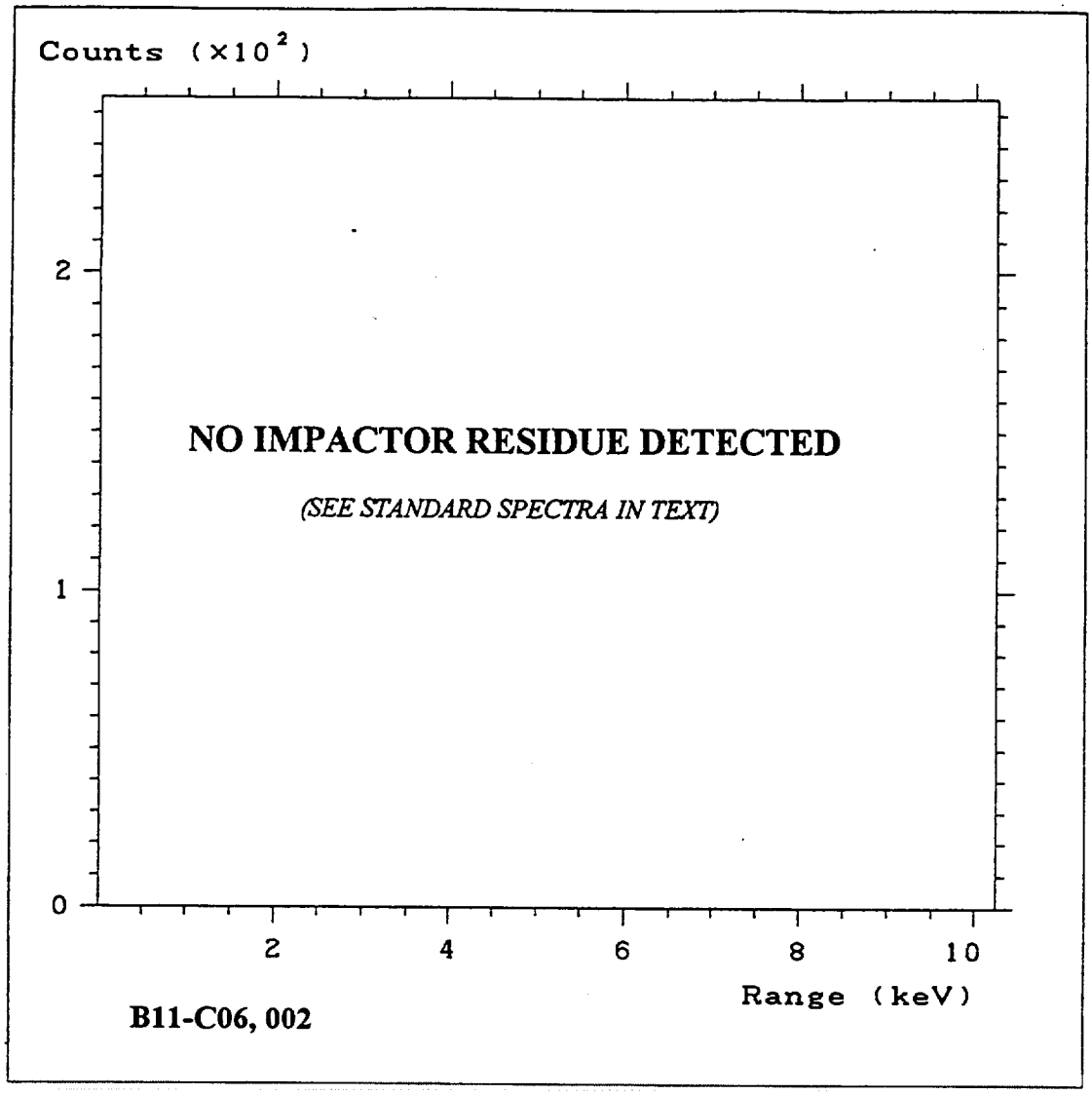


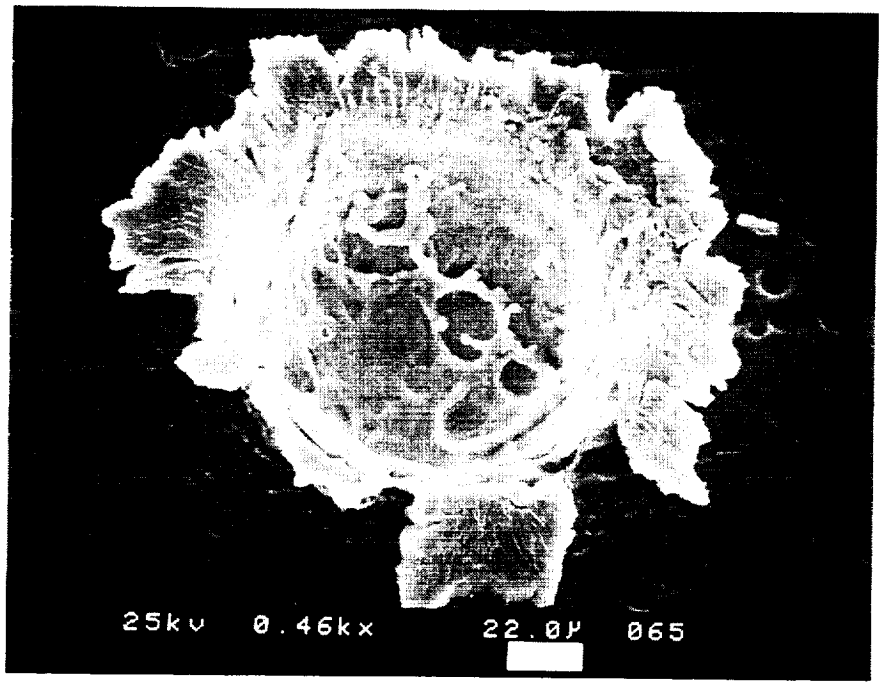
B11-C06


Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B11-C06, 001

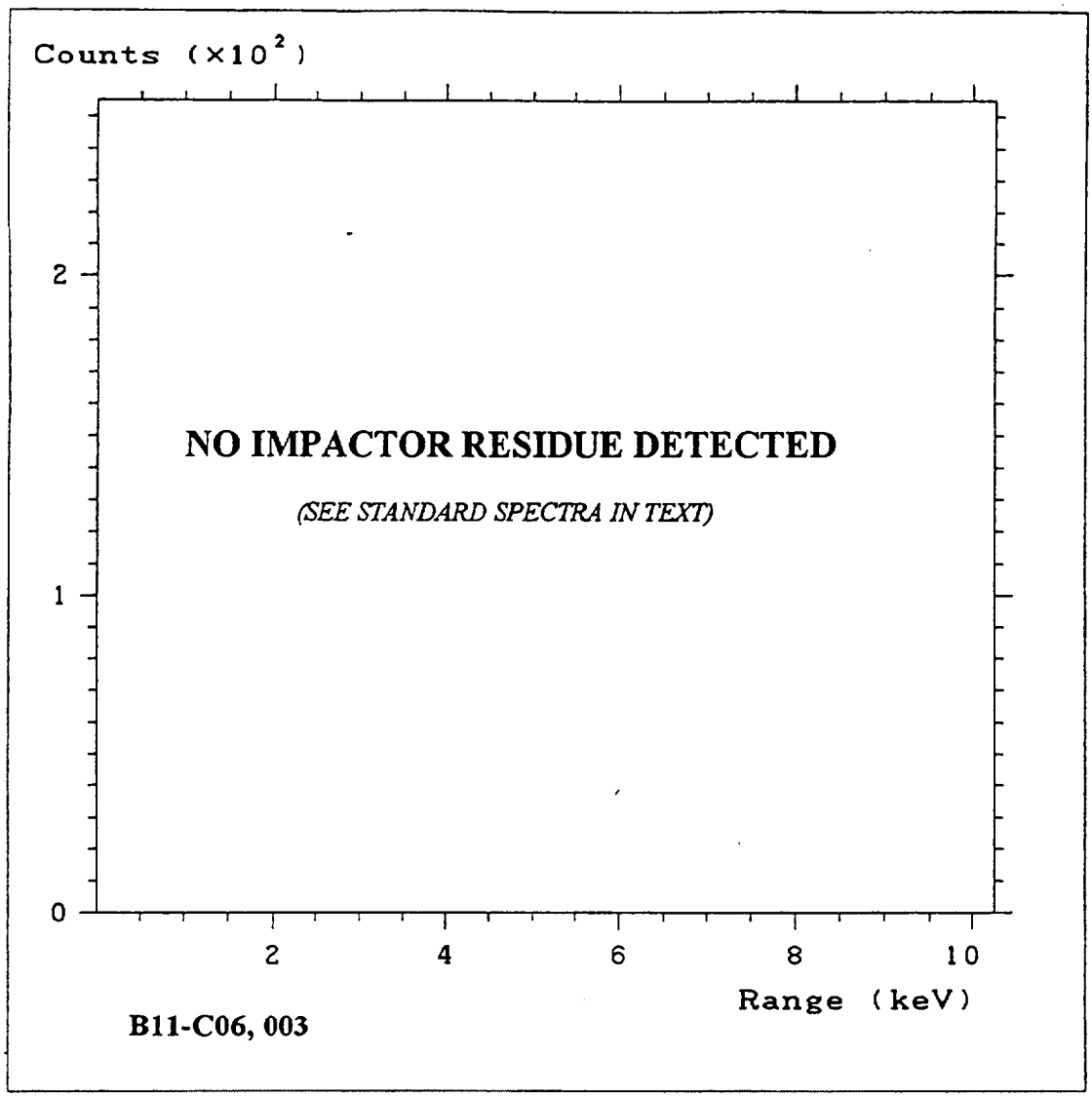

25kv 0.13kx 77.0µ 074

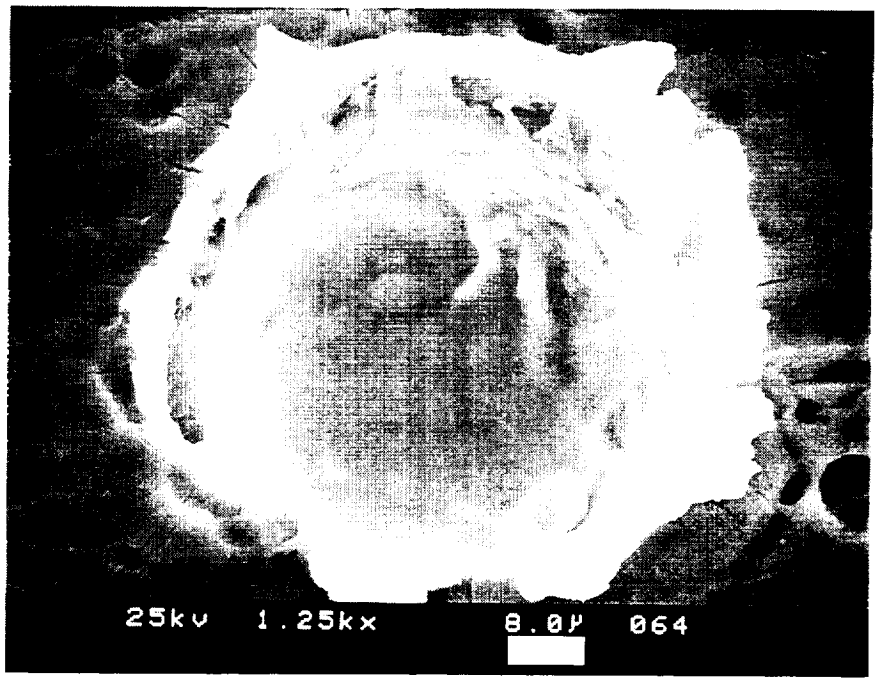
B11-C06 C01


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C06, 002

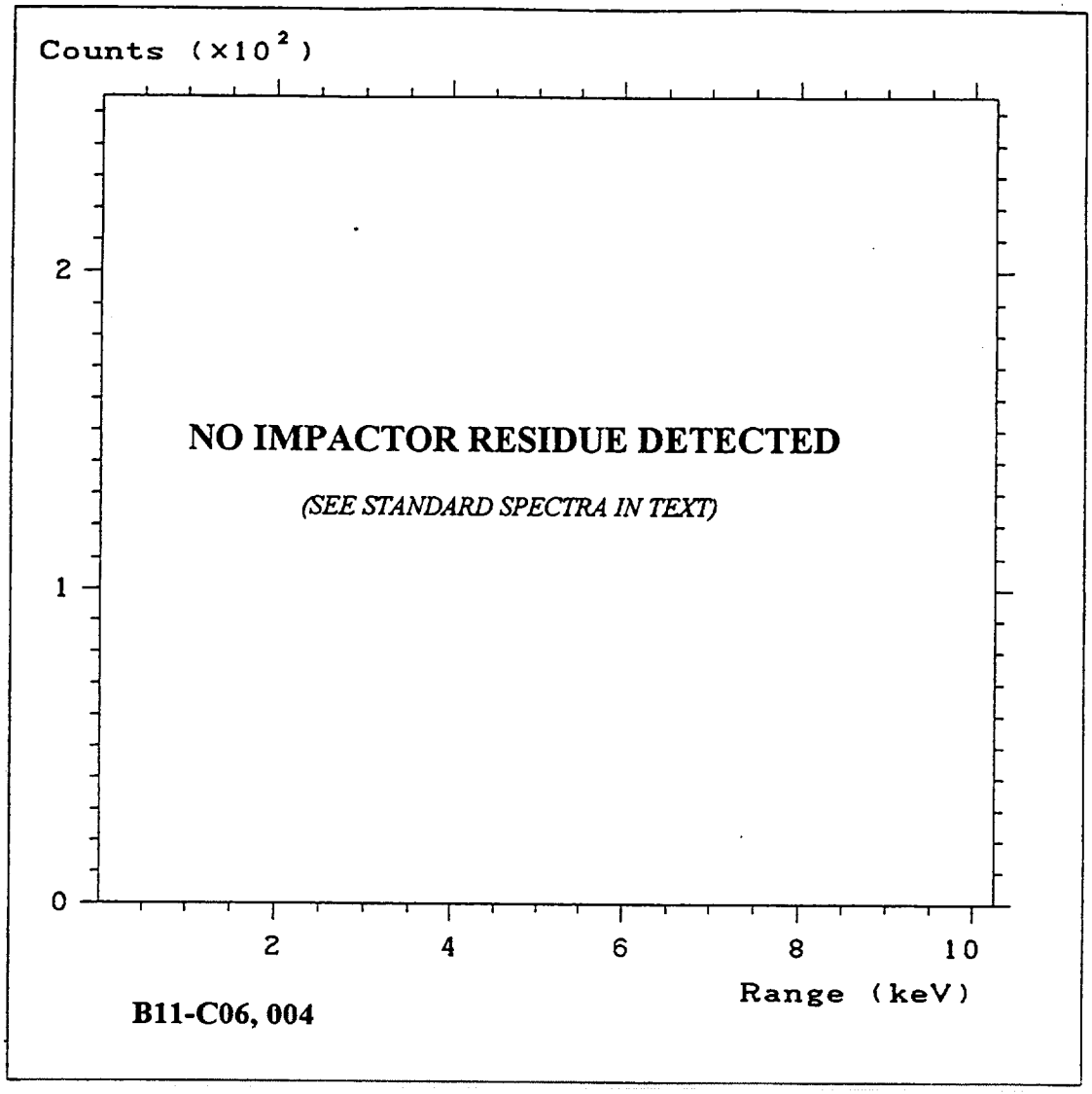

25kv 0.46kx 22.0μ 065

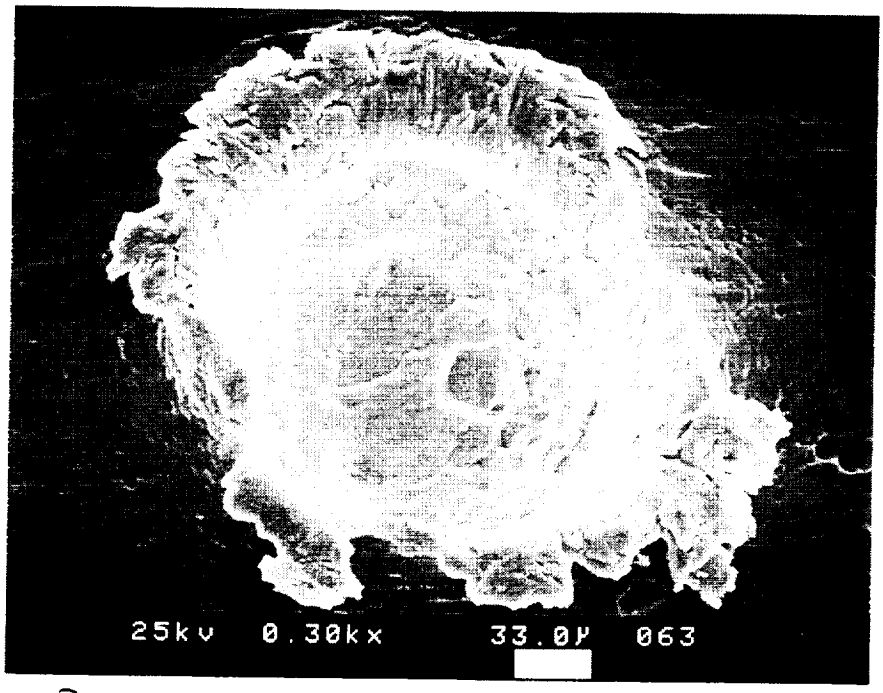
B11 - C06 002


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B11-C06, 003

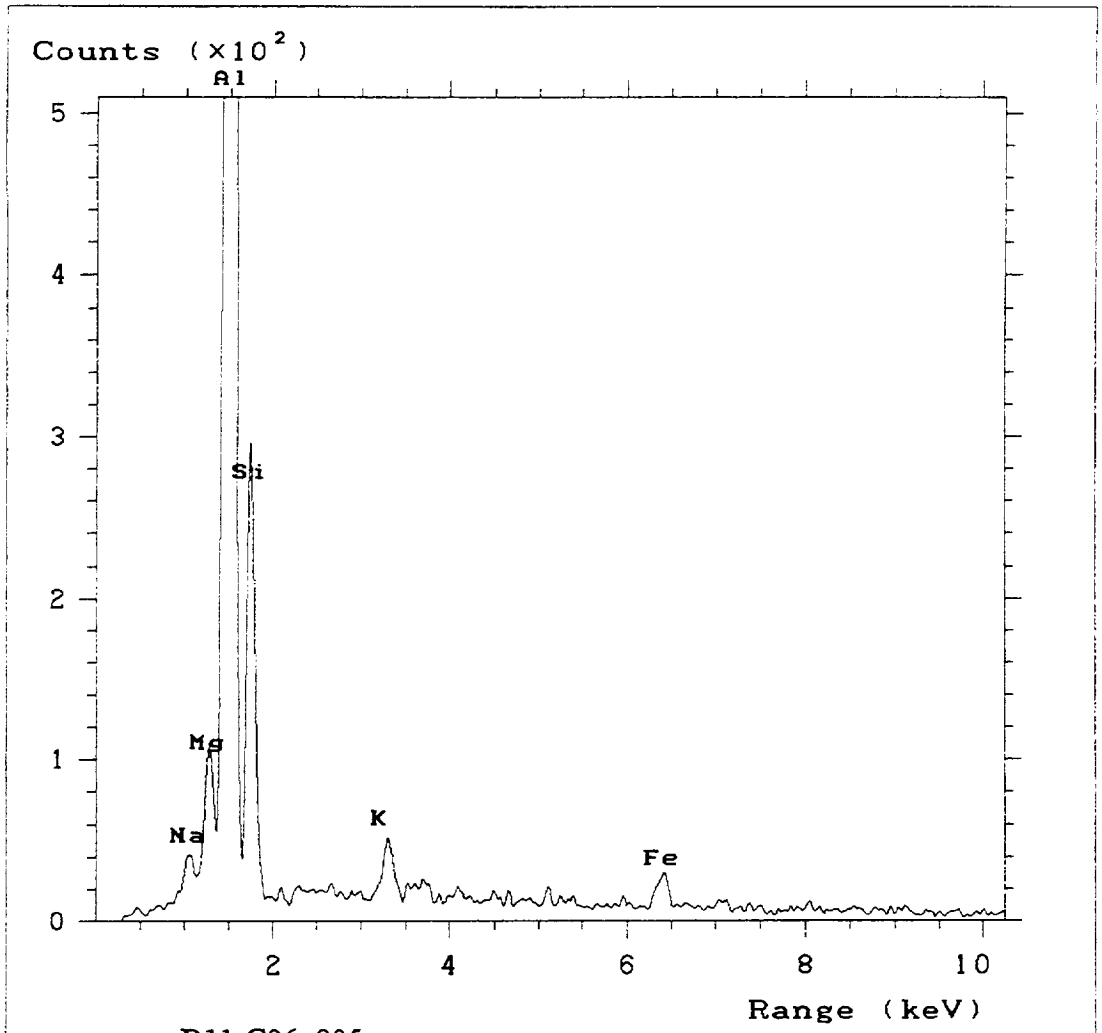

25kv 1.25kx 8.0µ 064

B11 - C06 C03

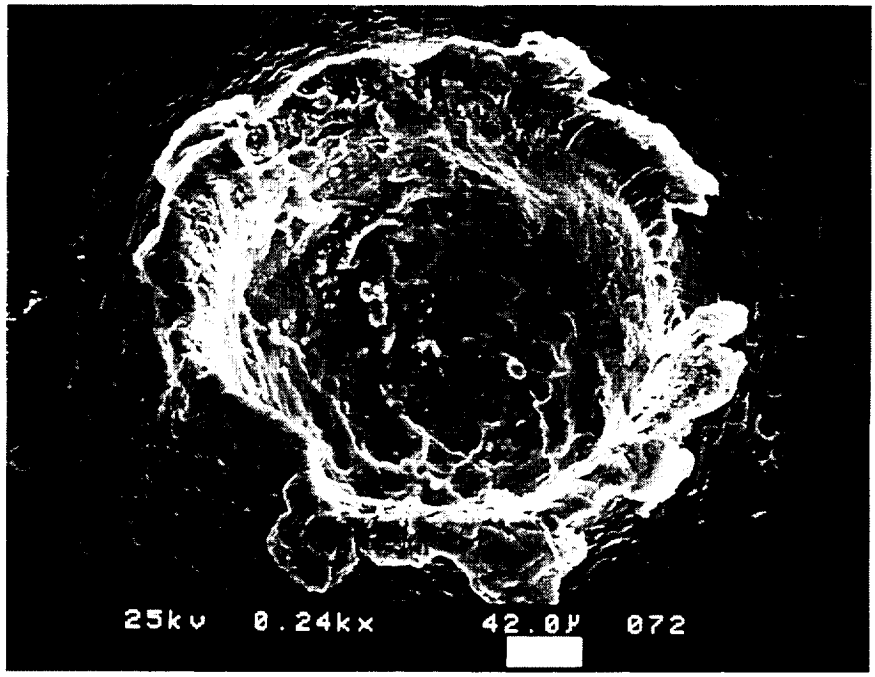

Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C06, 004


25kv 0.30kx 33.0µ 063

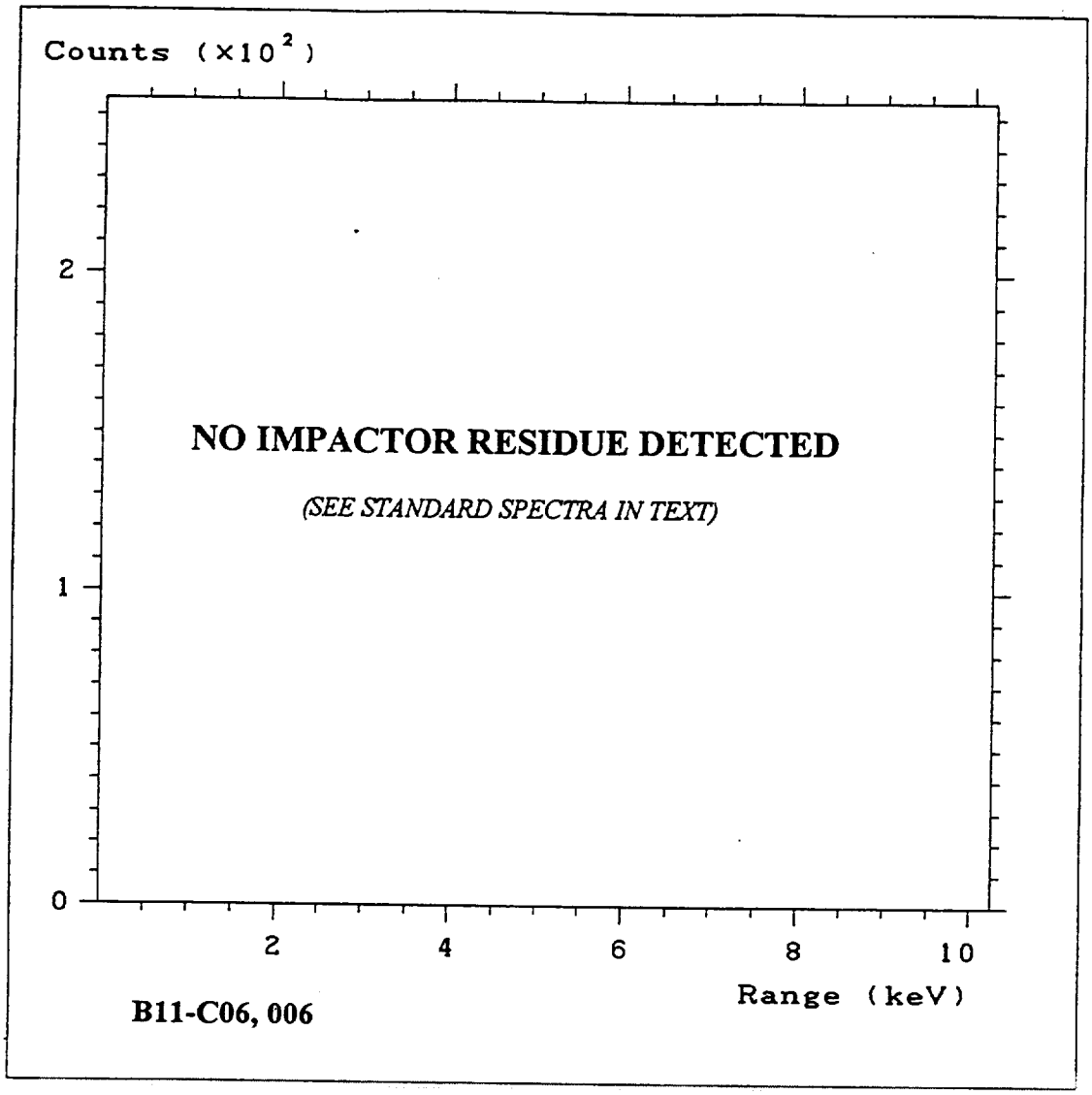
B11-C06 004

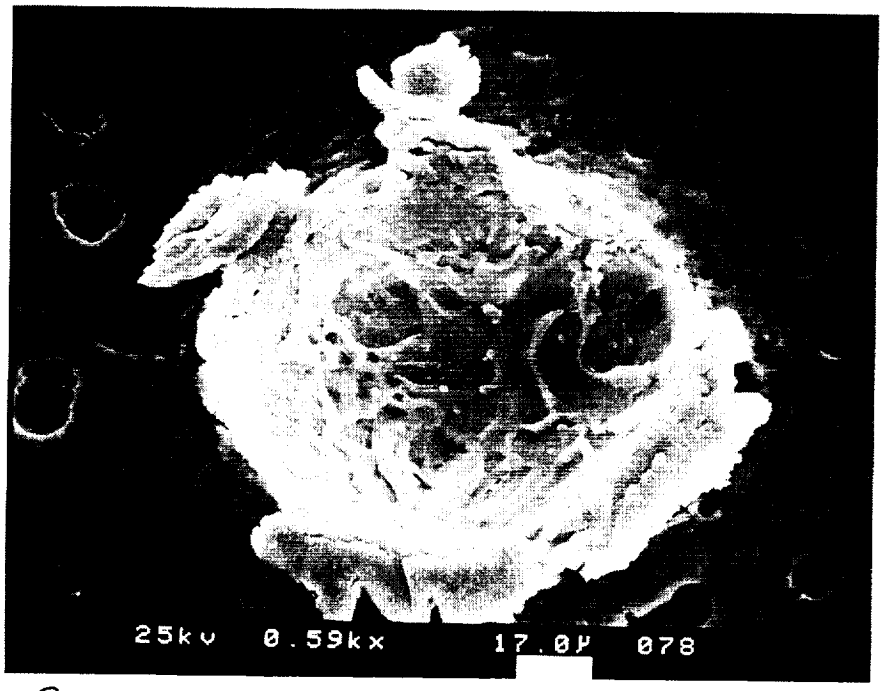


B11-C06, 005

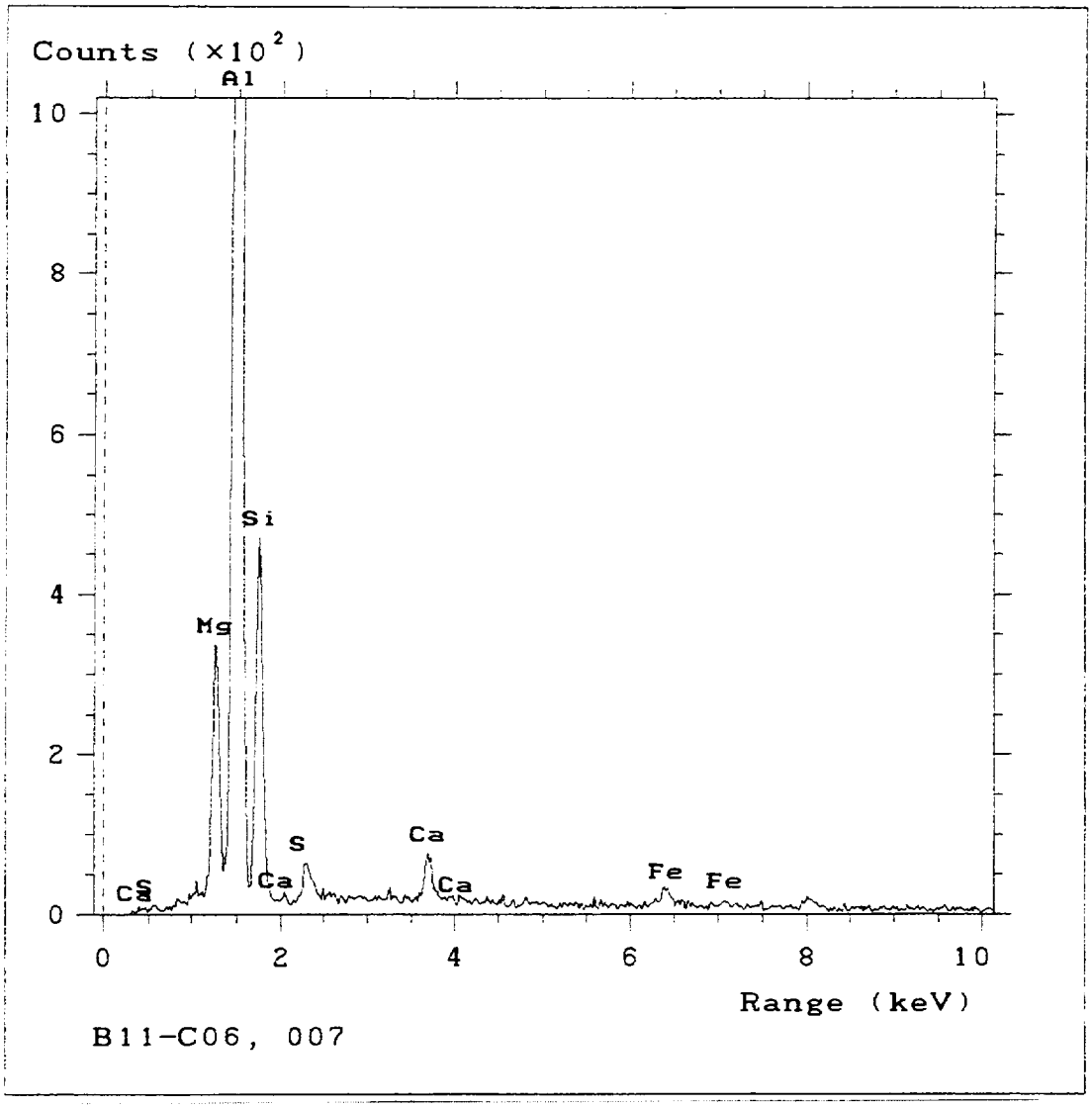


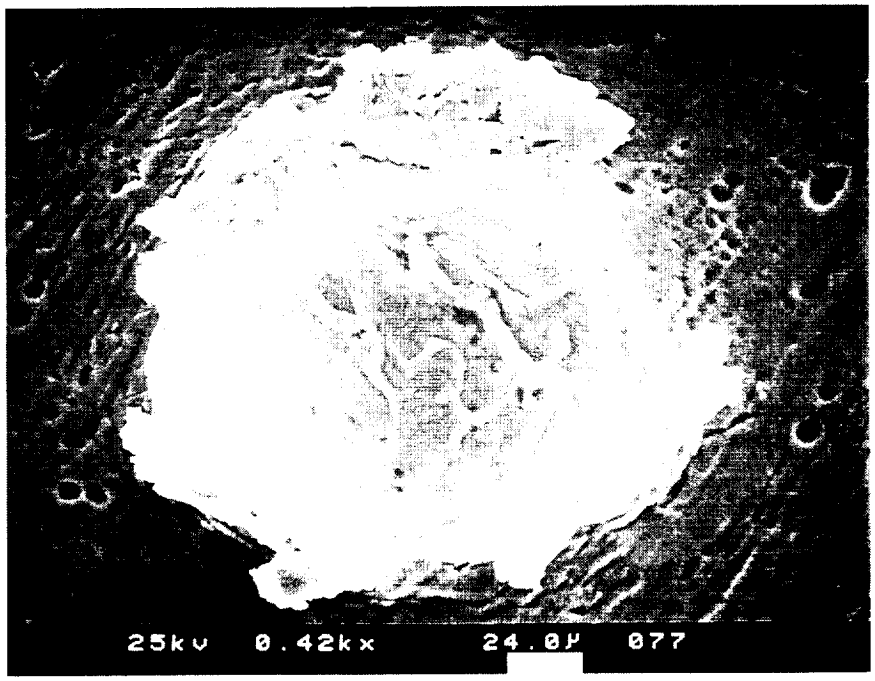
B11-C06 005 mm


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C06, 006

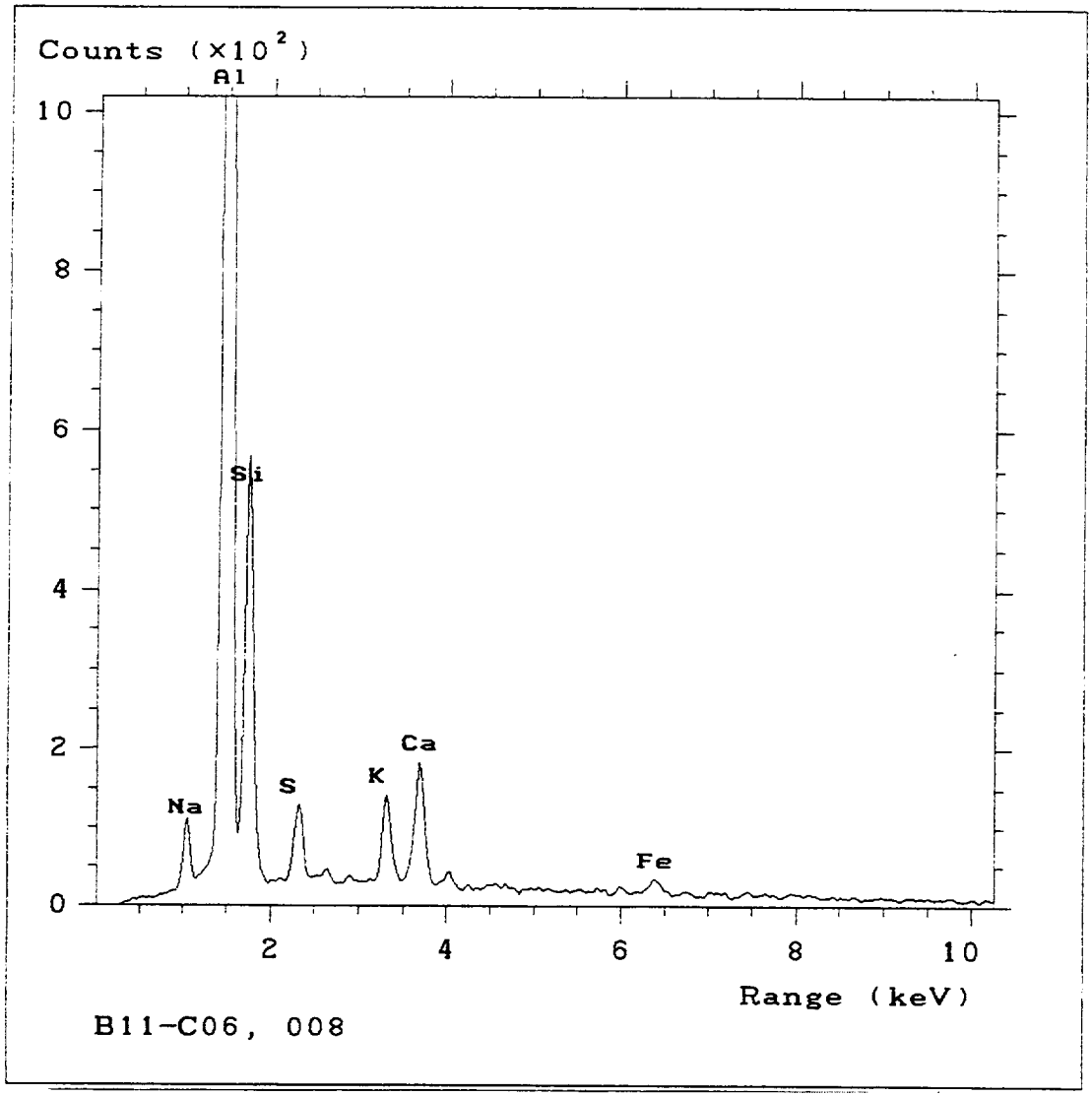

25kv 0.59kx 17.0µ 078

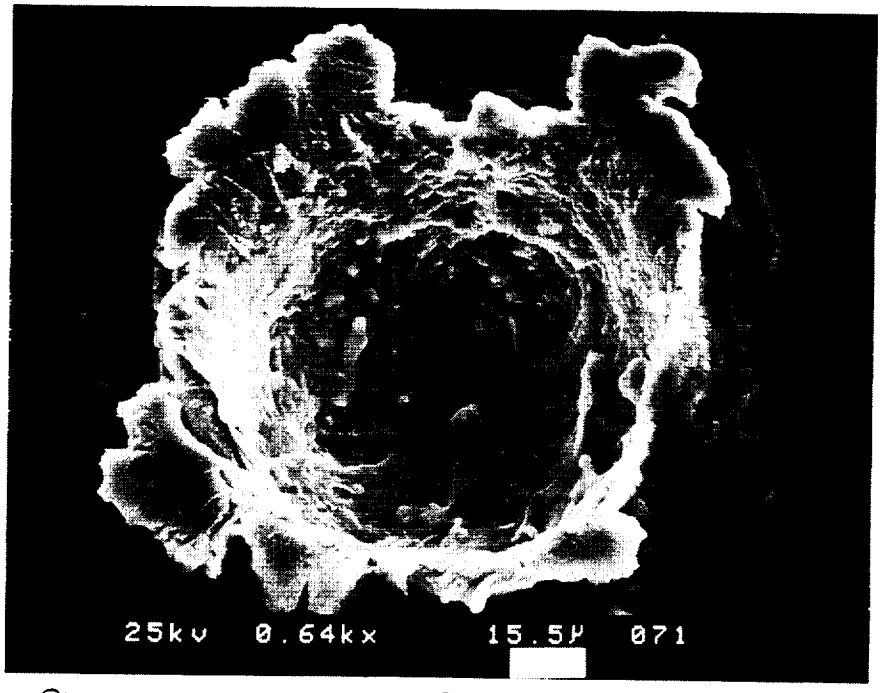
B11-C06 006


Counts (×10²)
Al
Si
Mg
S
Ca
Ca
Ca
S
Ca
Fe
Fe
0
2
4
6
8
10
Range (keV)
B11-C06, 007

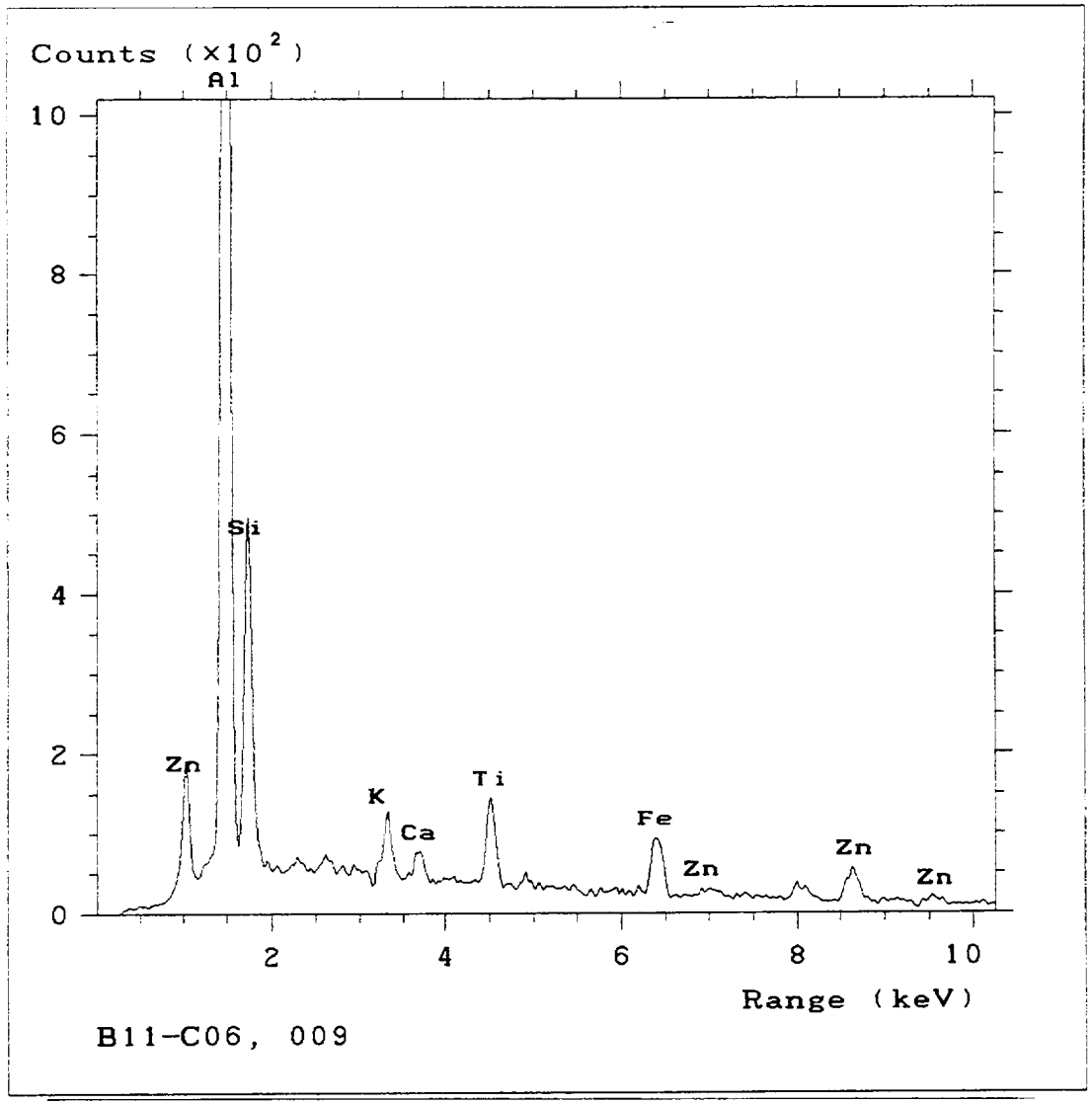

25kv 0.42kx 24.0μ 077

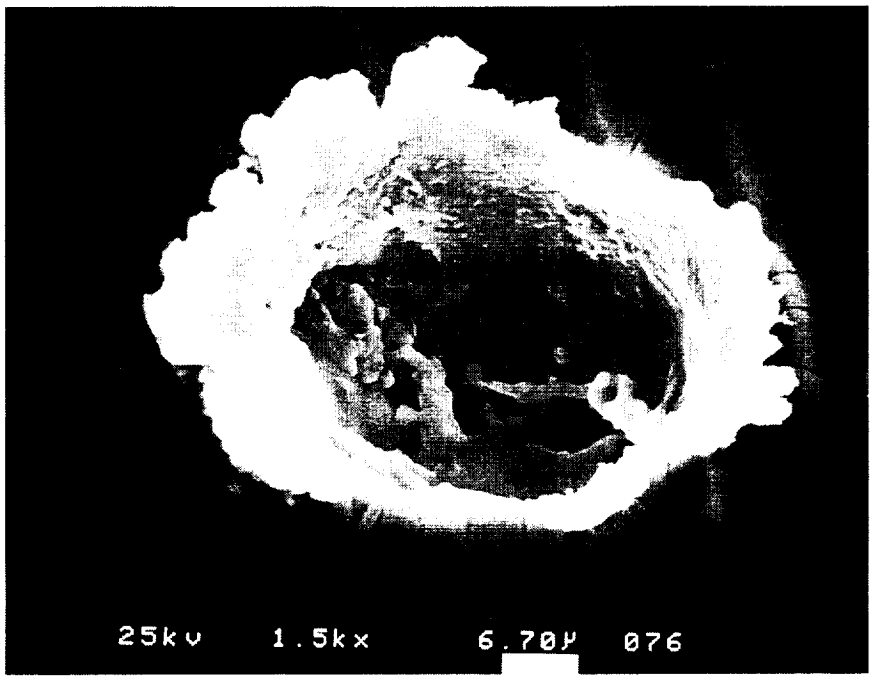
B11-C06 007



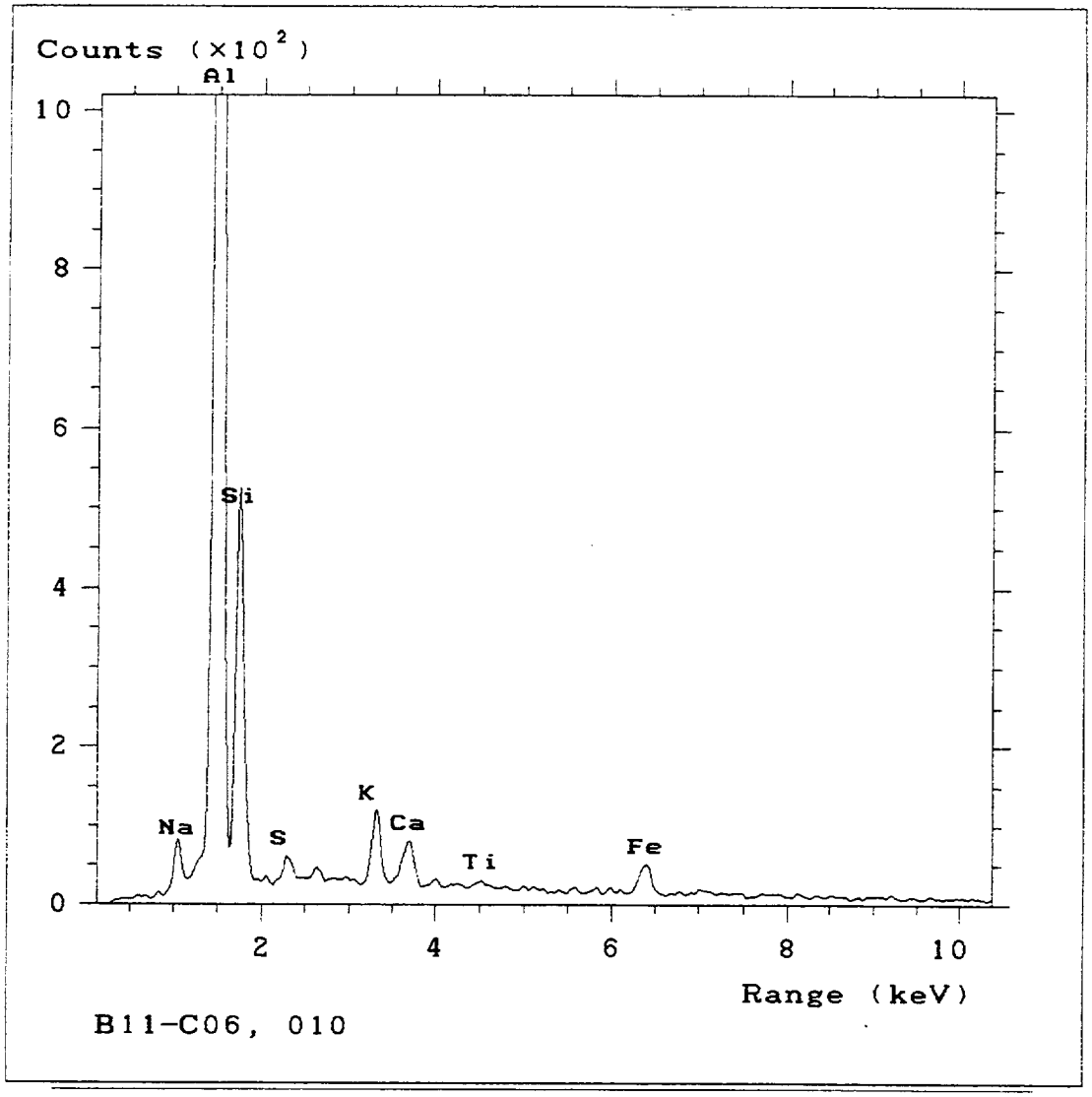


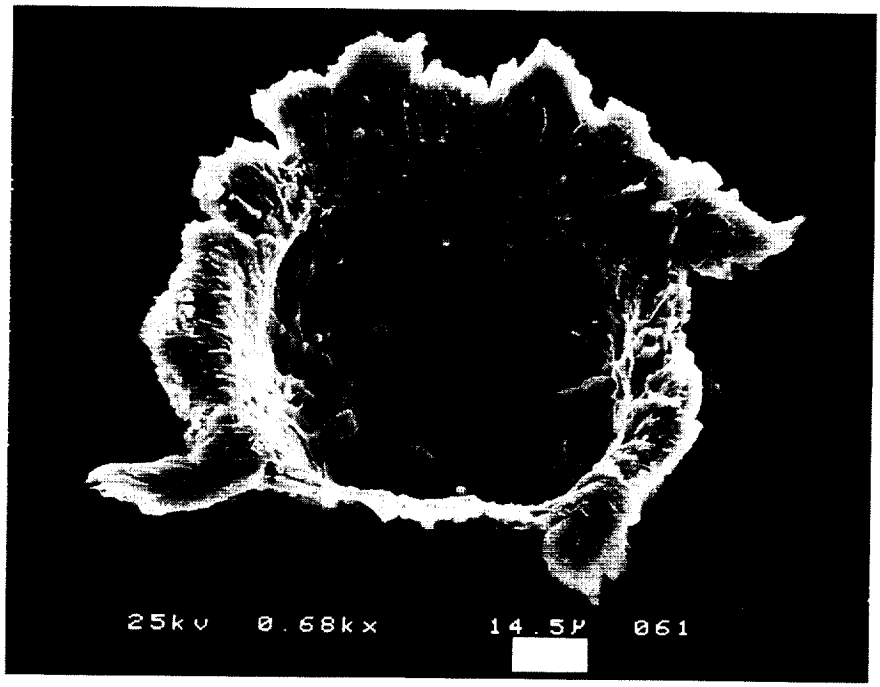
B11-C06 C08 mm



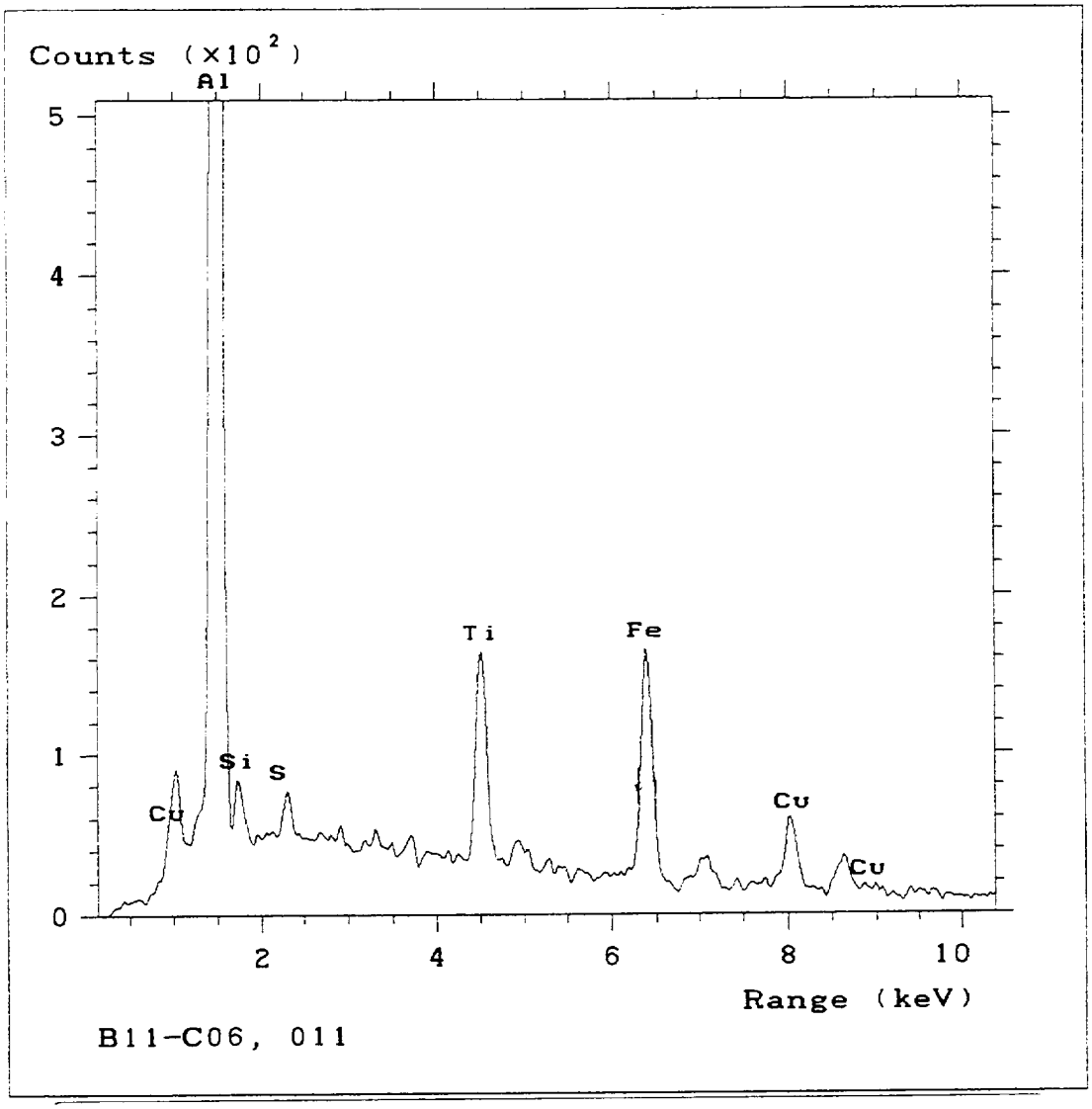


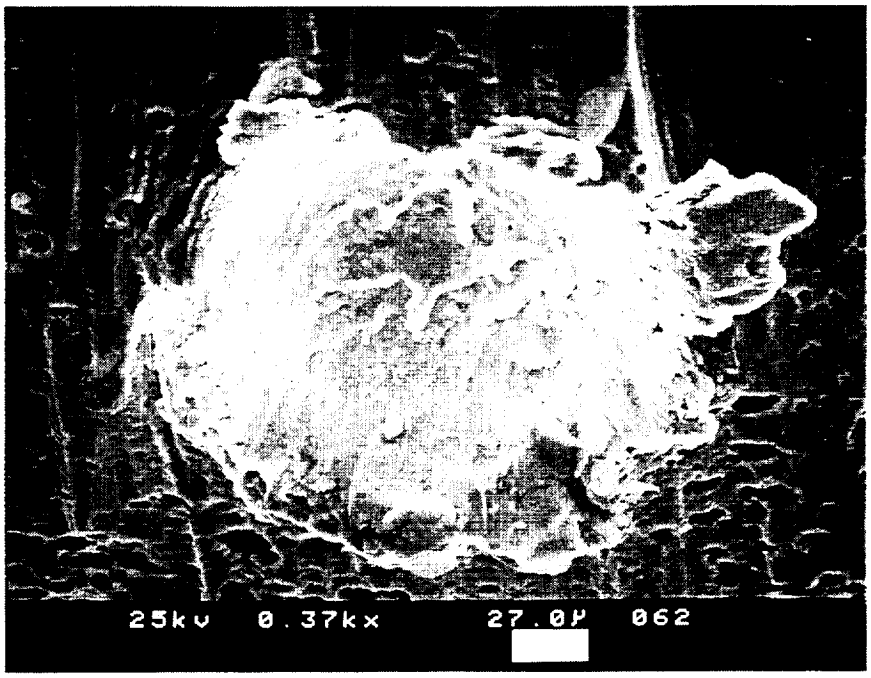
B11-C06 009 PAINT



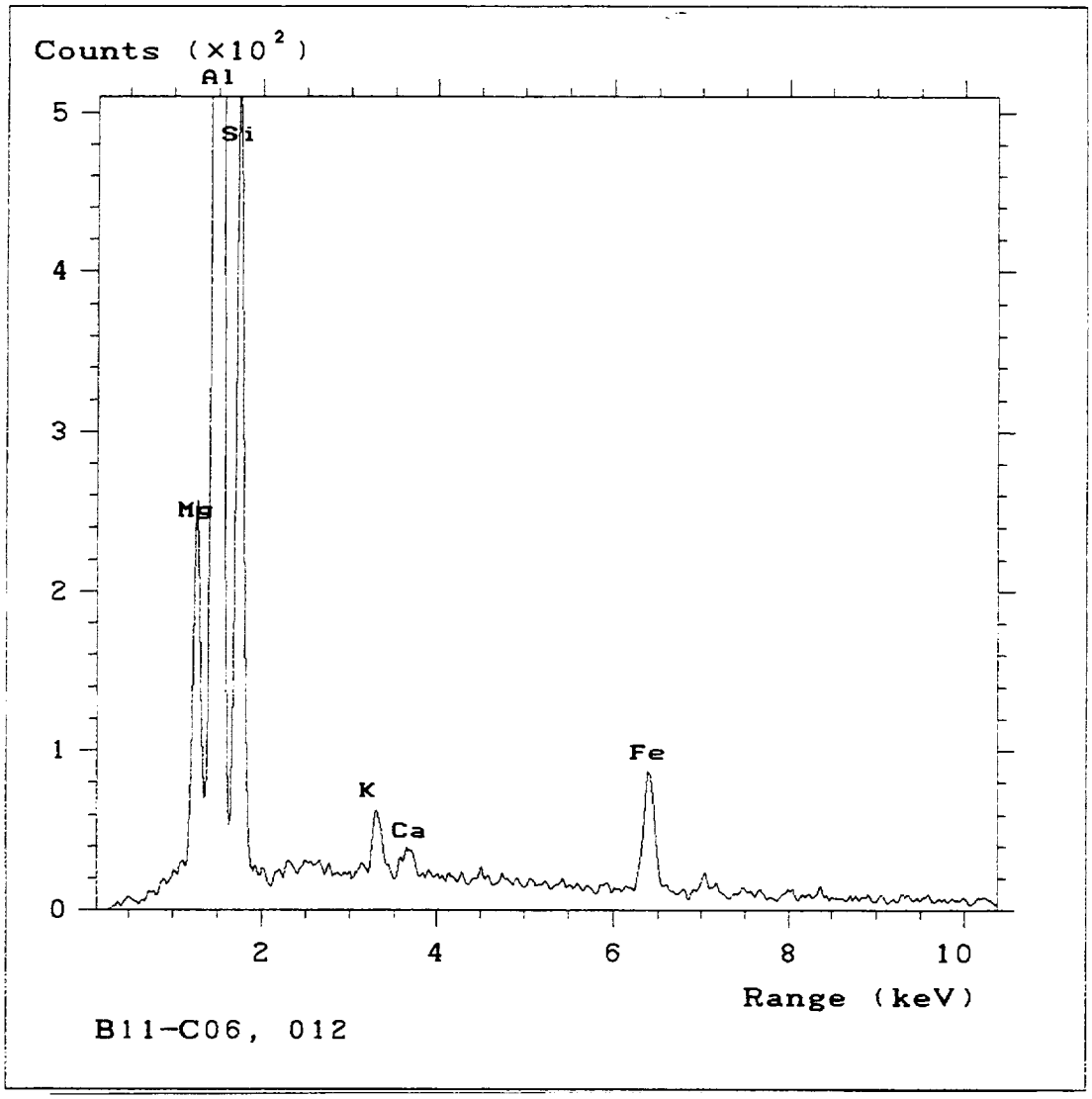


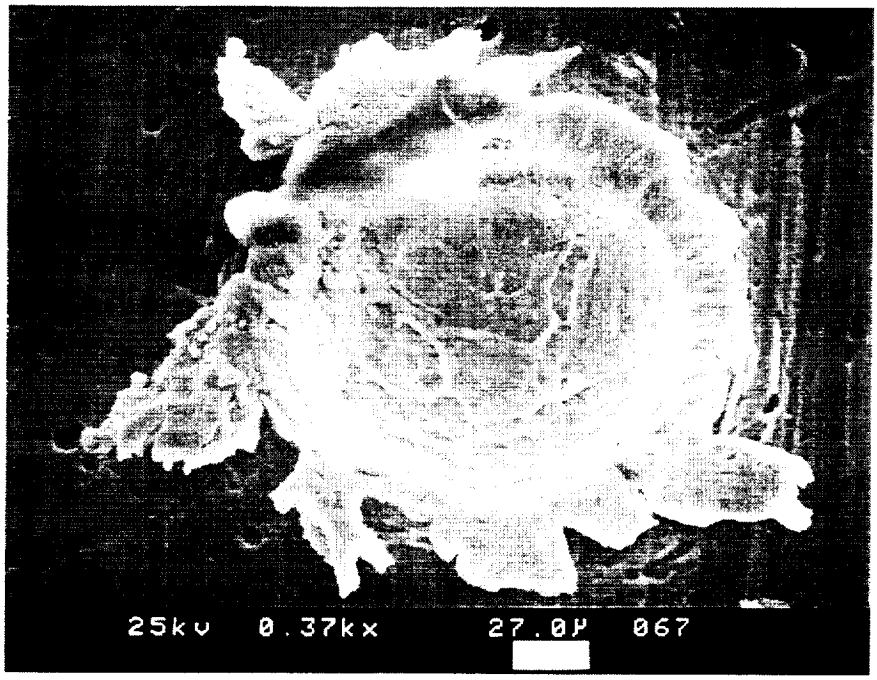
B11-C06 010 mm



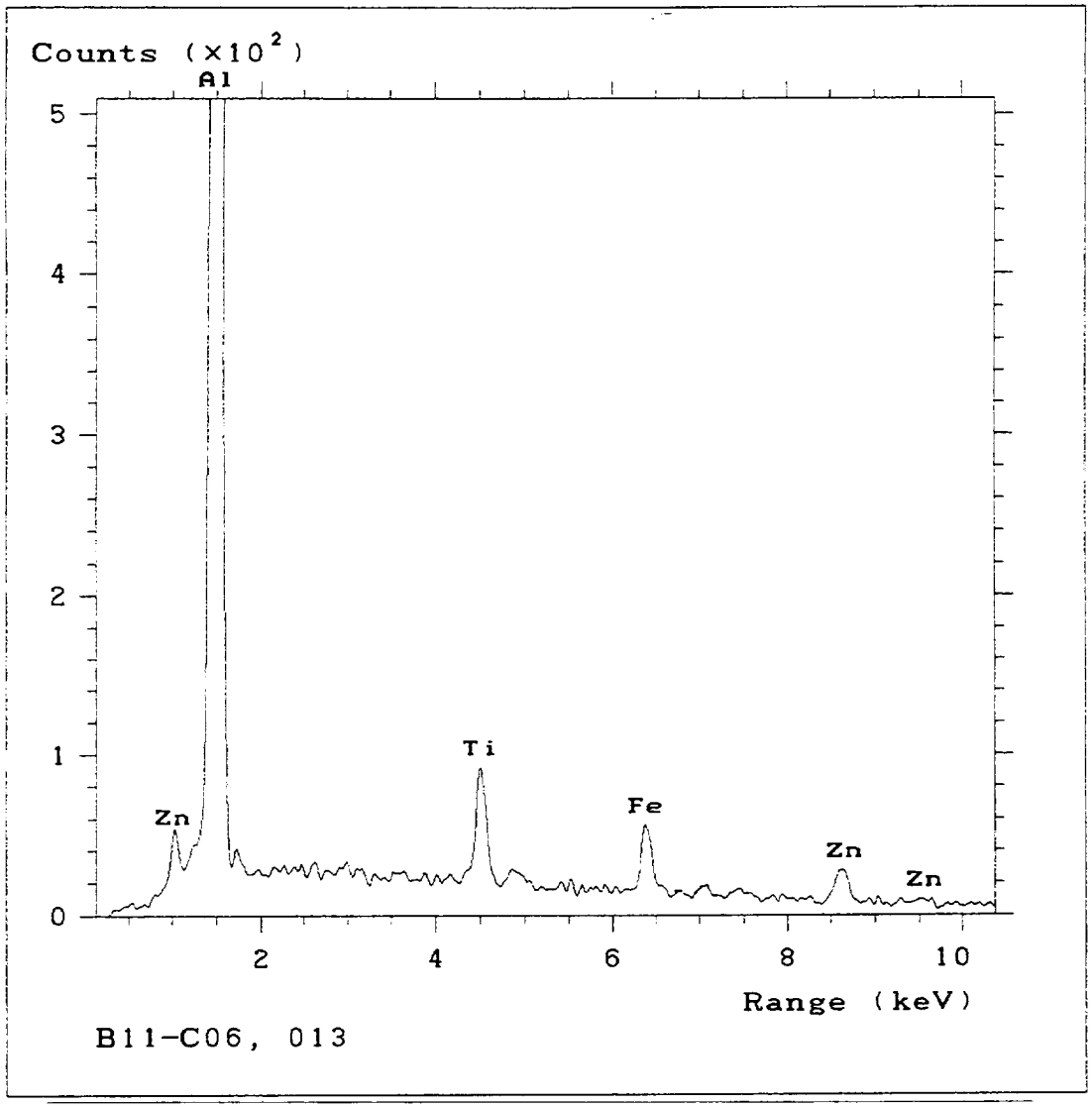


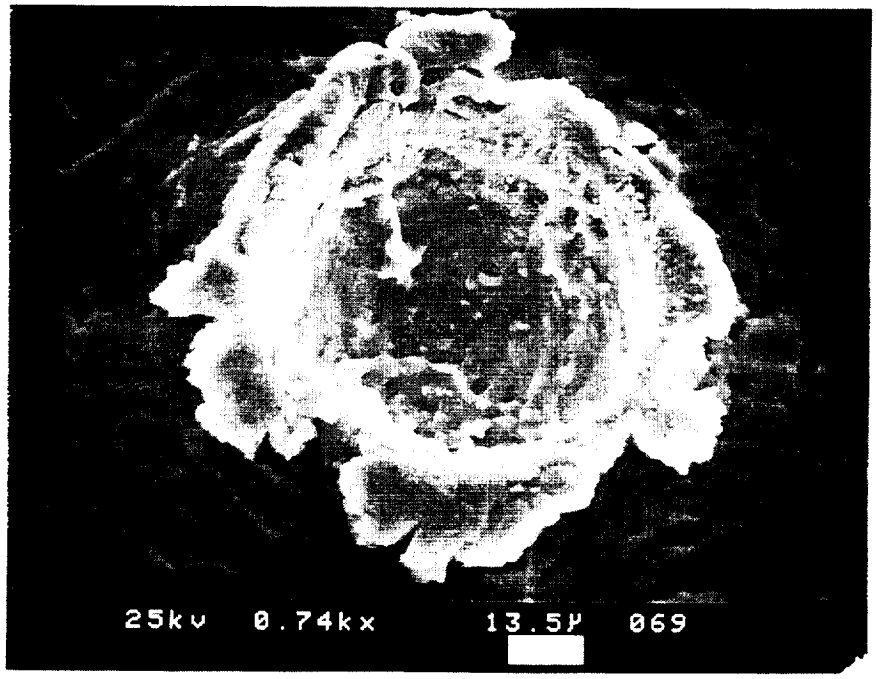
B11-C06 011 PAINT



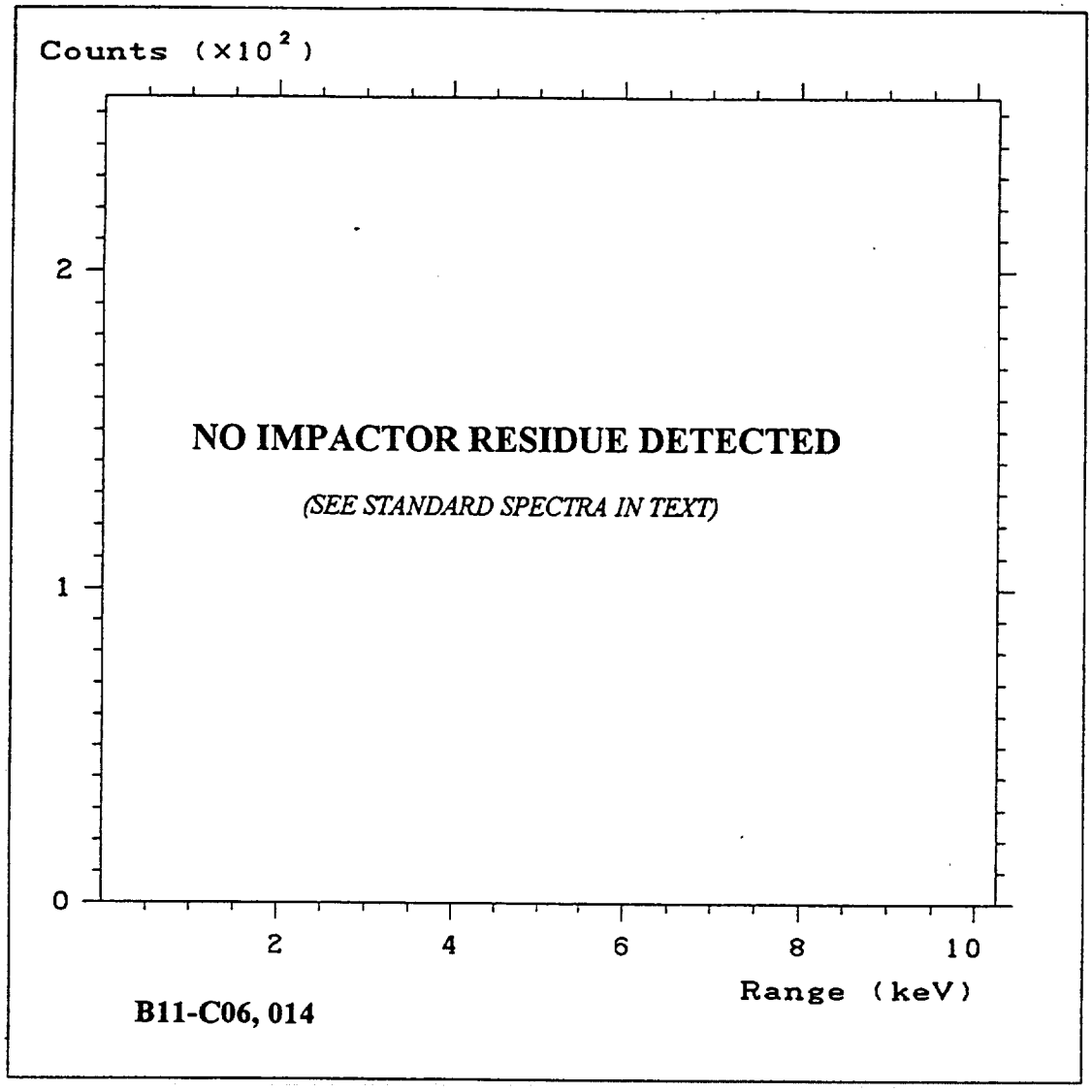


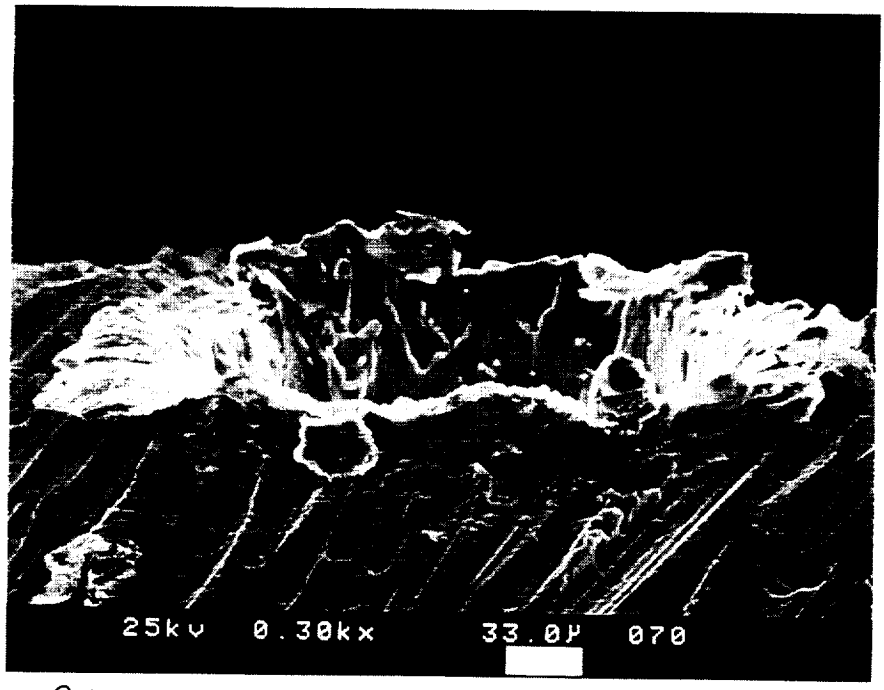
B11-C06 012 mm



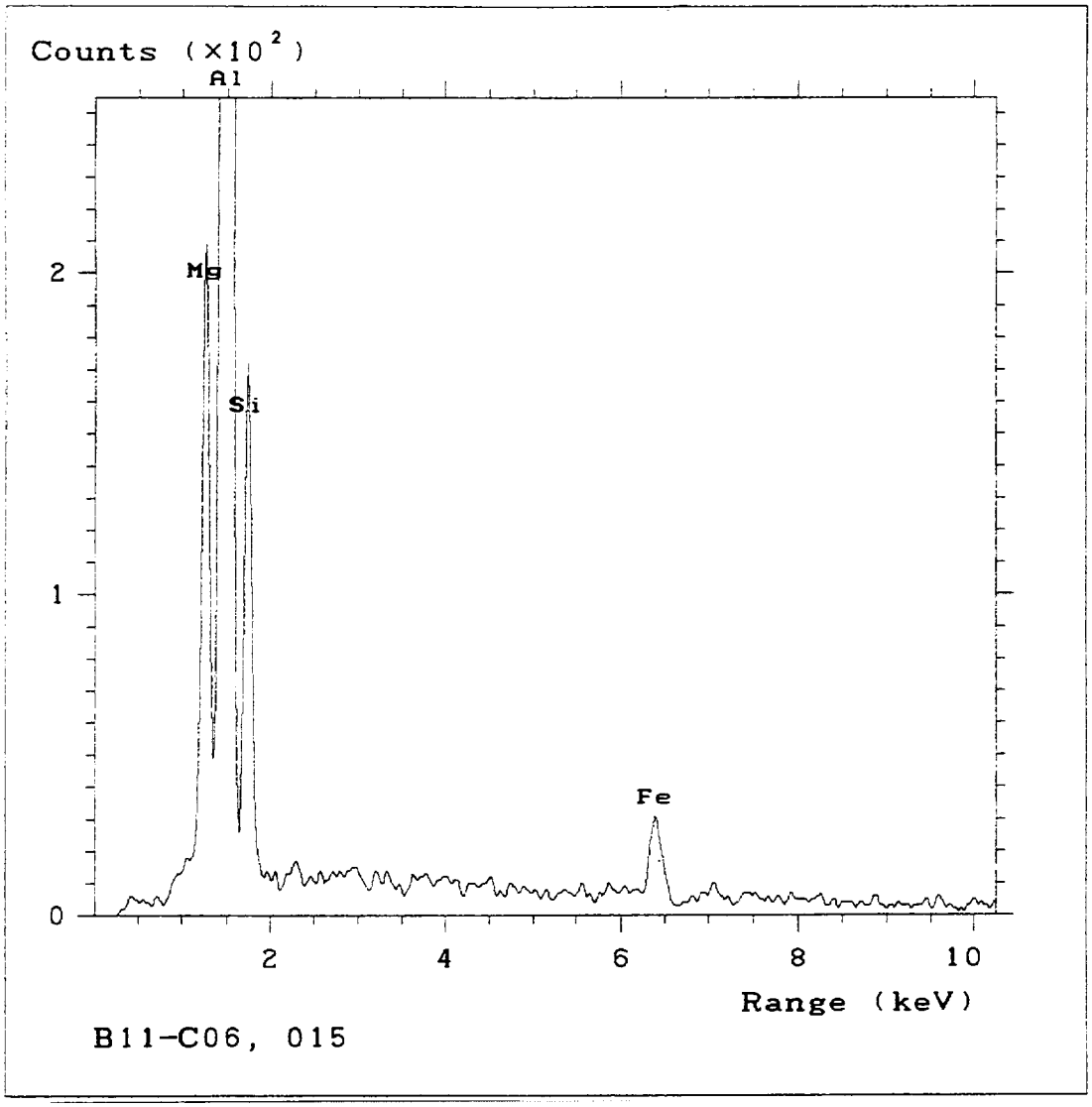


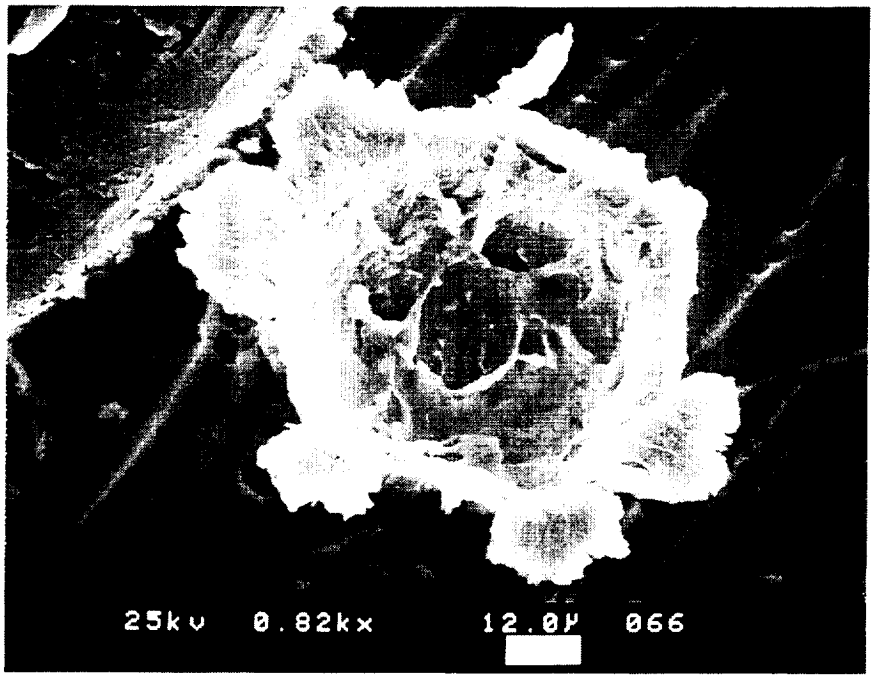
B11-C06 013 PAINT


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C06, 014


25kv 0.30kx 33.0µ 070

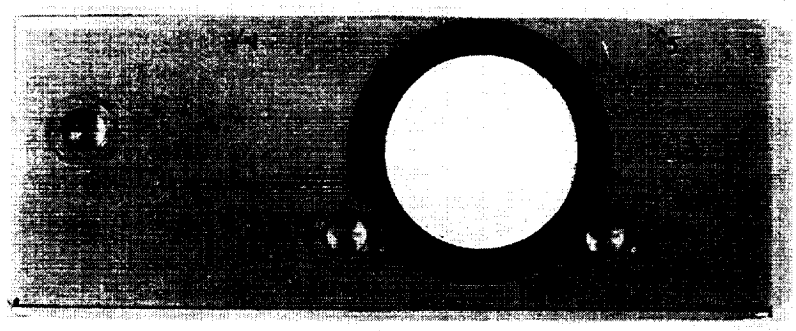
B11-C06 014

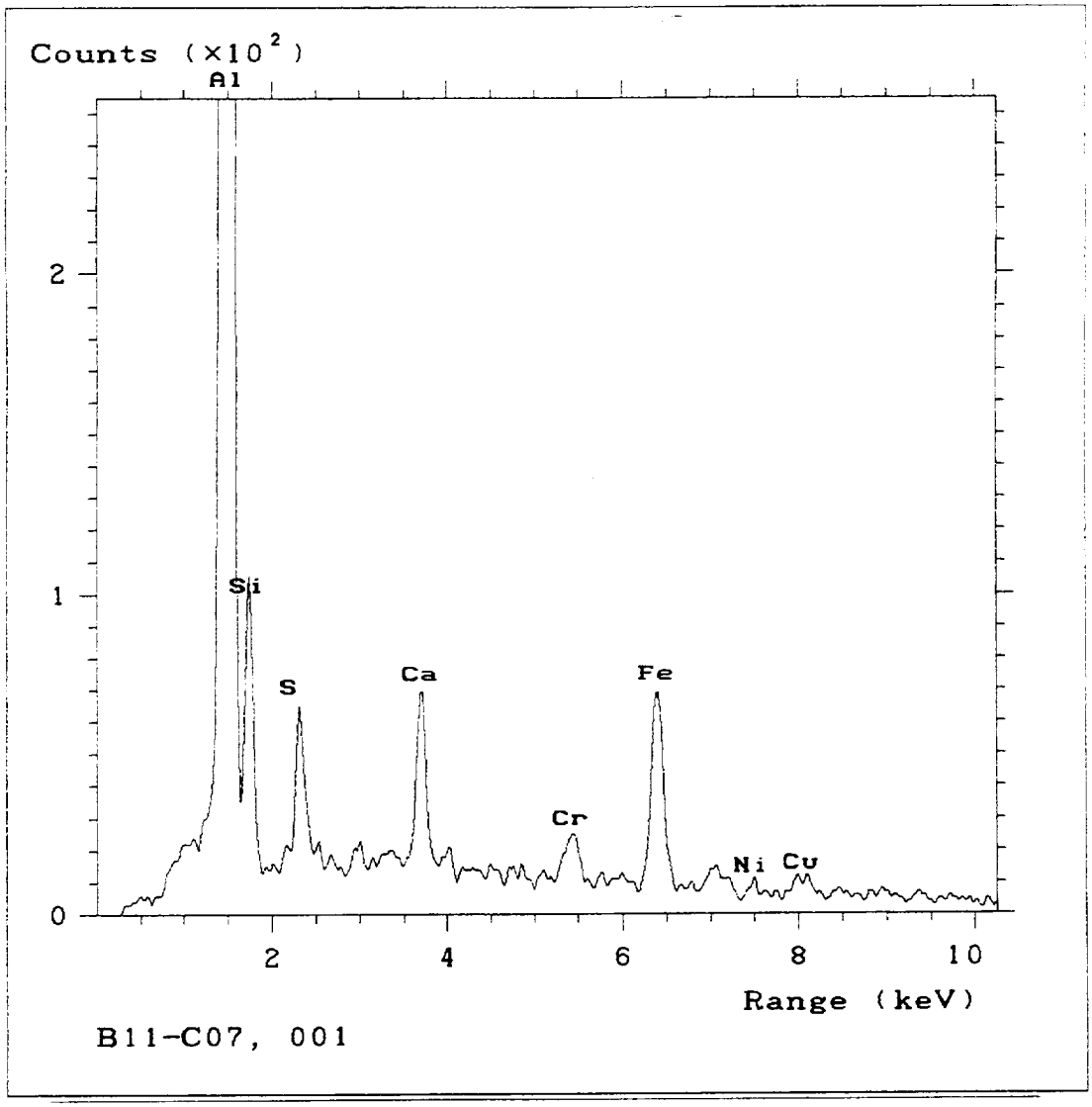


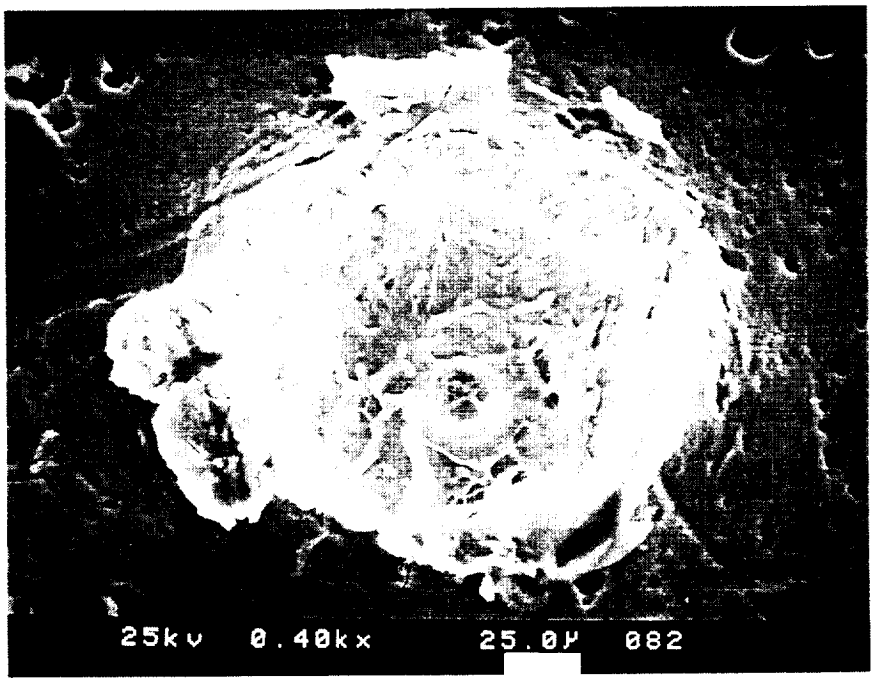


B11-C06 015 mm

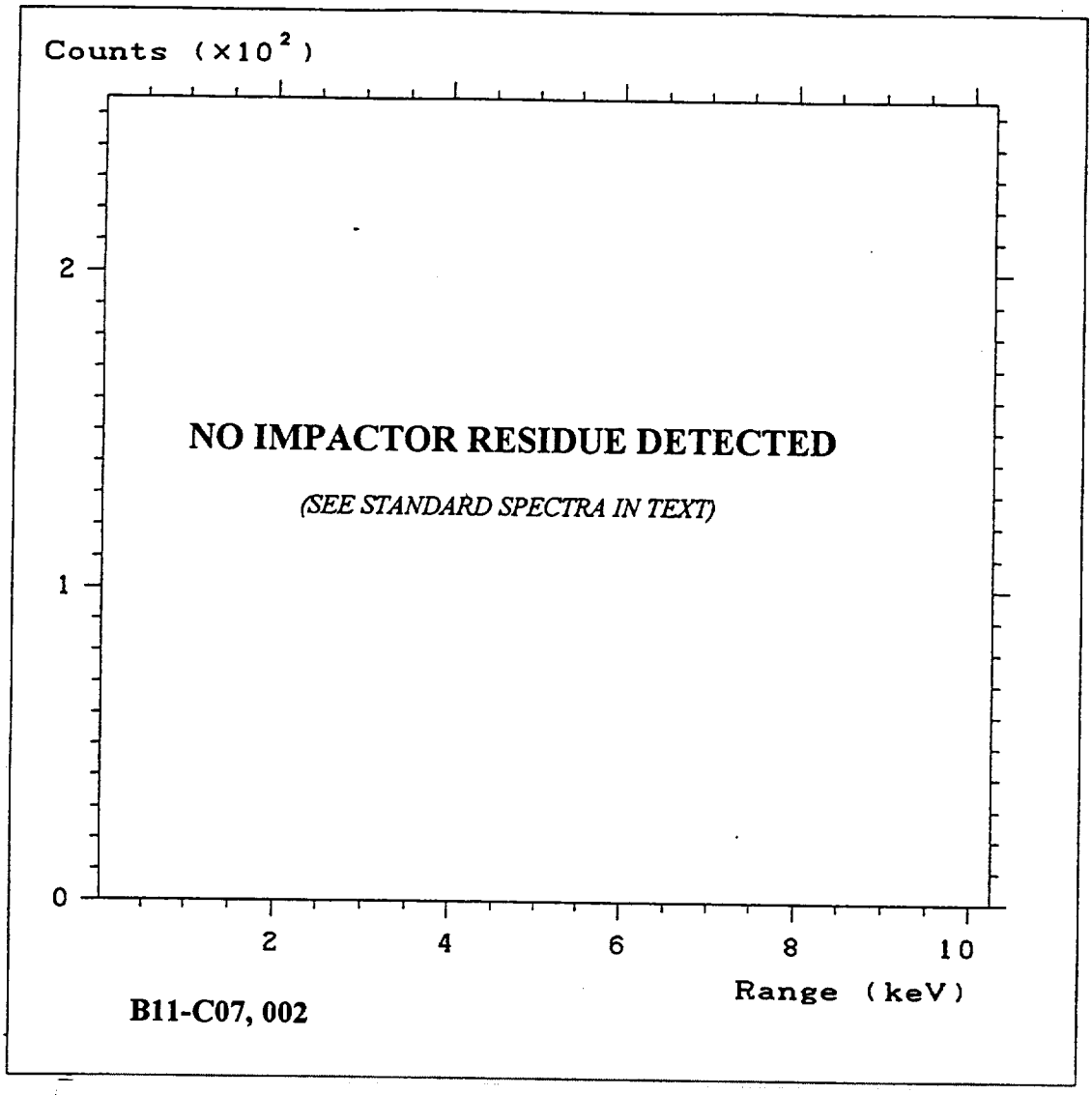
CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B11-C07	001	116	3	170	MICROMETEORITIC
	002	49	19	200	UNKNOWN
	003	88	27	150	PAINT PATCH
	004	36	42	250	MICROMETEORITIC
	005	109	46	60	UNKNOWN

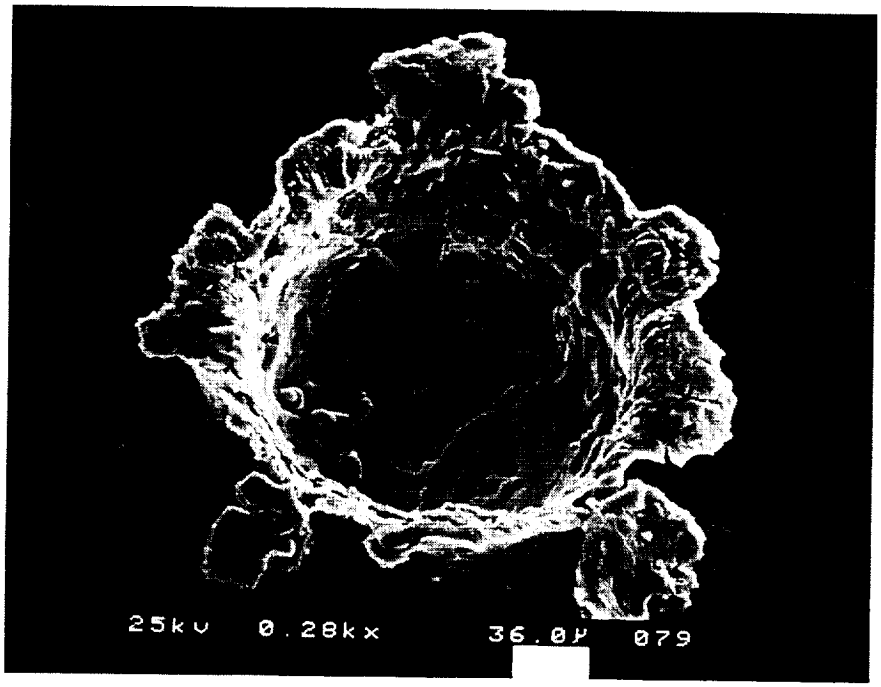




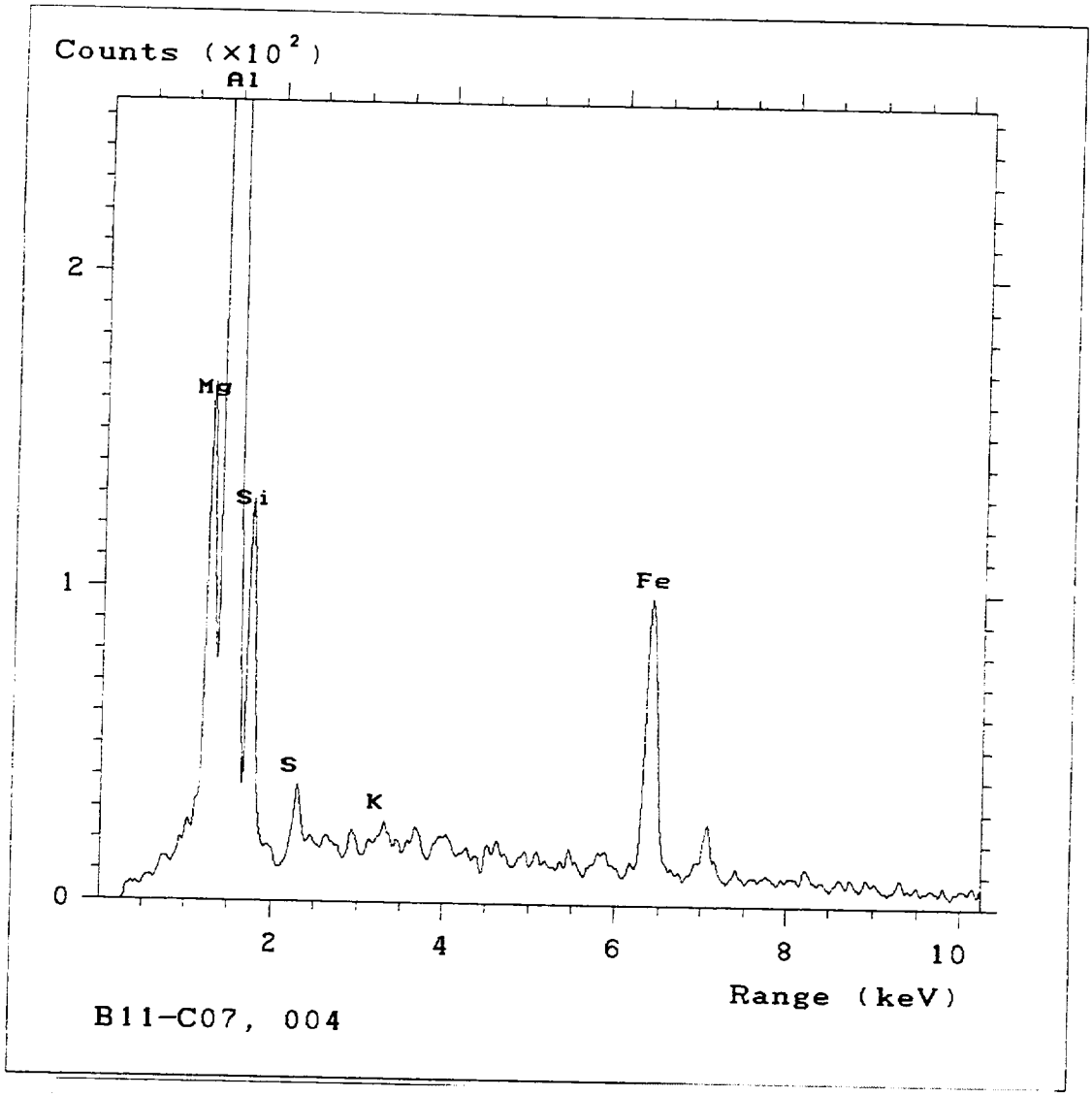


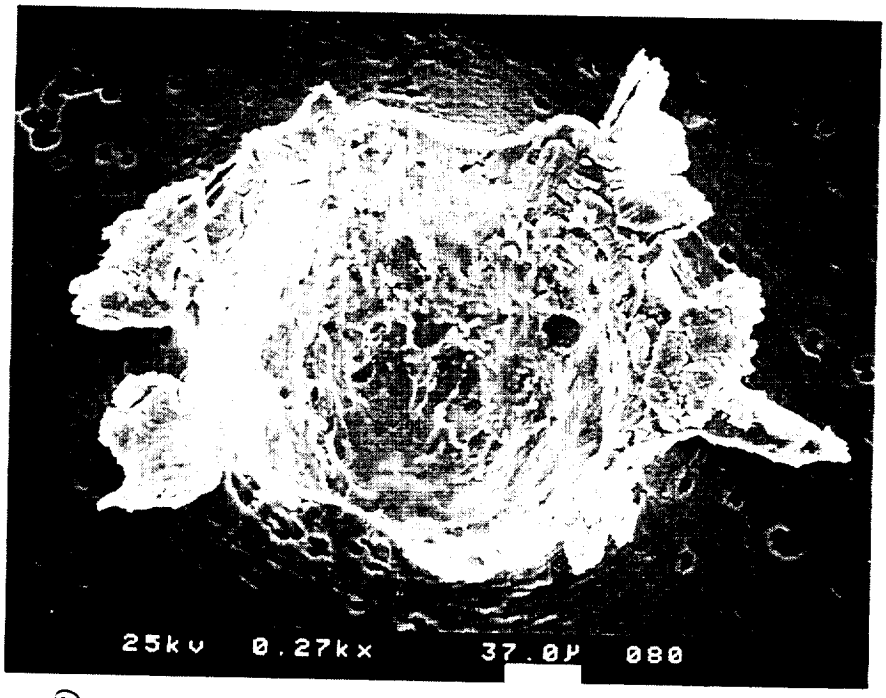
B11-C07 001 mm


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C07, 002

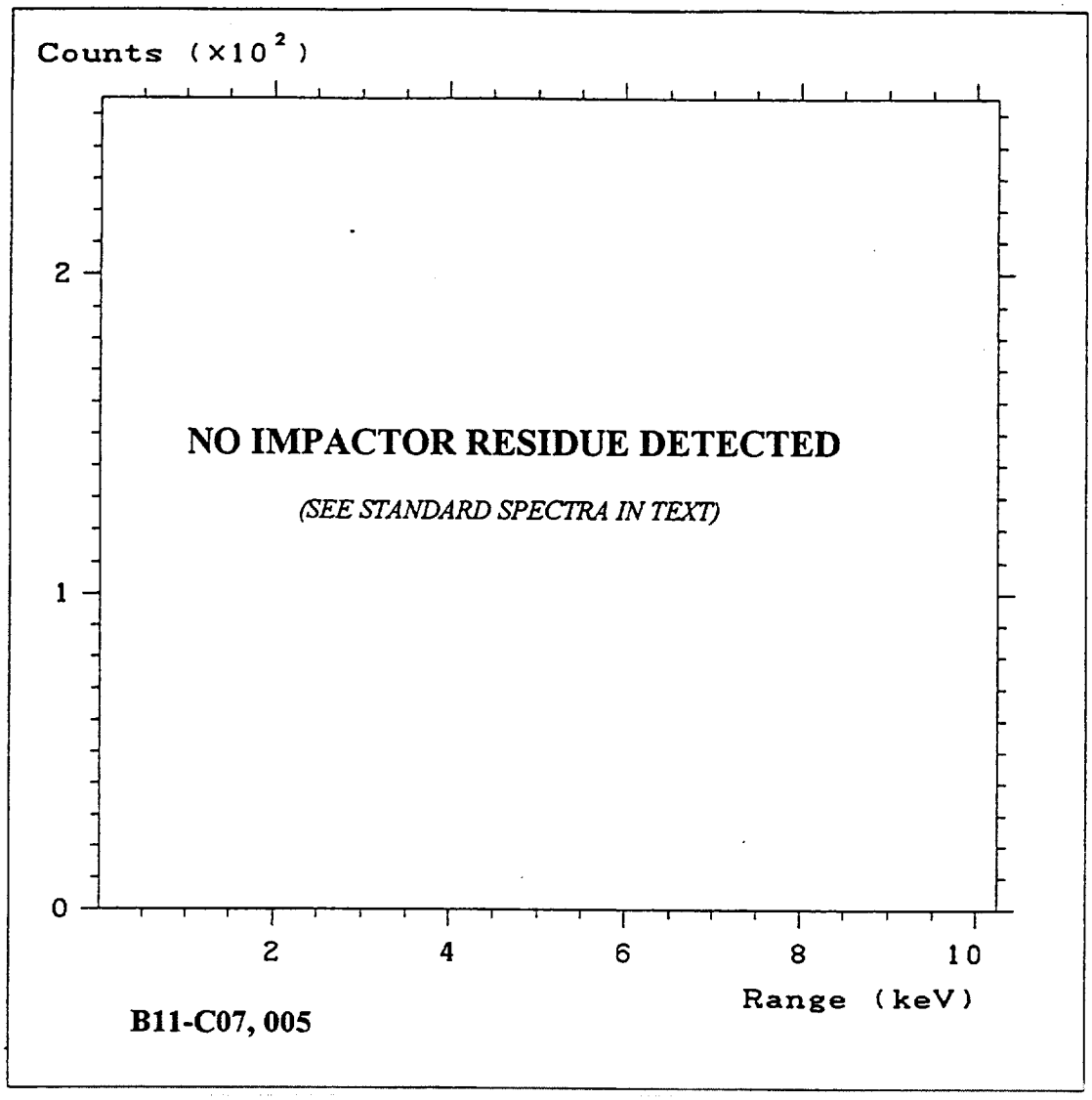

25kv 0.28kx 36.0µ 079

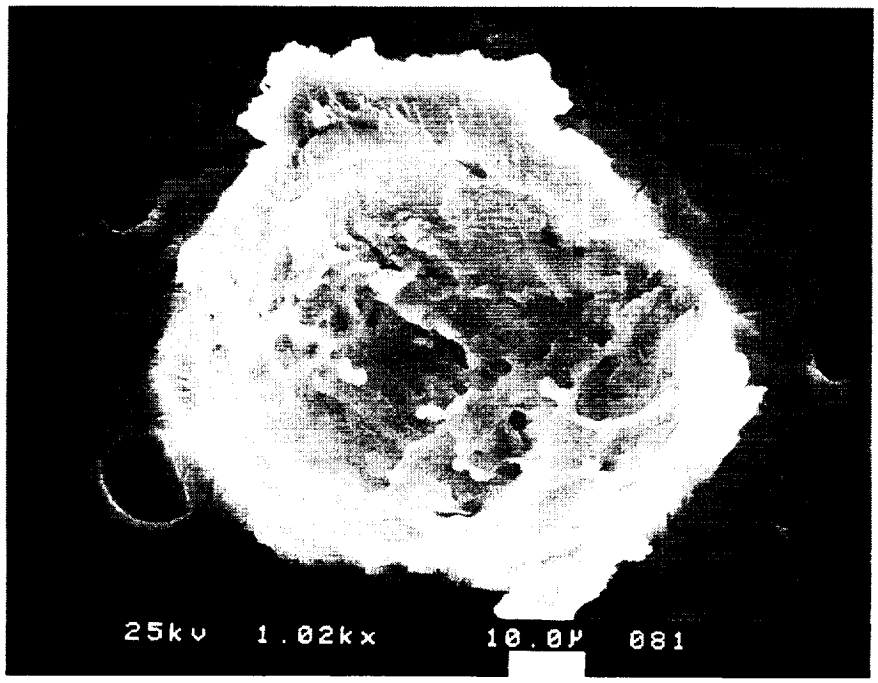
B11 - C07 002





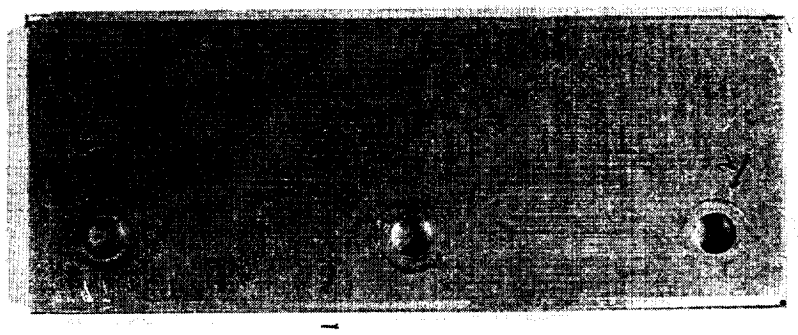
B11-C07 004 MM


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B11-C07, 005

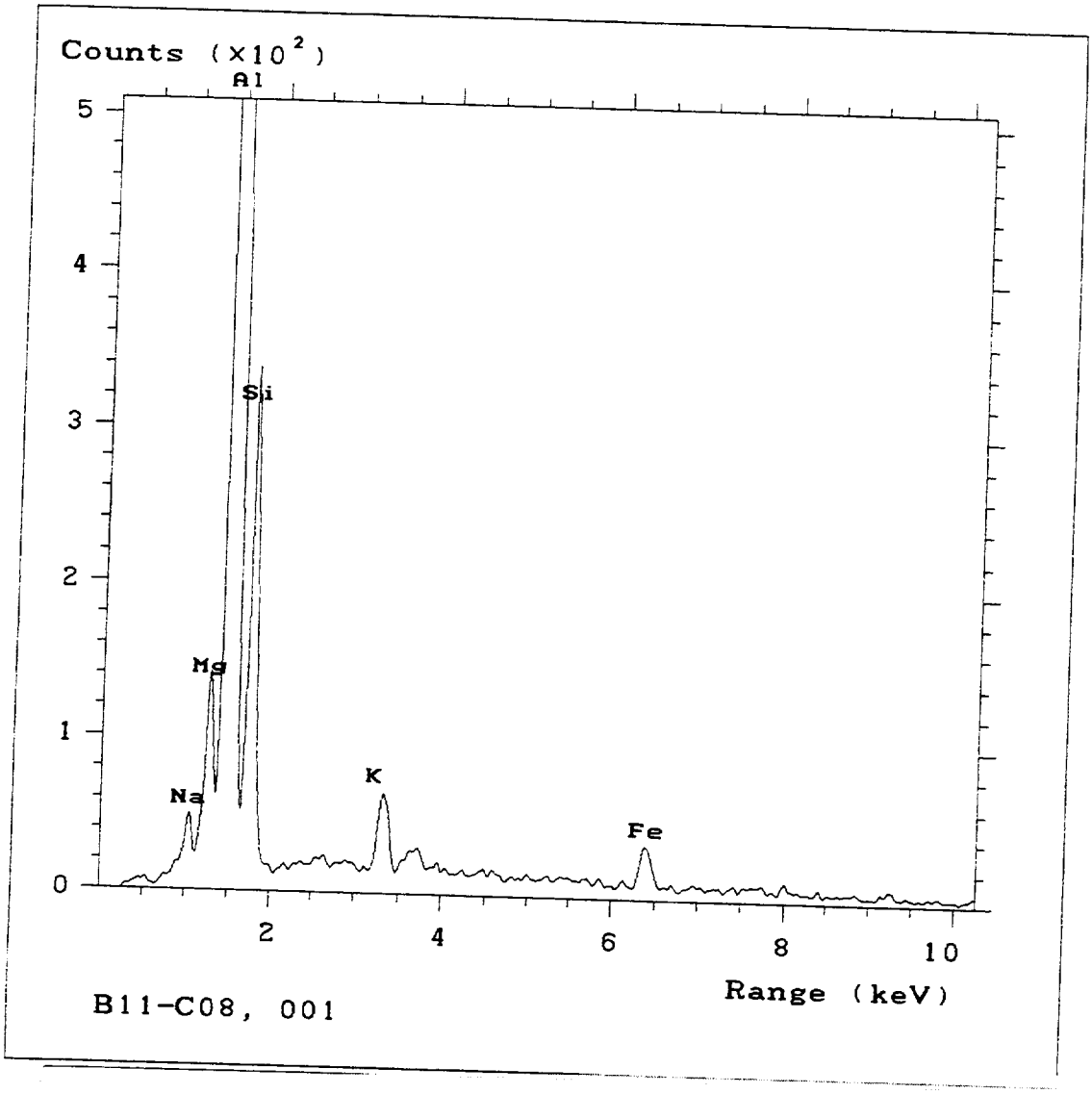

25kv 1.02kx 10.0µ 081

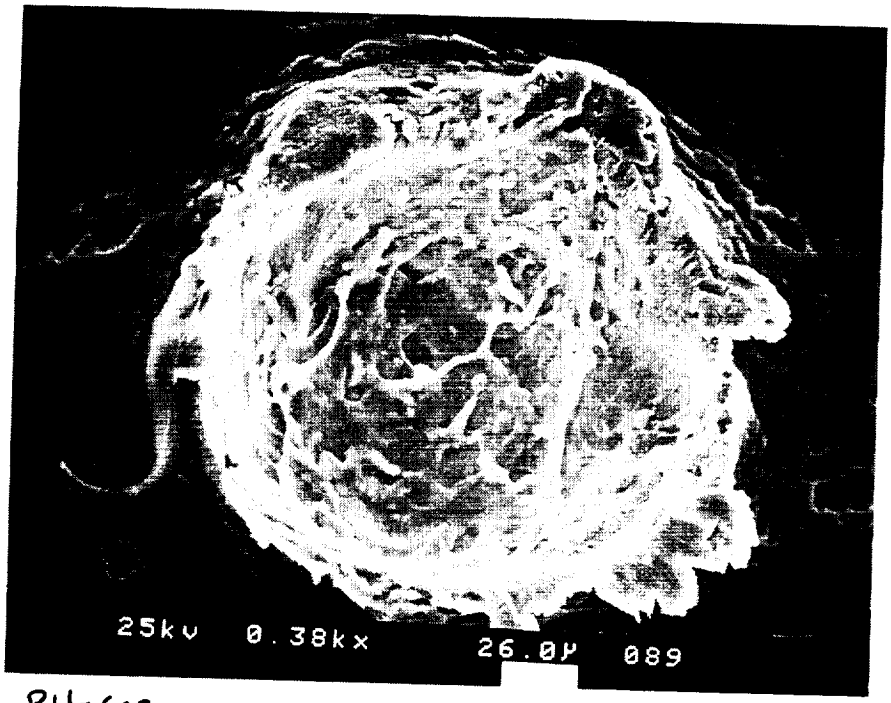
B11-C07 005

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B11-C08	001	2	77	200	MICROMETEORITIC
	002	18	10	500	UNKNOWN
	003	21	74	220	UNKNOWN
	004	24	79	70	MICROMETEORITIC
	005	22	84	160	MICROMETEORITIC
	006	44	99	150	MICROMETEORITIC
	007	24	120	30	PAINT
	008	25	109	30	ELECTRICAL



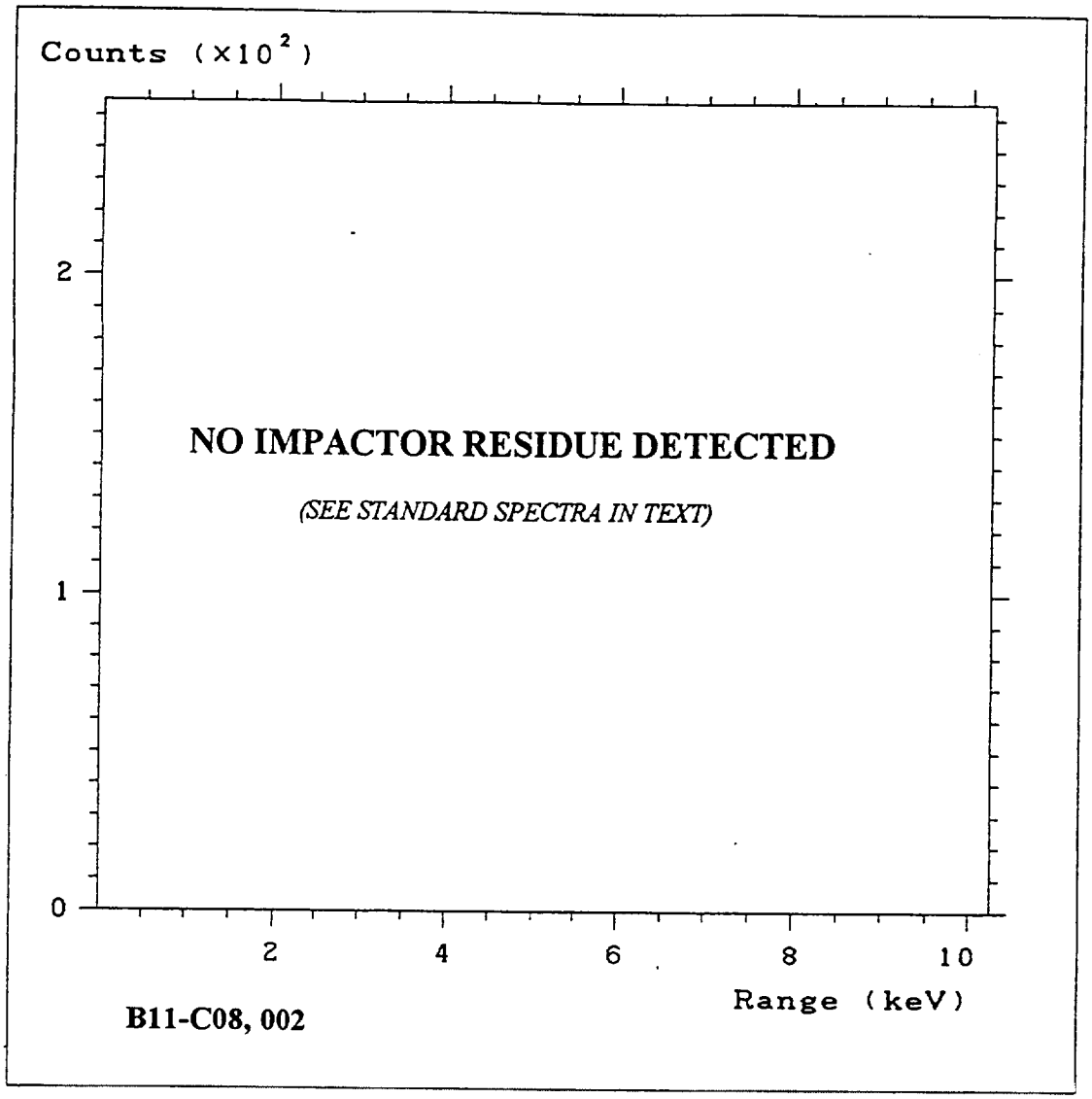
B11-C08

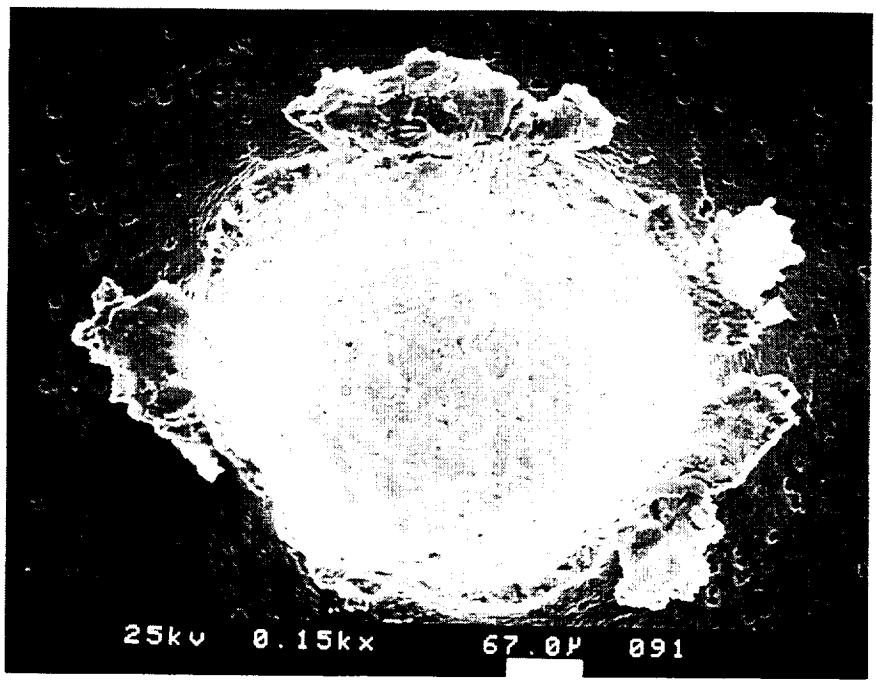




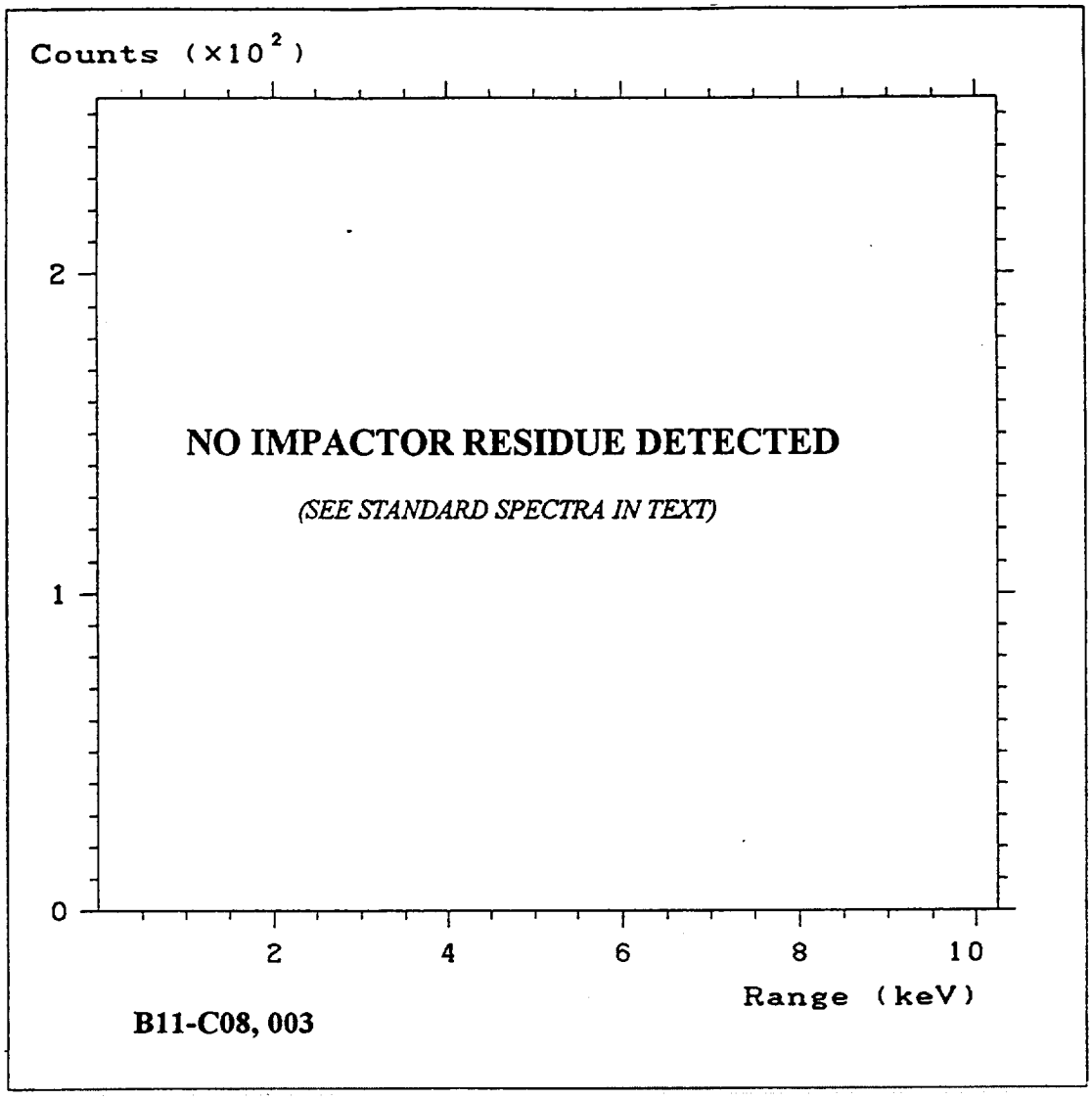
B11-C08 001

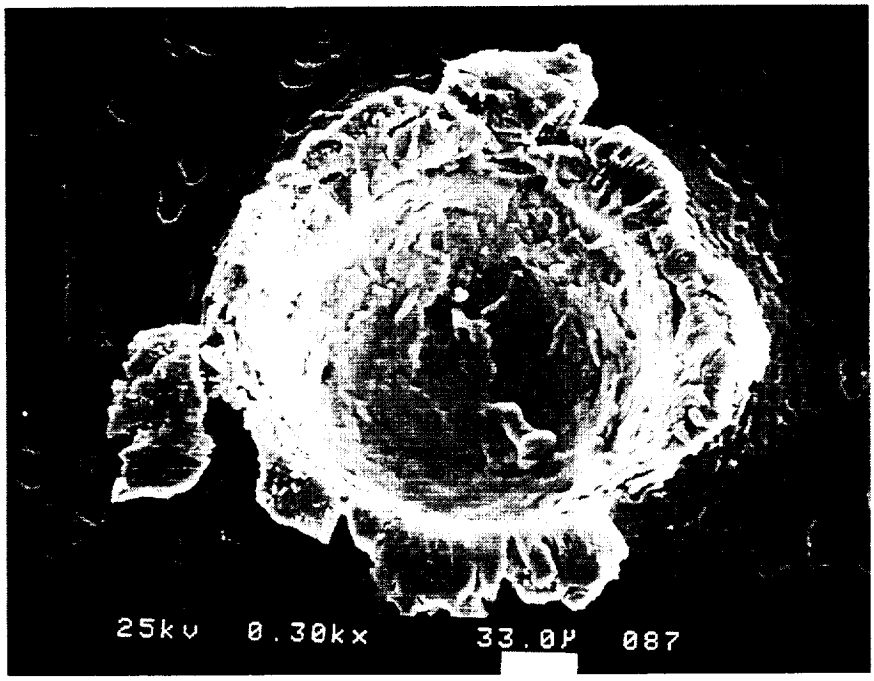
MM


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C08, 002

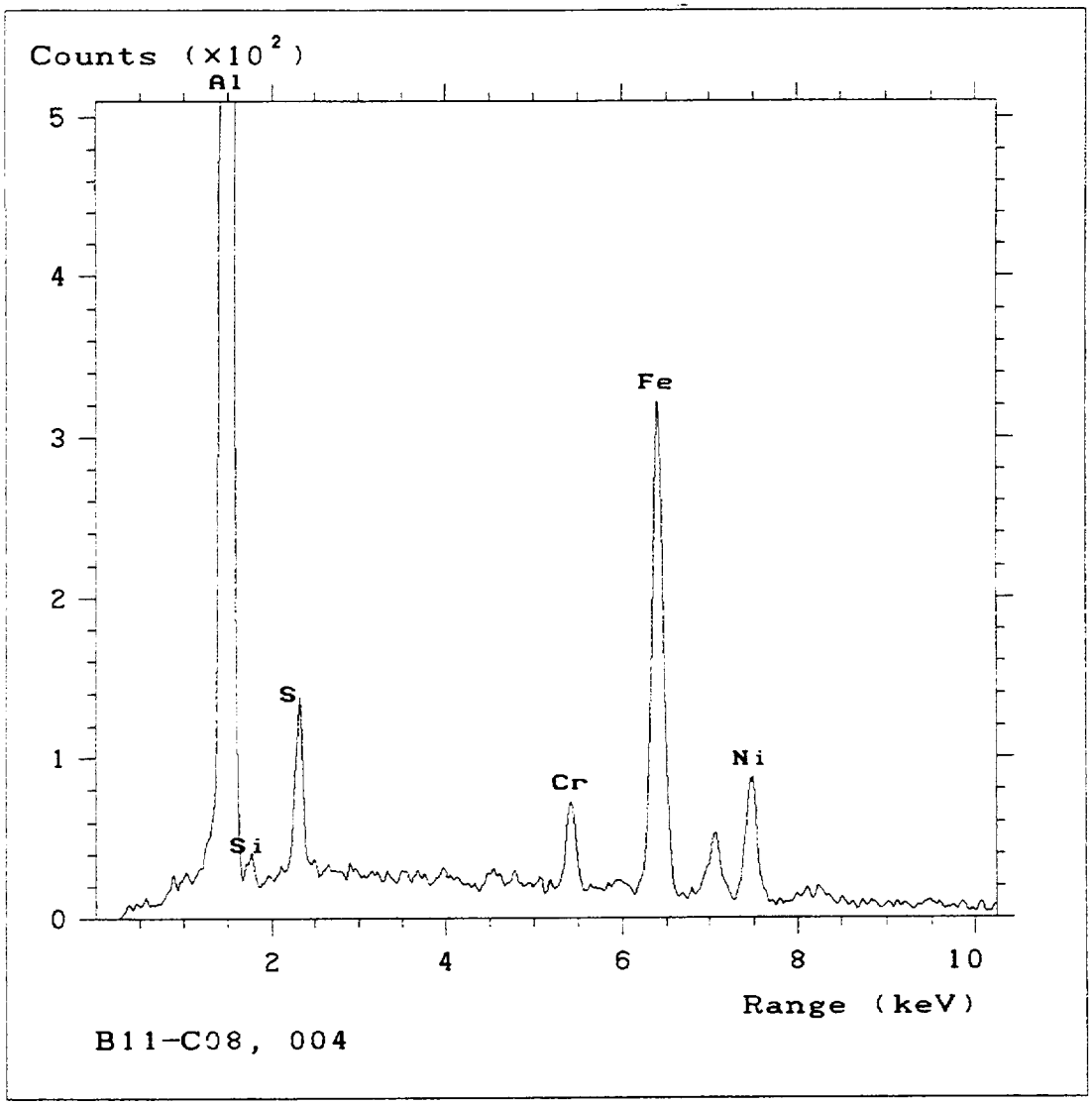

25kv 0.15kx 67.0µ 091

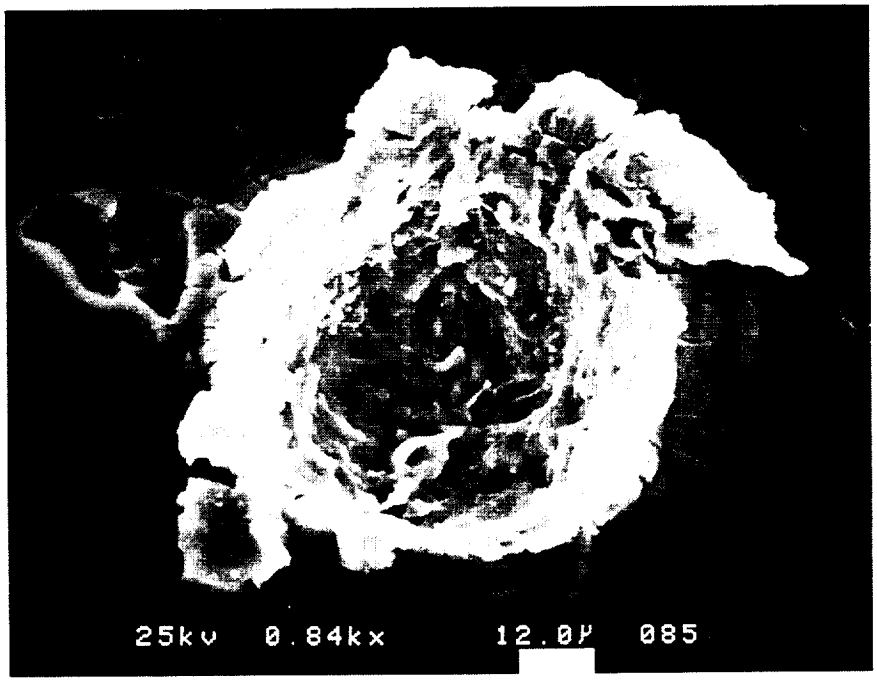
B11-C08 002


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B11-C08, 003

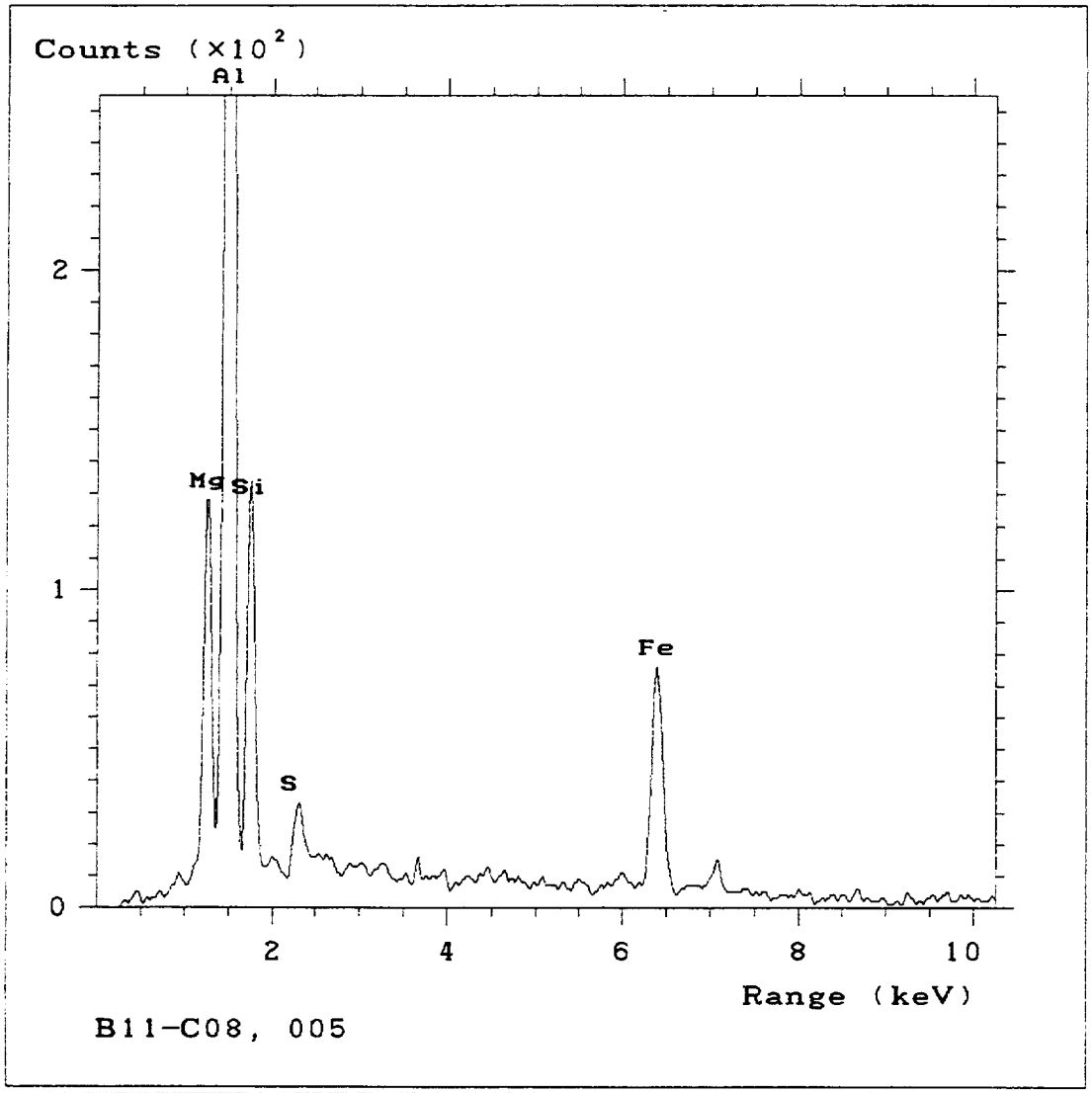

25kv 0.30kx 33.0µ 087

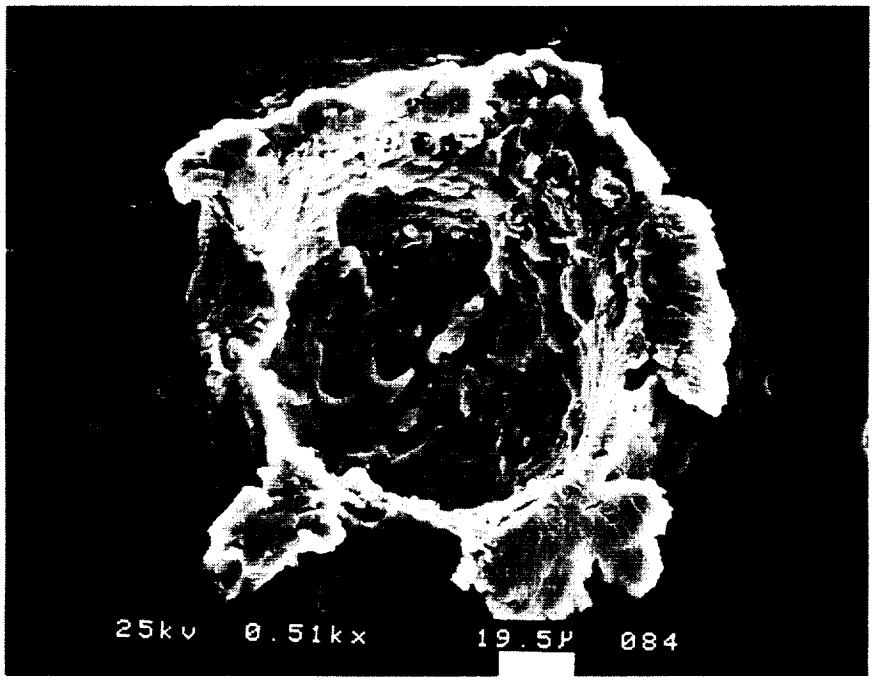
B11-C08 003



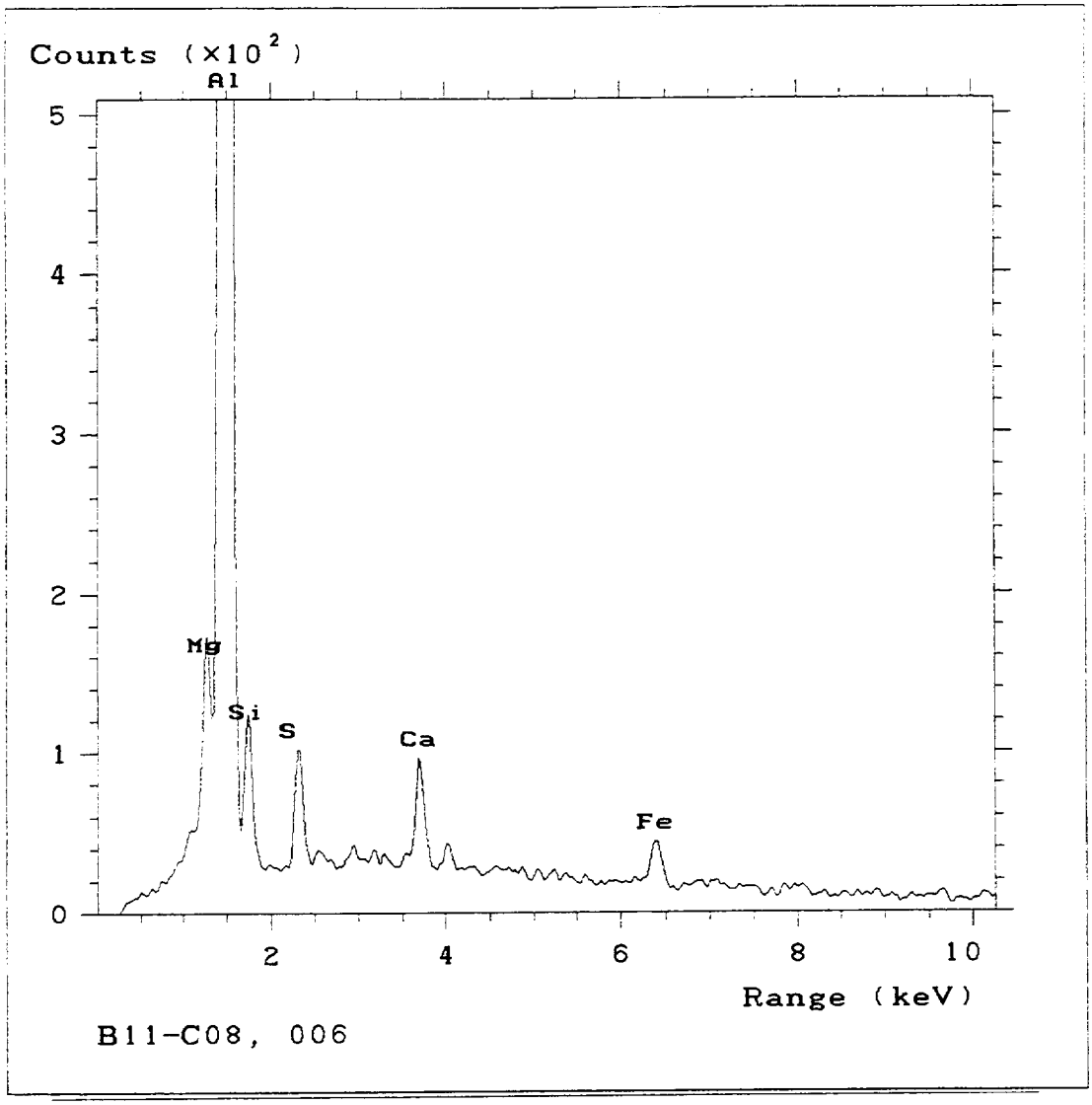


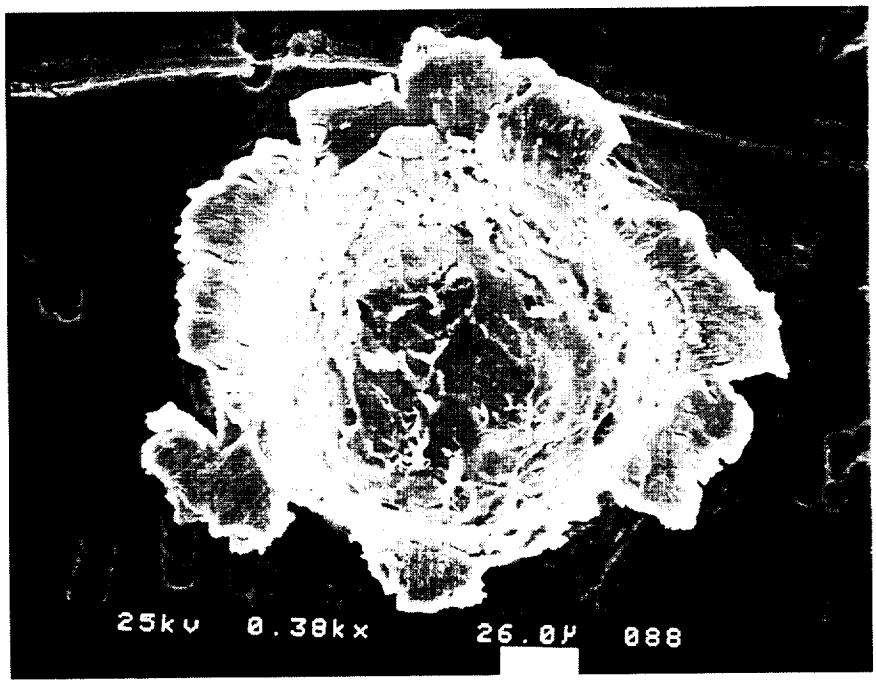
B11-C08 004 Fe,Ni, S



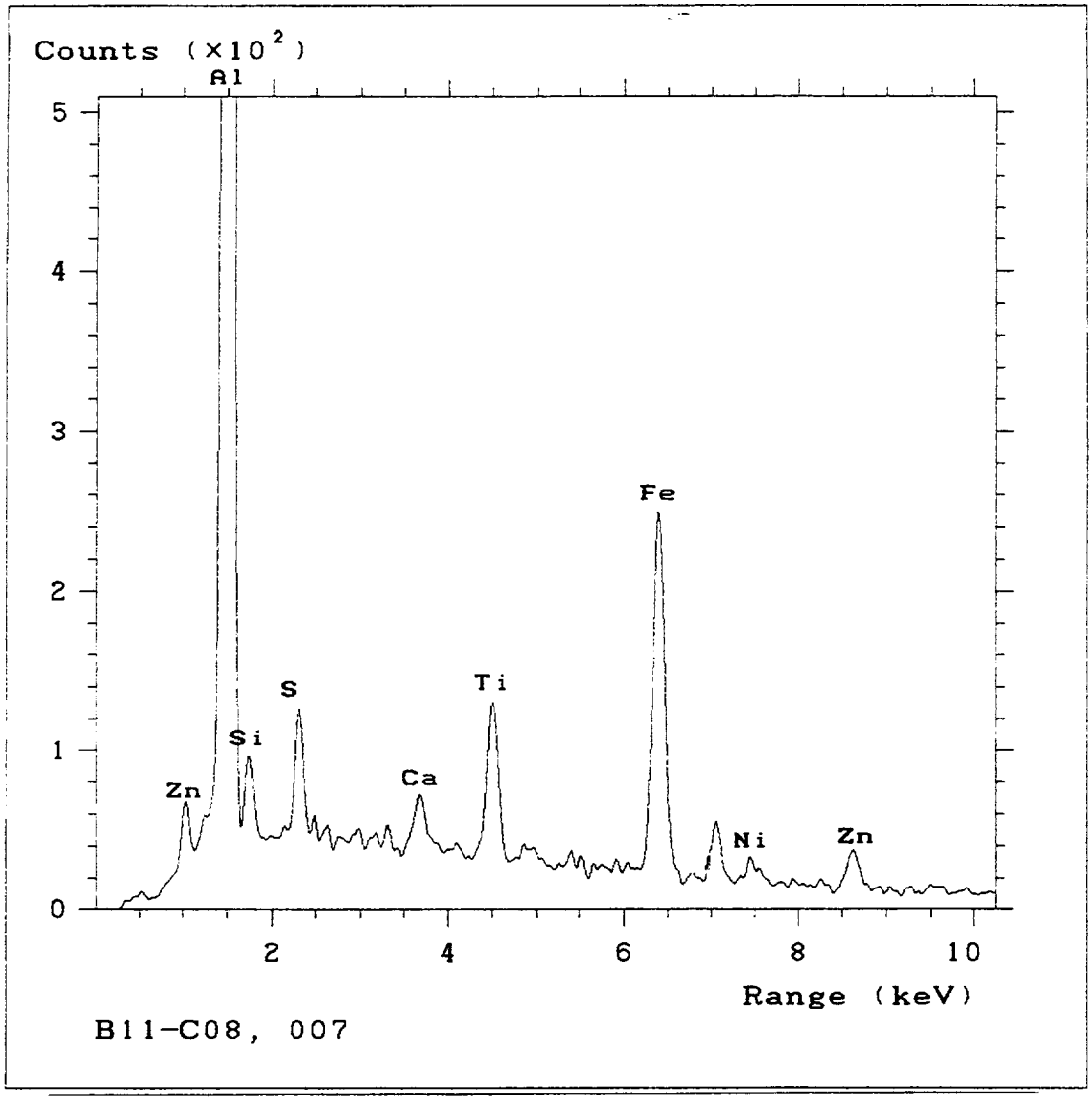


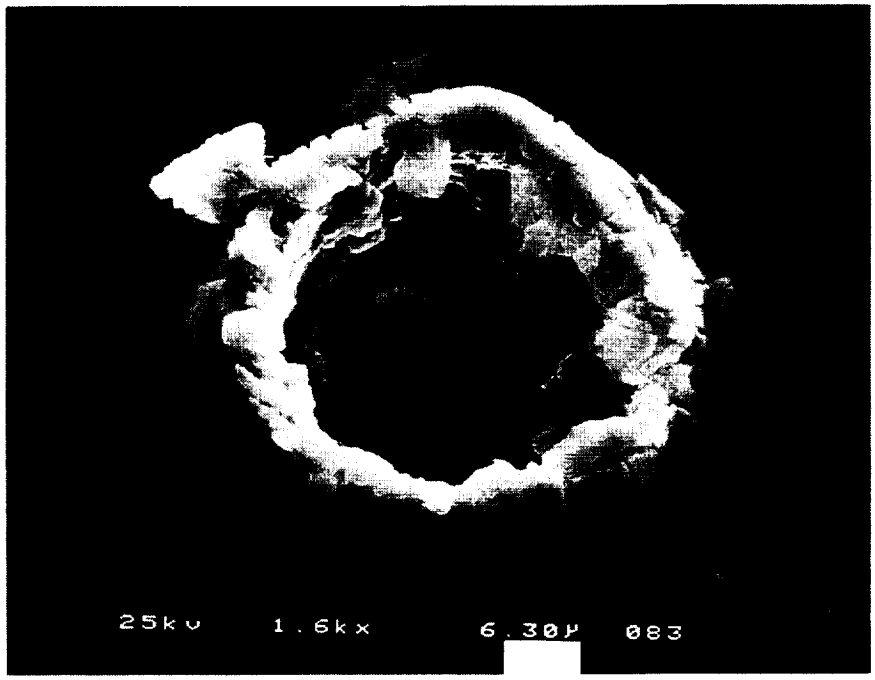
B11- C08 ~~003~~ 005 MM


Counts (×10²)
Al
Mg
Si
S
Ca
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B11-C08, 006

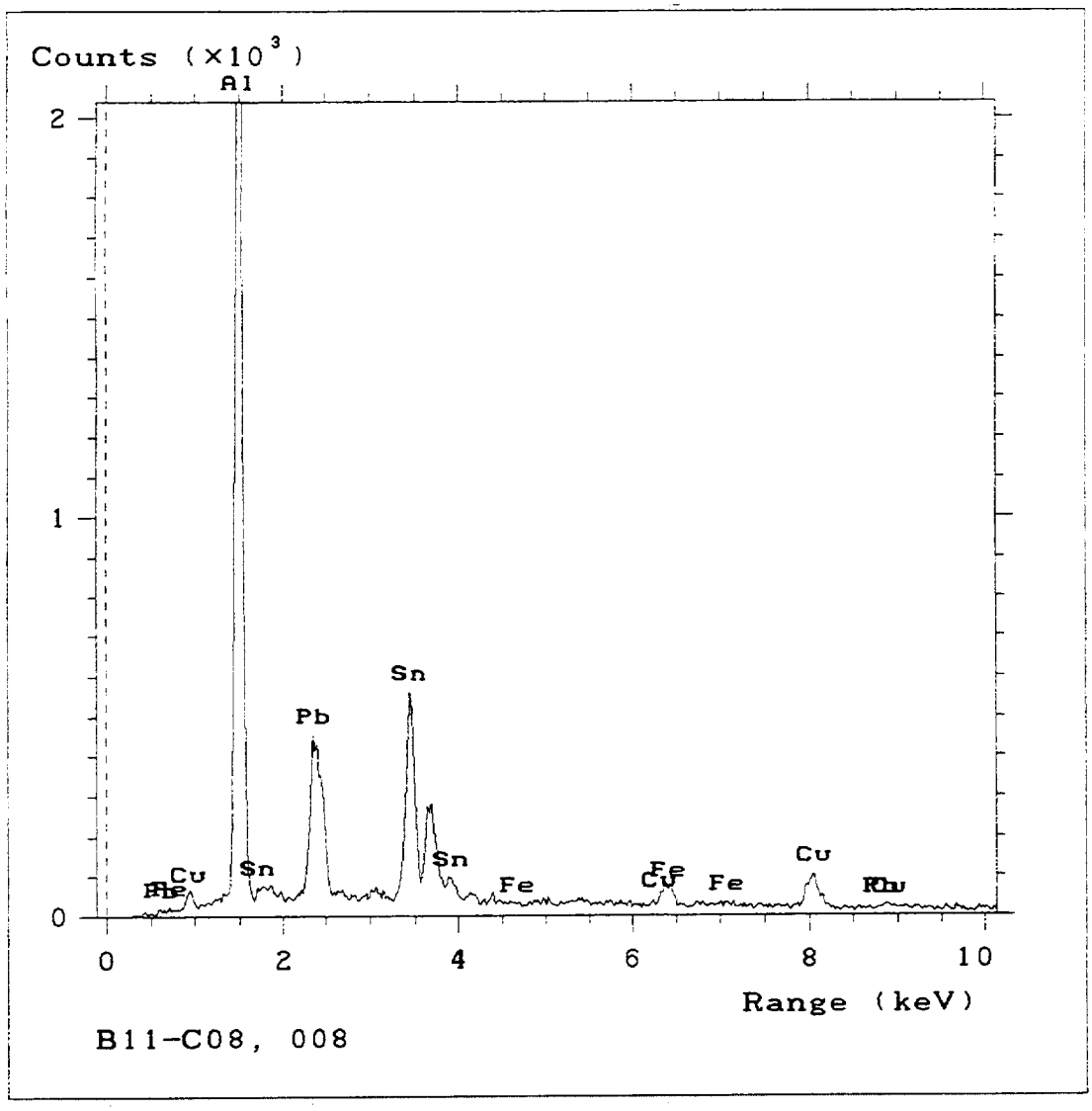

25kv 0.38kx 26.0µ 088

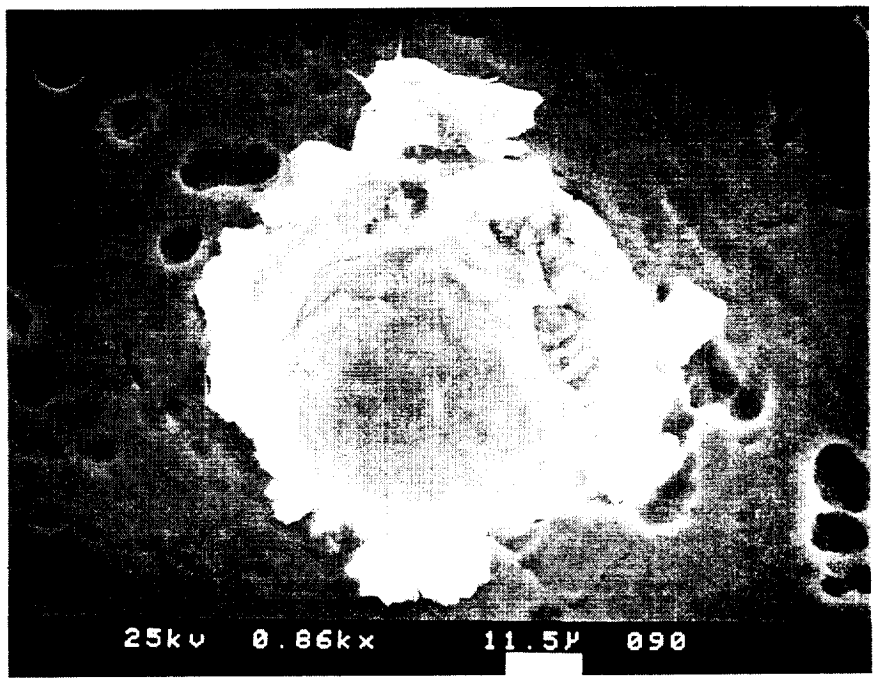
B11-C08 006





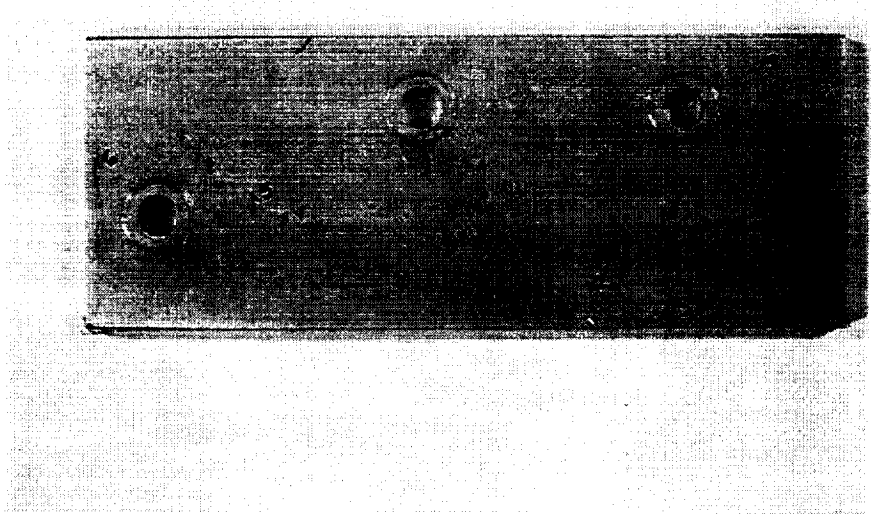
B11-C08 007 PAINT



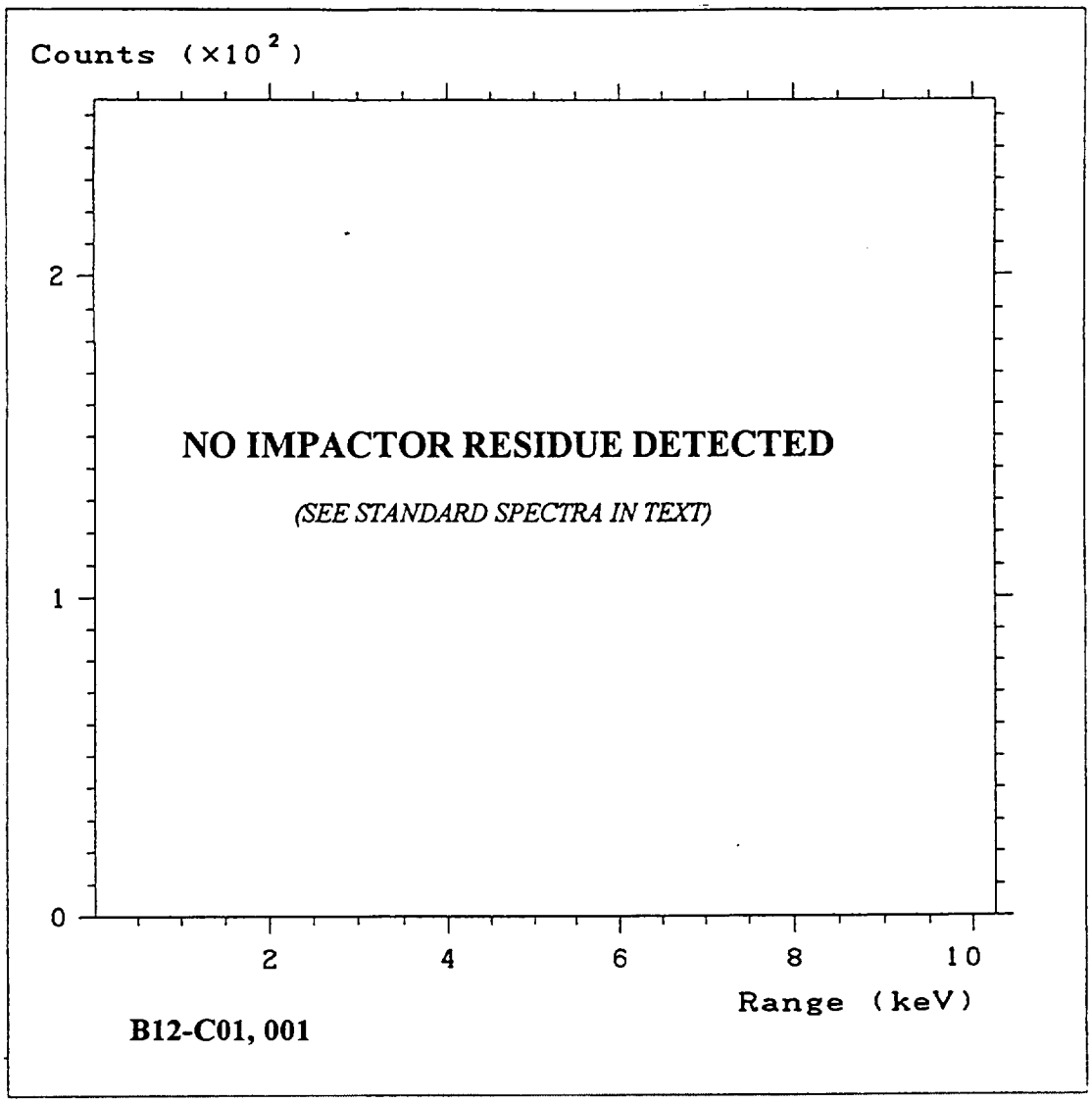


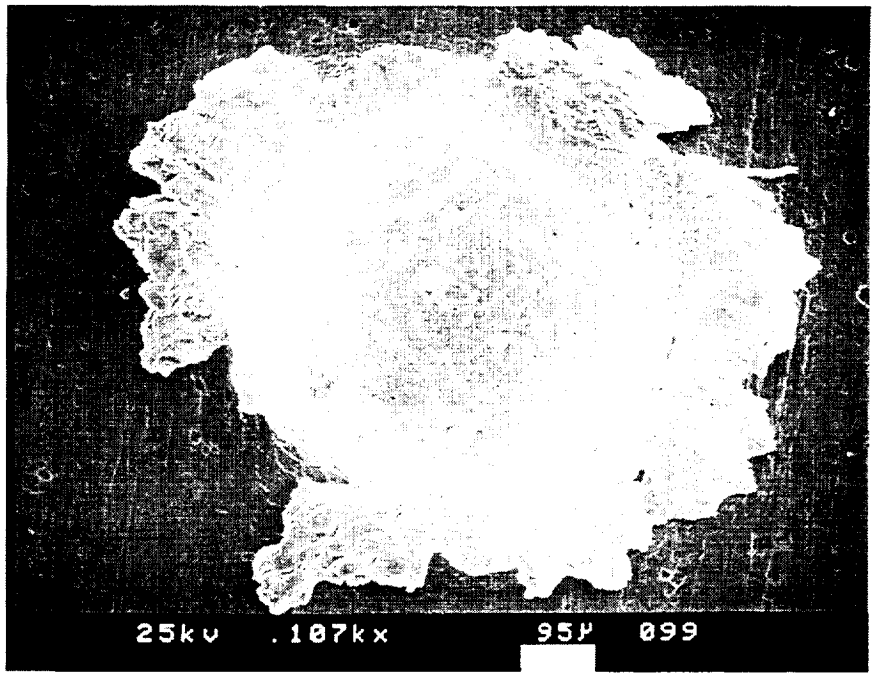
B11-C08 008 elect.

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B12-C01	001	96	21	600	UNKNOWN
	002	89	9	170	UNKNOWN
	003	96	1	200	UNKNOWN
	004	32	19	130	UNKNOWN
	005	27	22	370	UNKNOWN
	006	2	28	21	UNKNOWN
	007	19	29	60	PAINT
	008	127	39	150	EDGE
	009	117	40	140	UNKNOWN

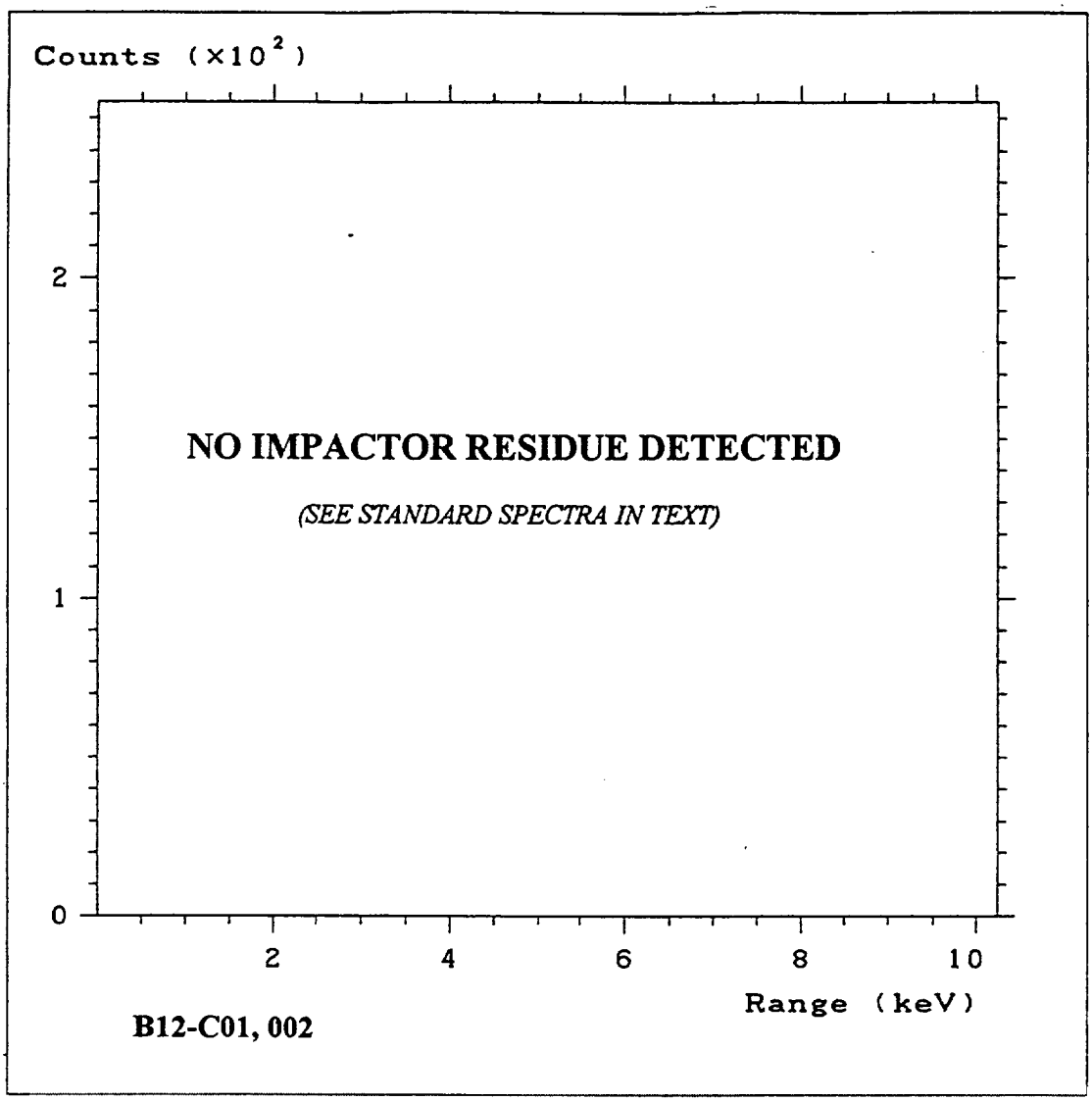


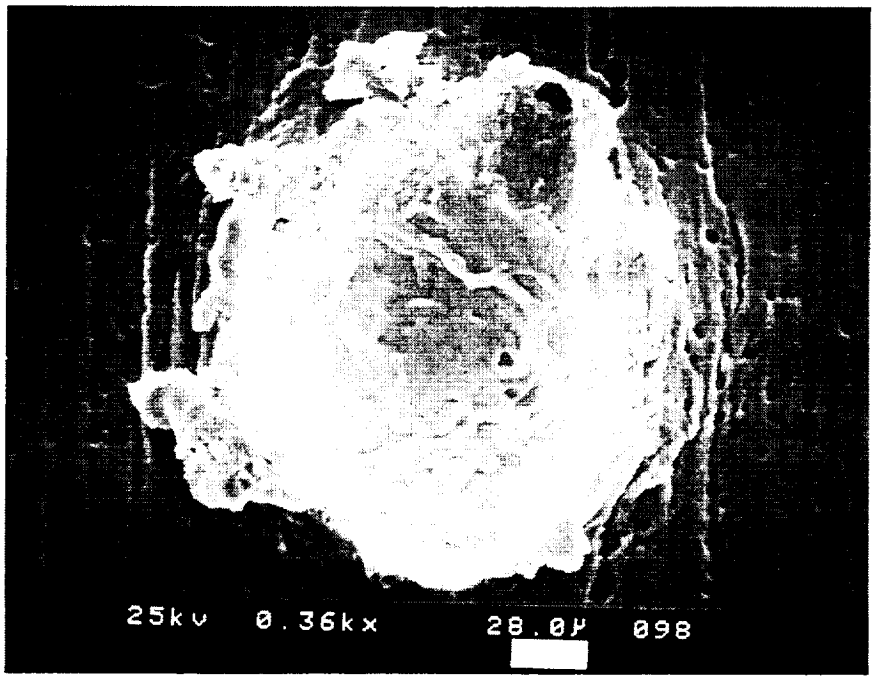
B12-C01


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B12-C01, 001

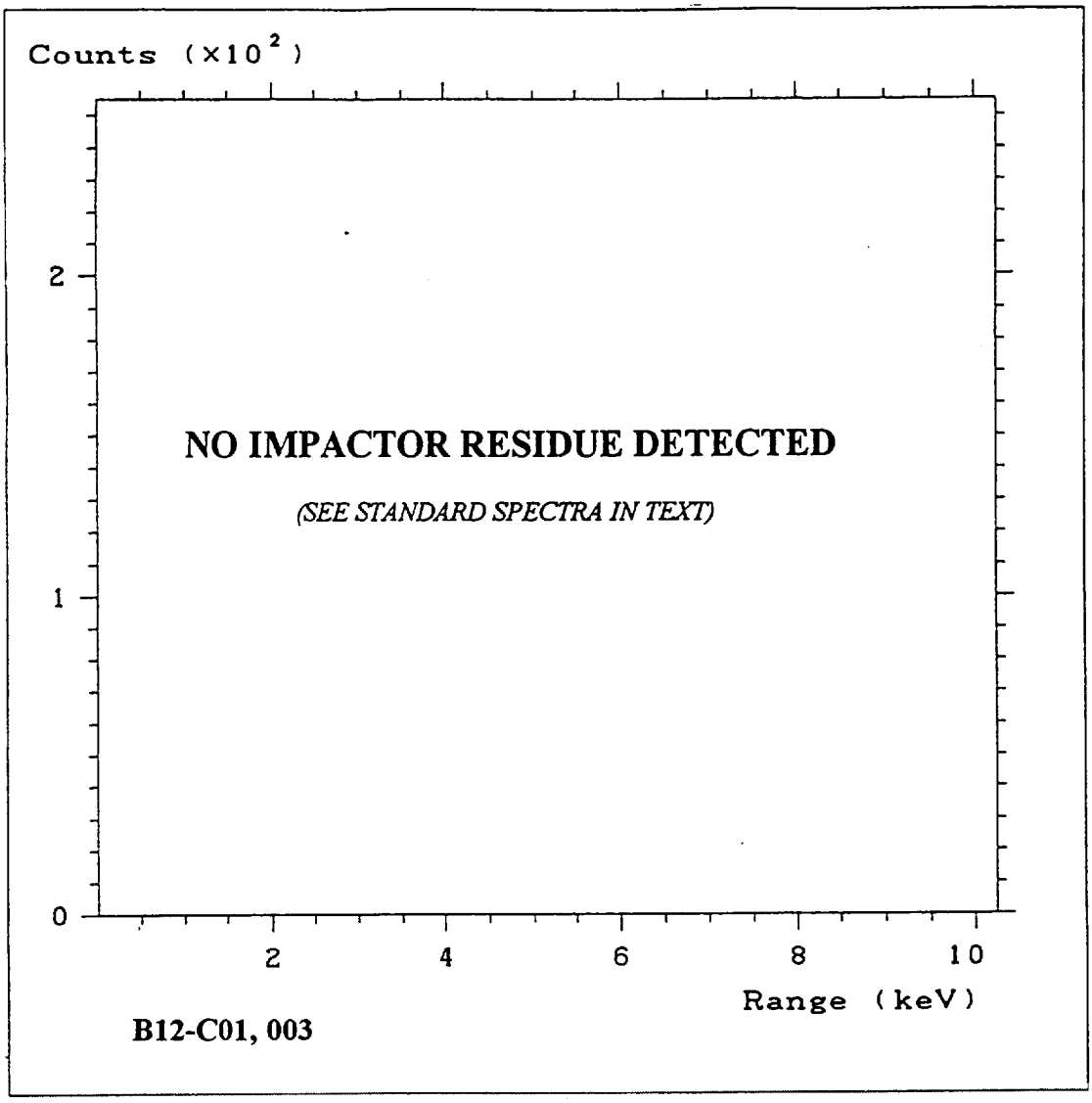

25kv .107kx 95µ 099

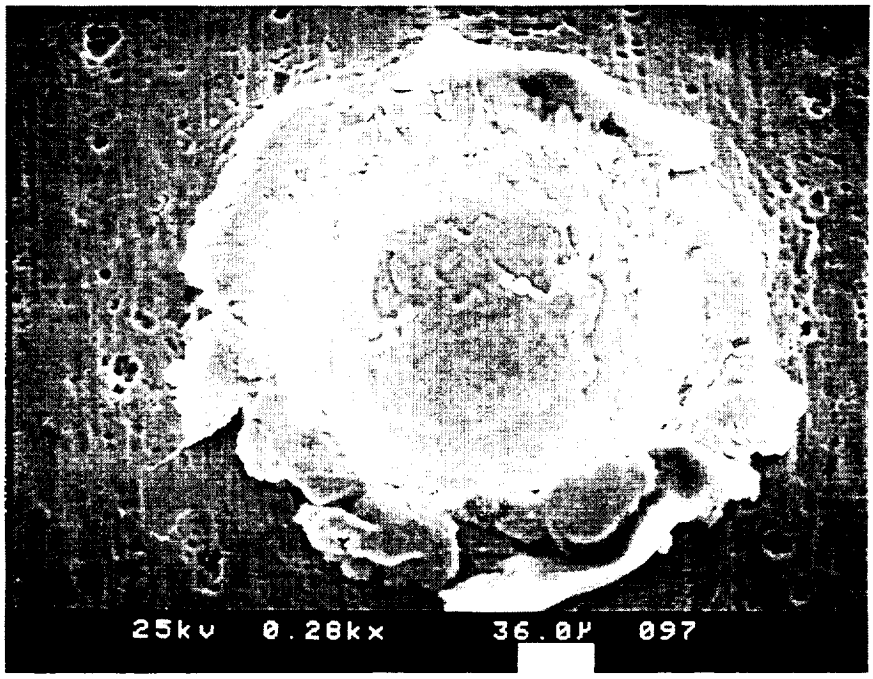
B12-C01 001


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B12-C01, 002

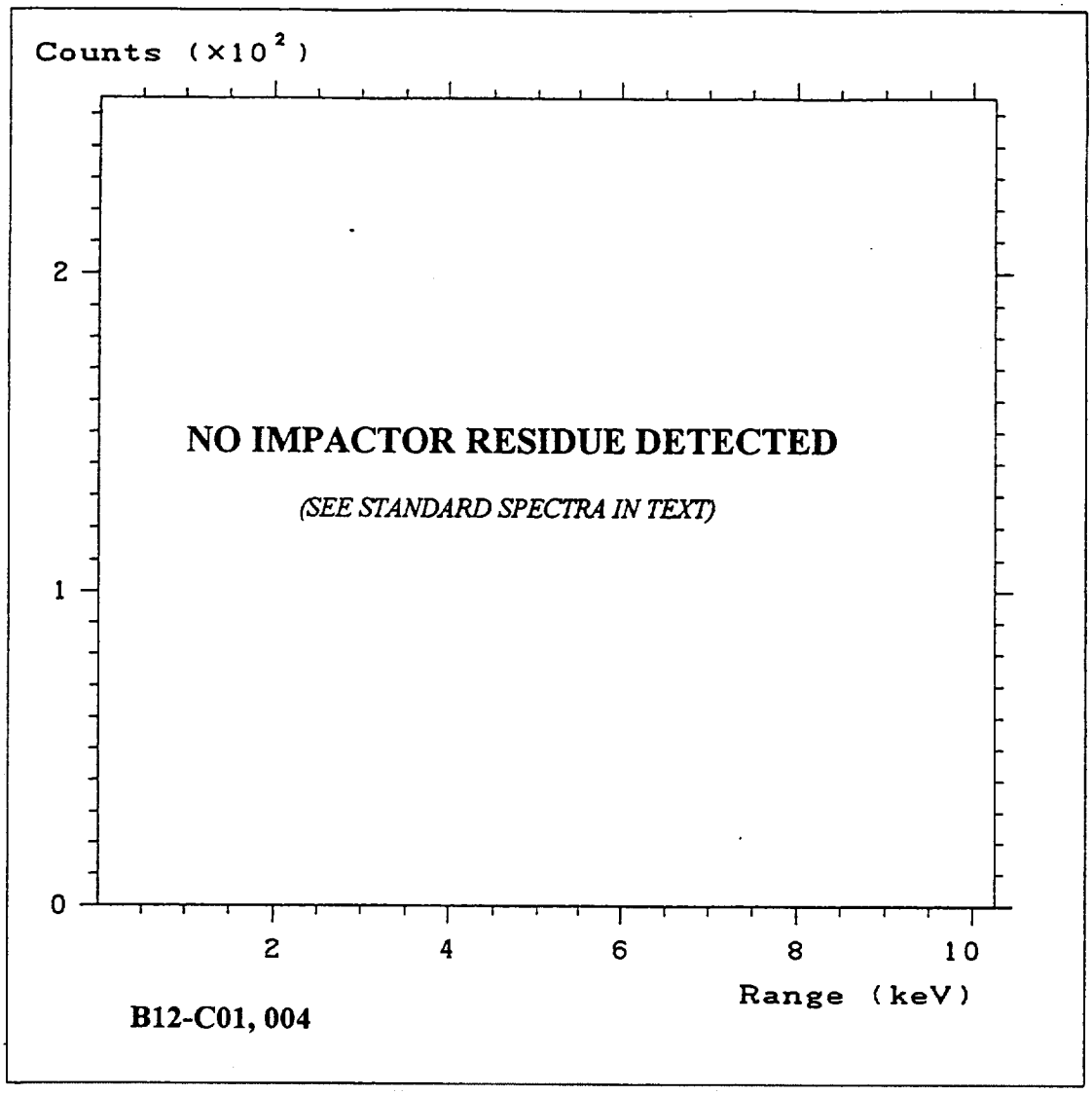

25kv 0.36kx 28.0μ 098

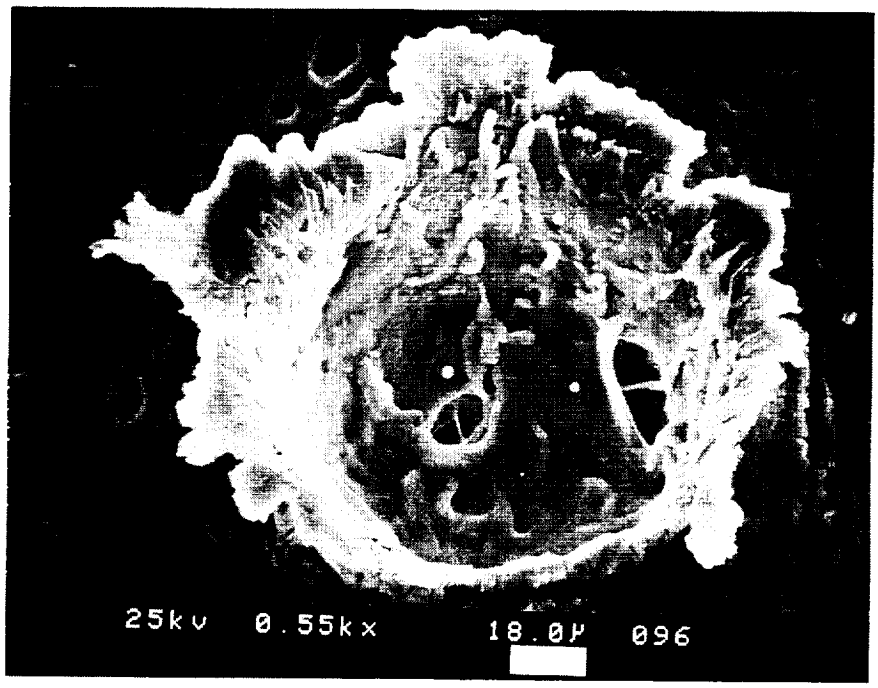
B12-C01 002


Counts (x10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B12-C01, 003

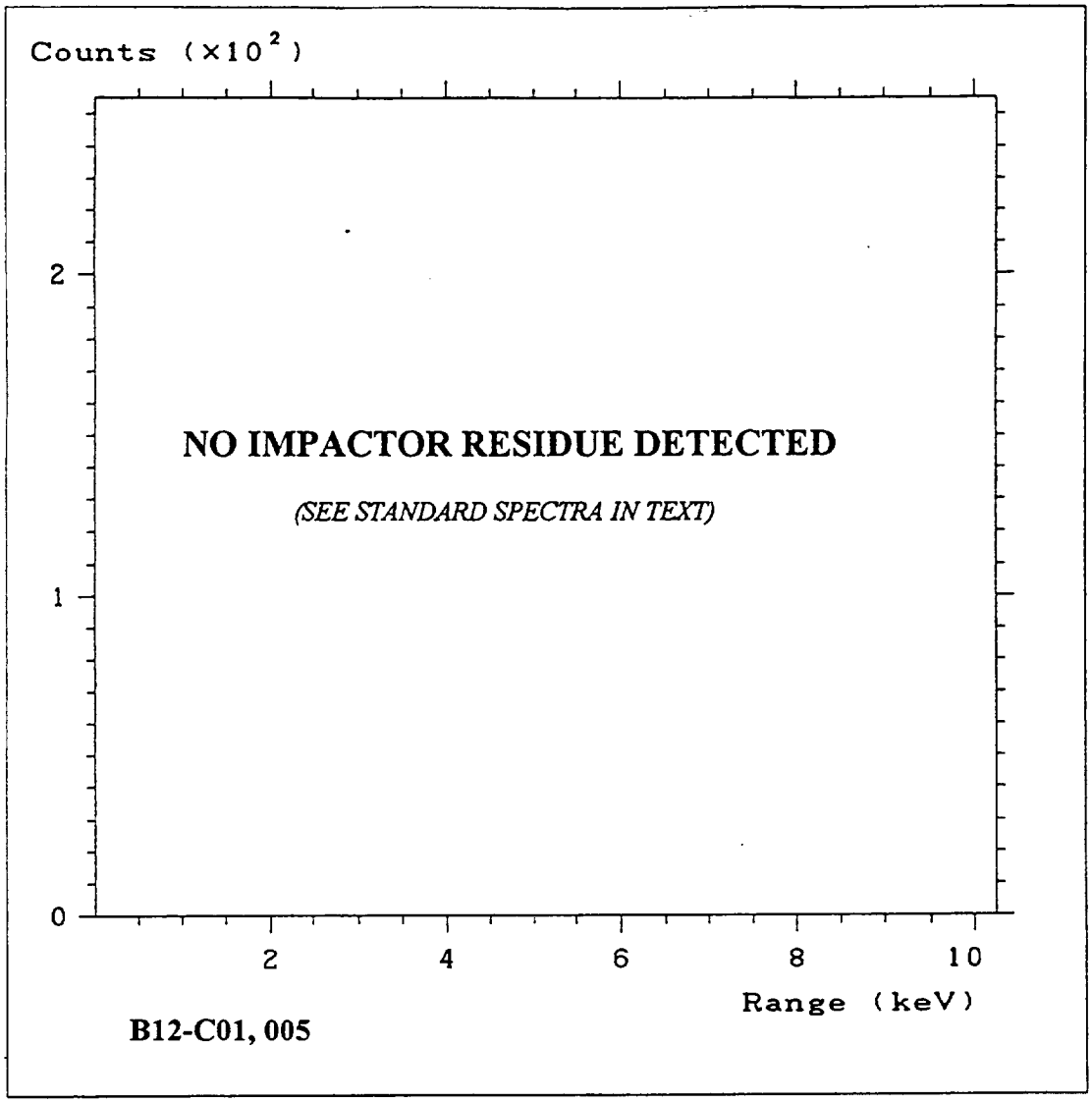

25kv 0.28kx 36.0µ 097

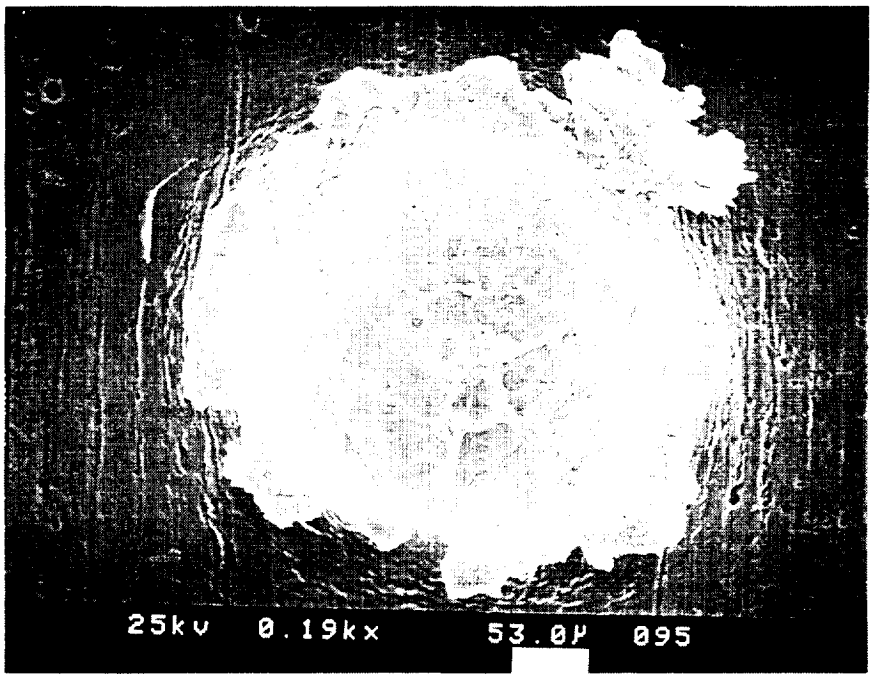
B12-C01 003


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C01, 004

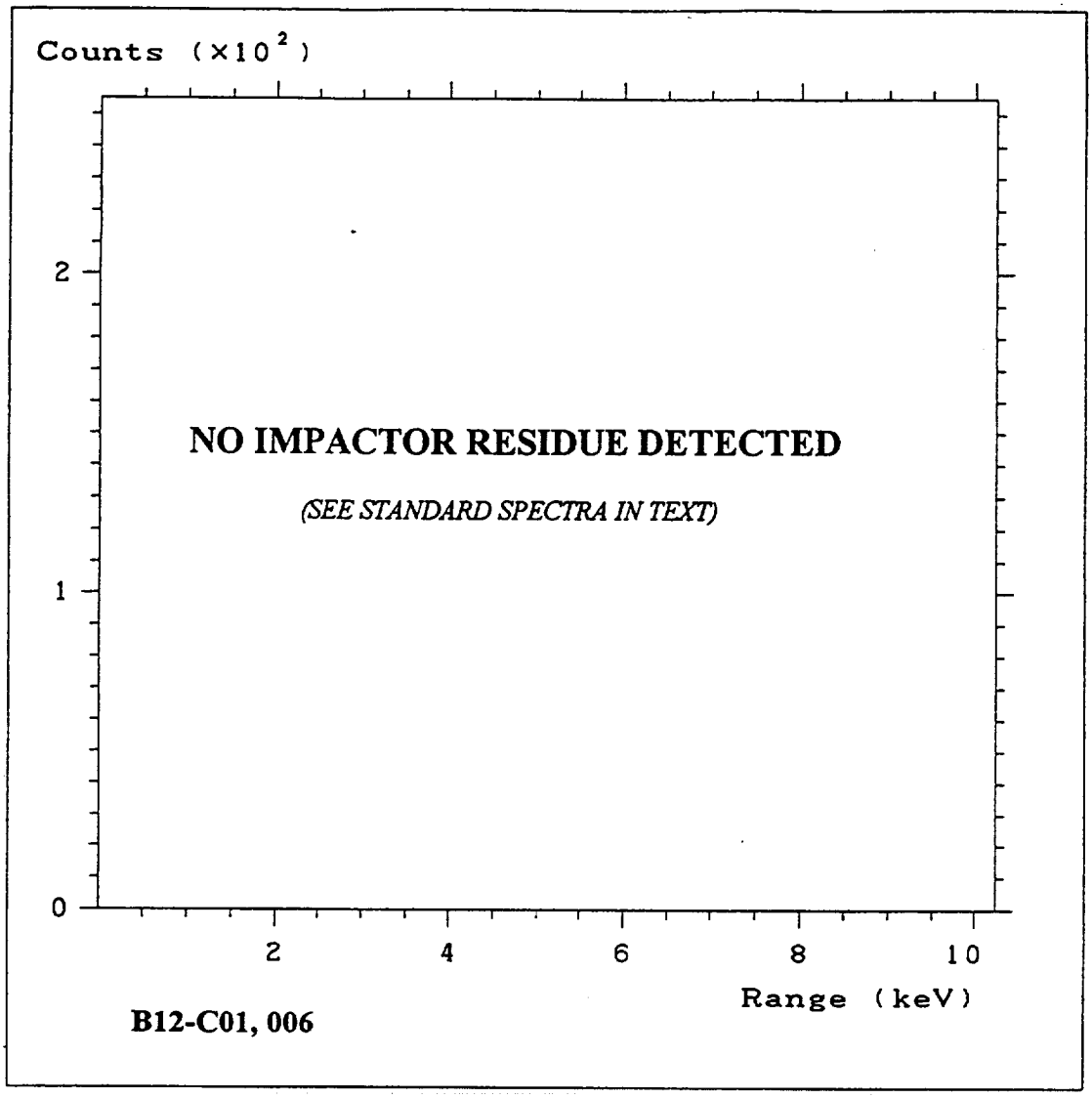

25kv 0.55kx 18.0μ 096

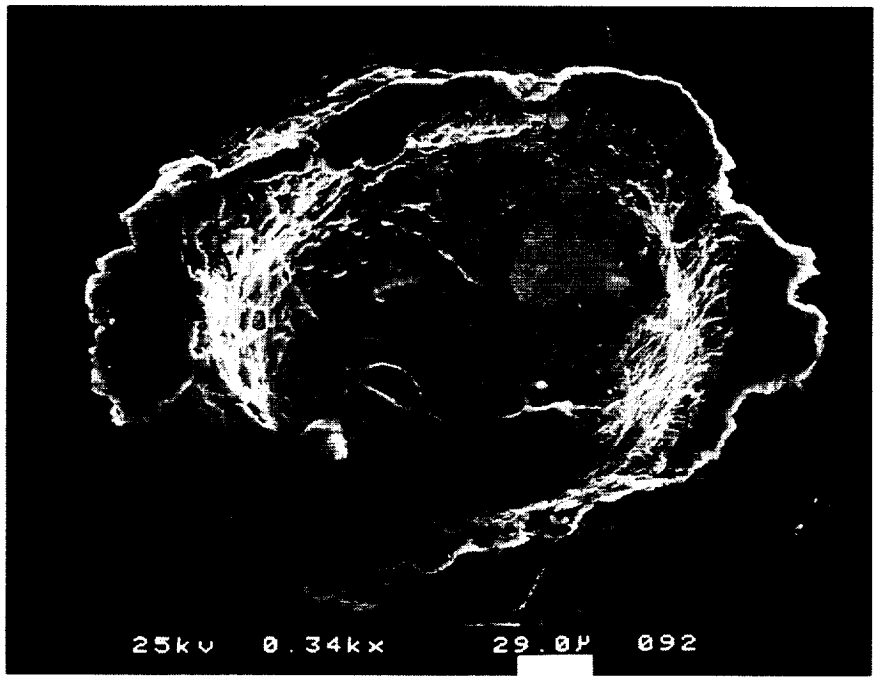
B12-C01 004


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C01, 005

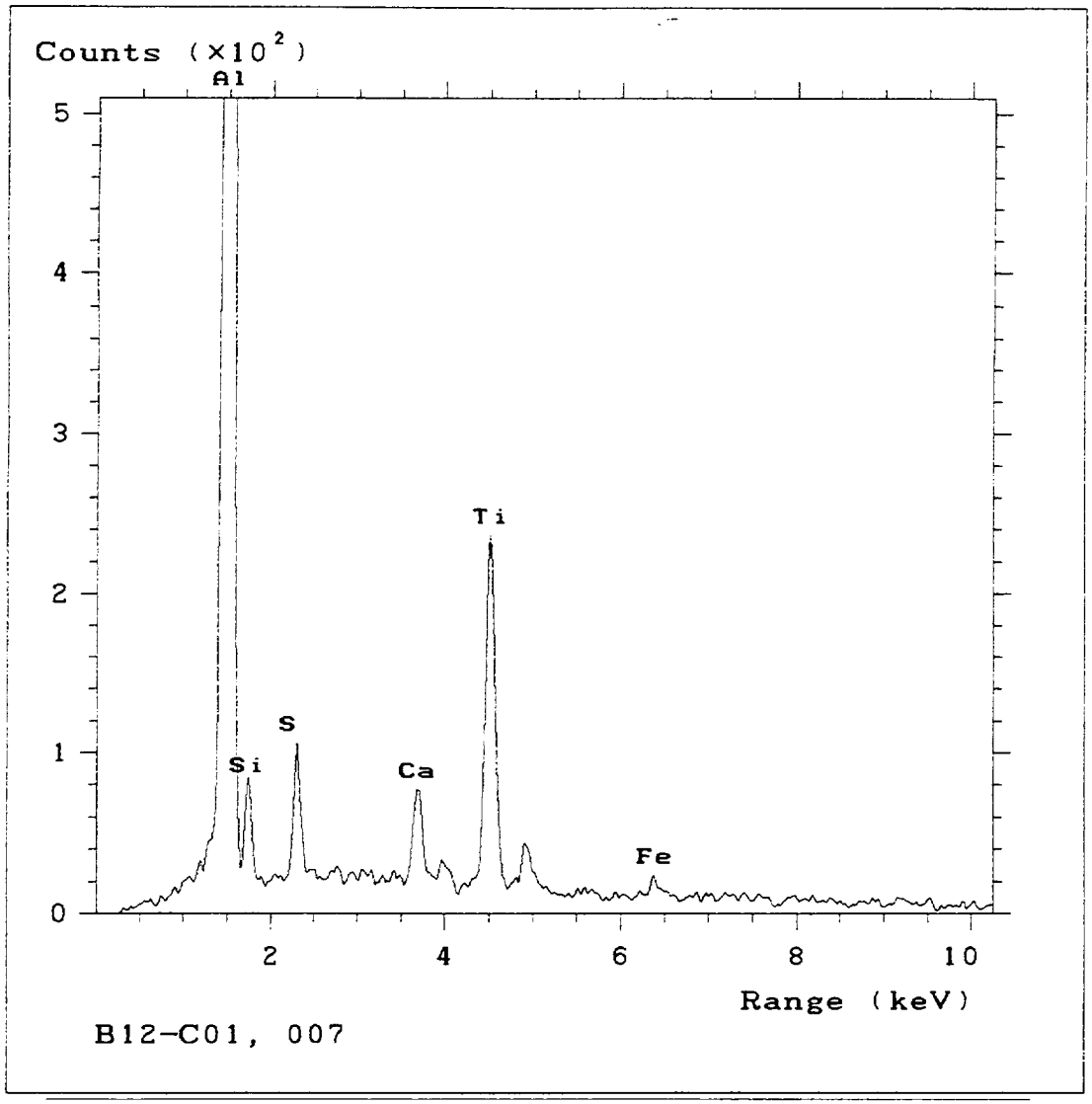

25kv 0.19kx 53.0μ 095

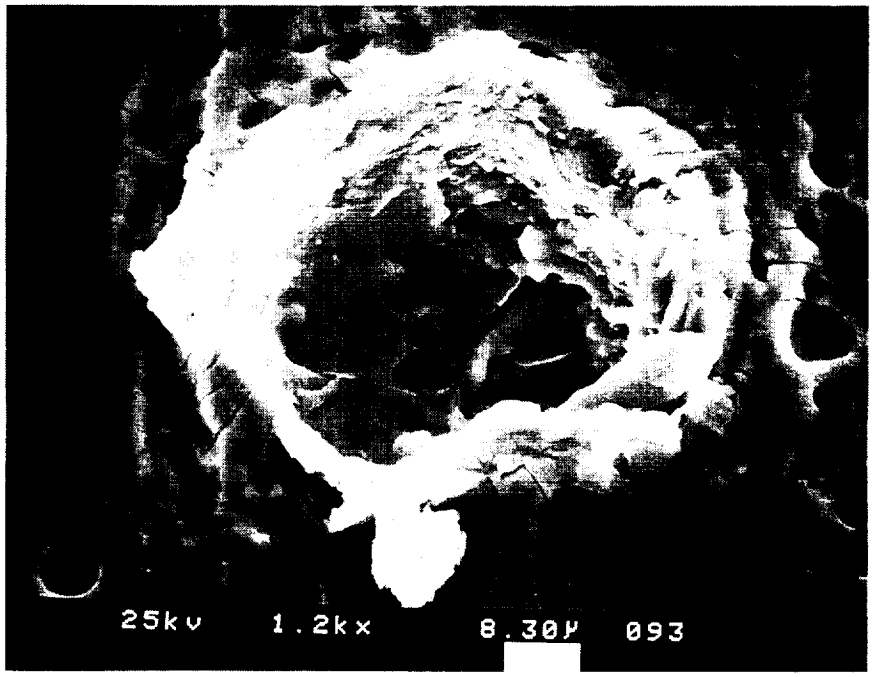
B12-C01 005


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C01, 006

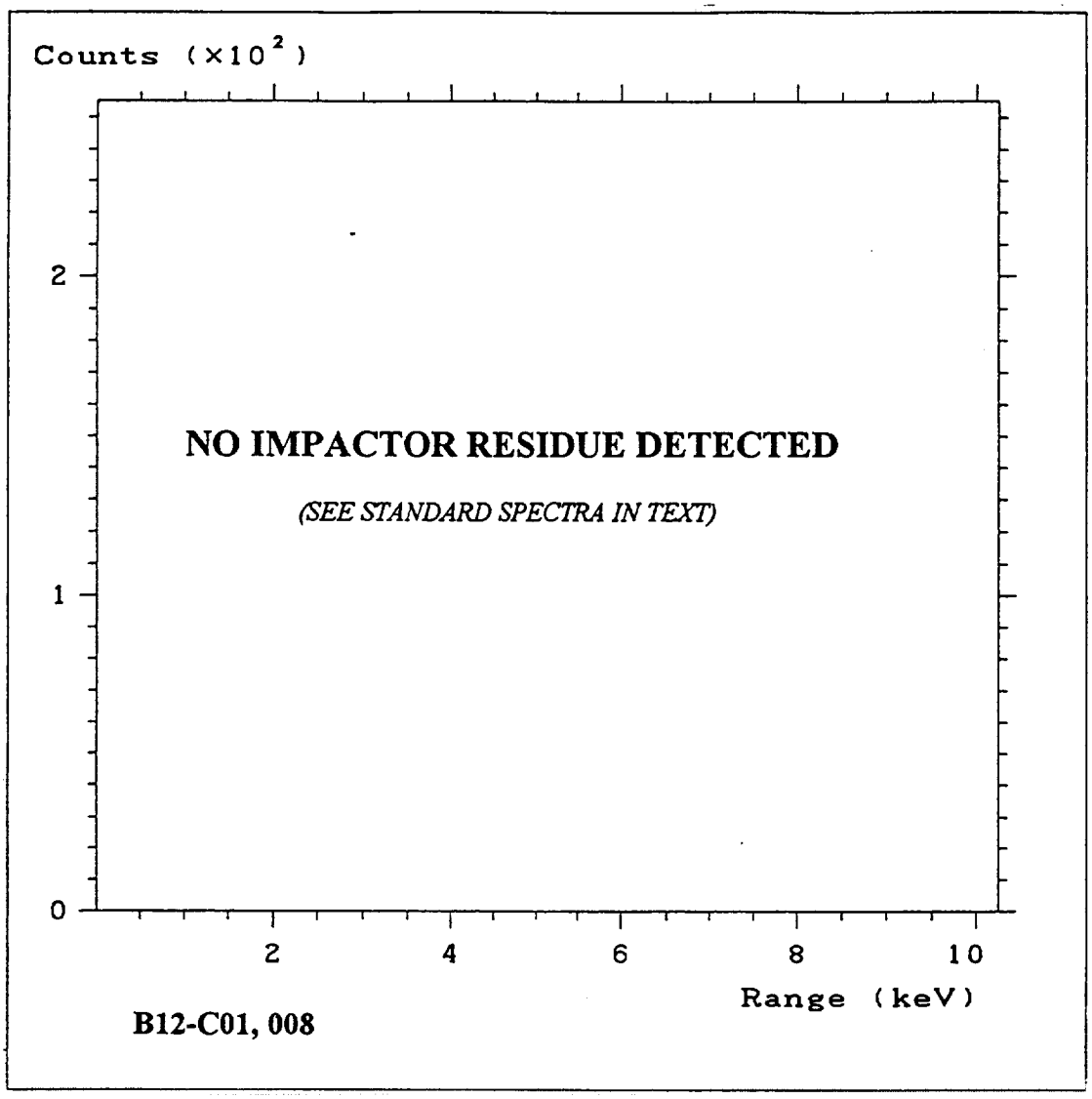

25kv 0.34kx 29.0µ 092

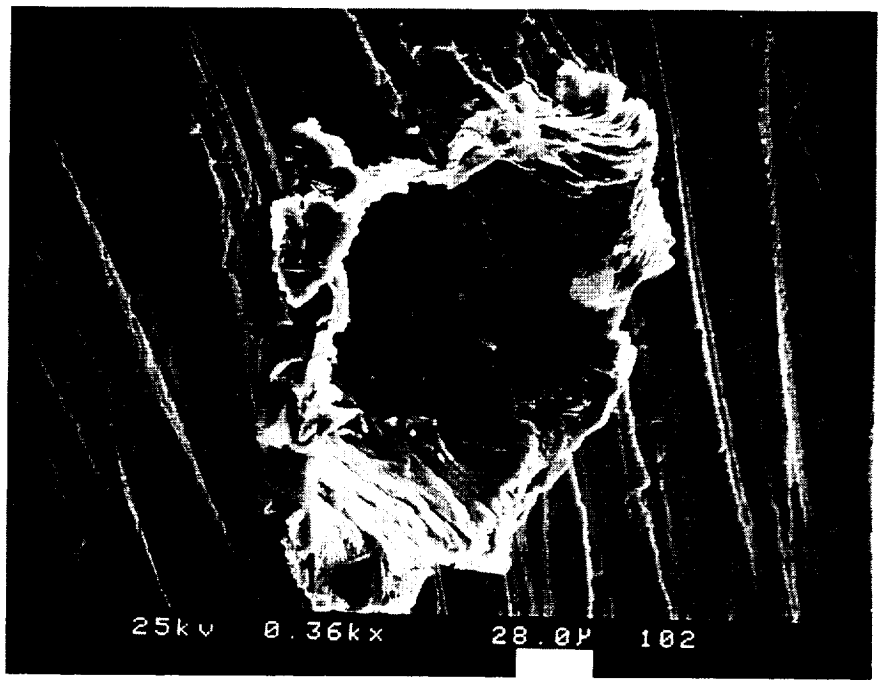
B12-C01 006


Counts (×10²)
Al
Si
S
Ca
Ti
Fe
0
1
2
3
4
5
2
4
6
8
10
Range (keV)
B12-C01, 007

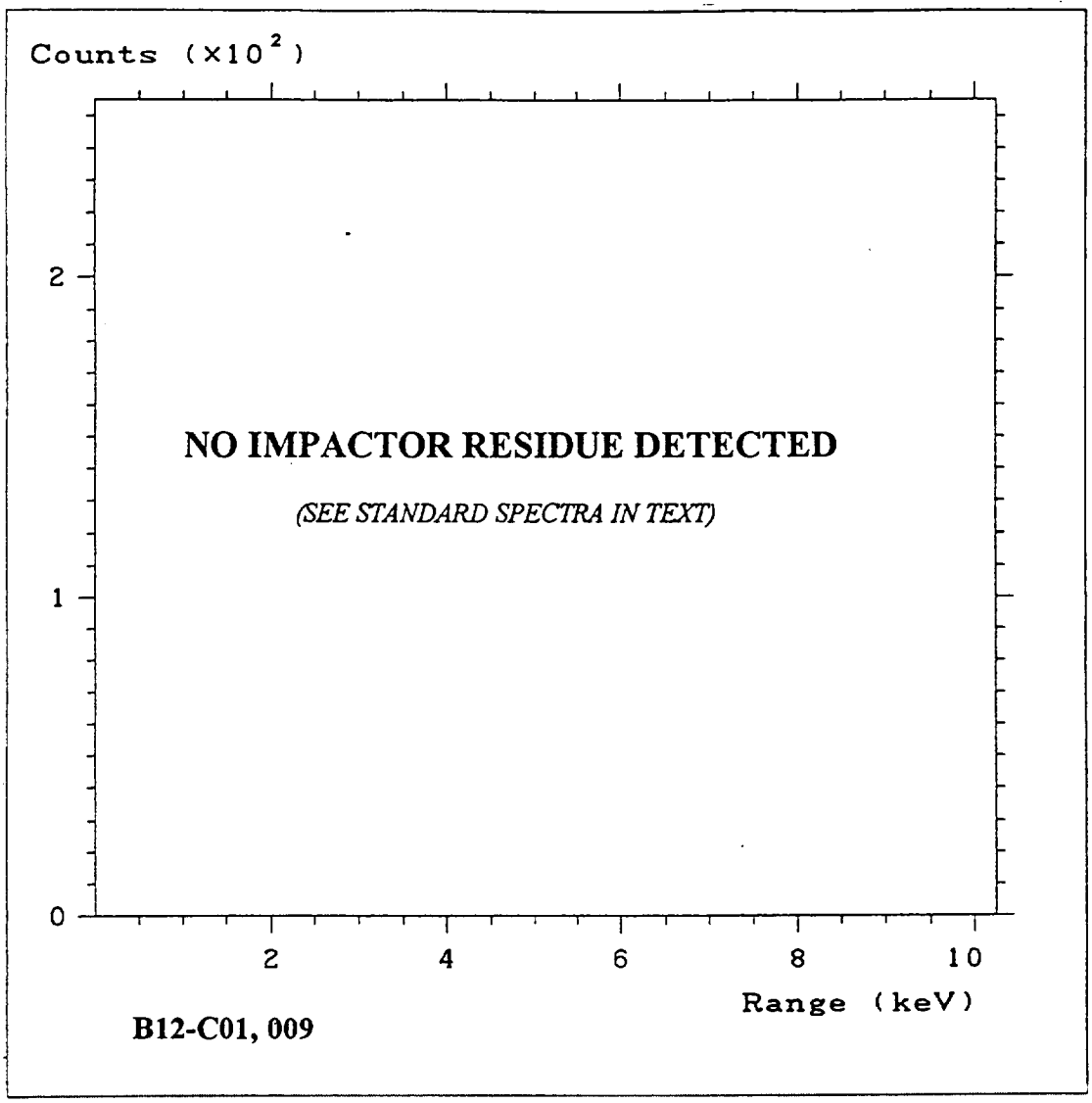

25kv 1.2kx 8.30μ 093

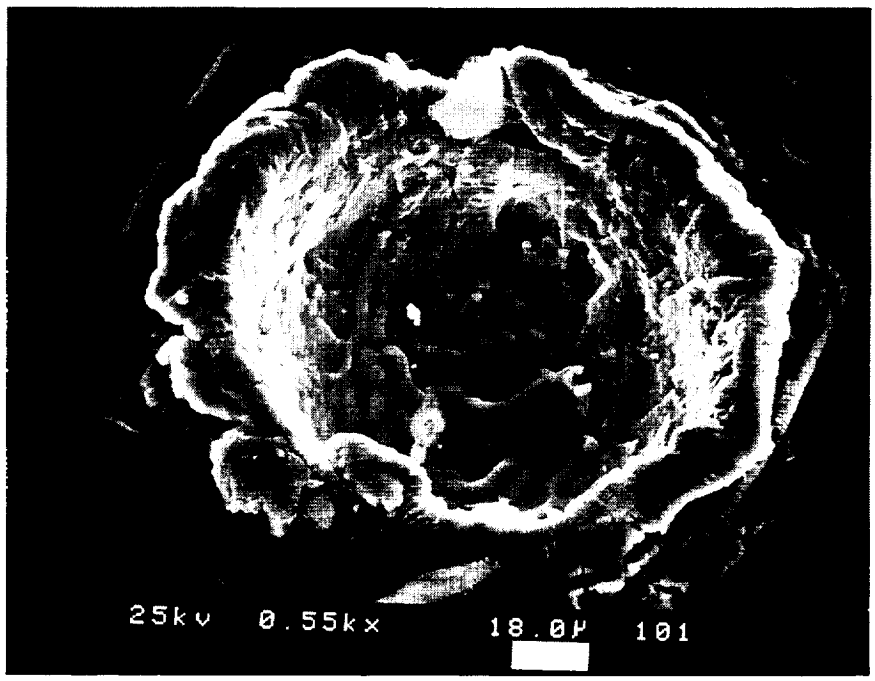
B12 - C01 007


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C01, 008


25kv 0.36kx 28.0µ 102

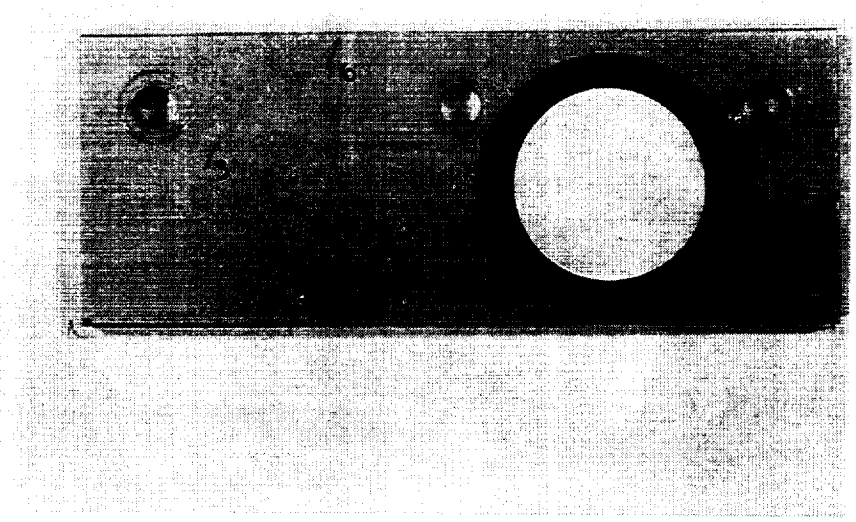
B12-C01 008


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C01, 009

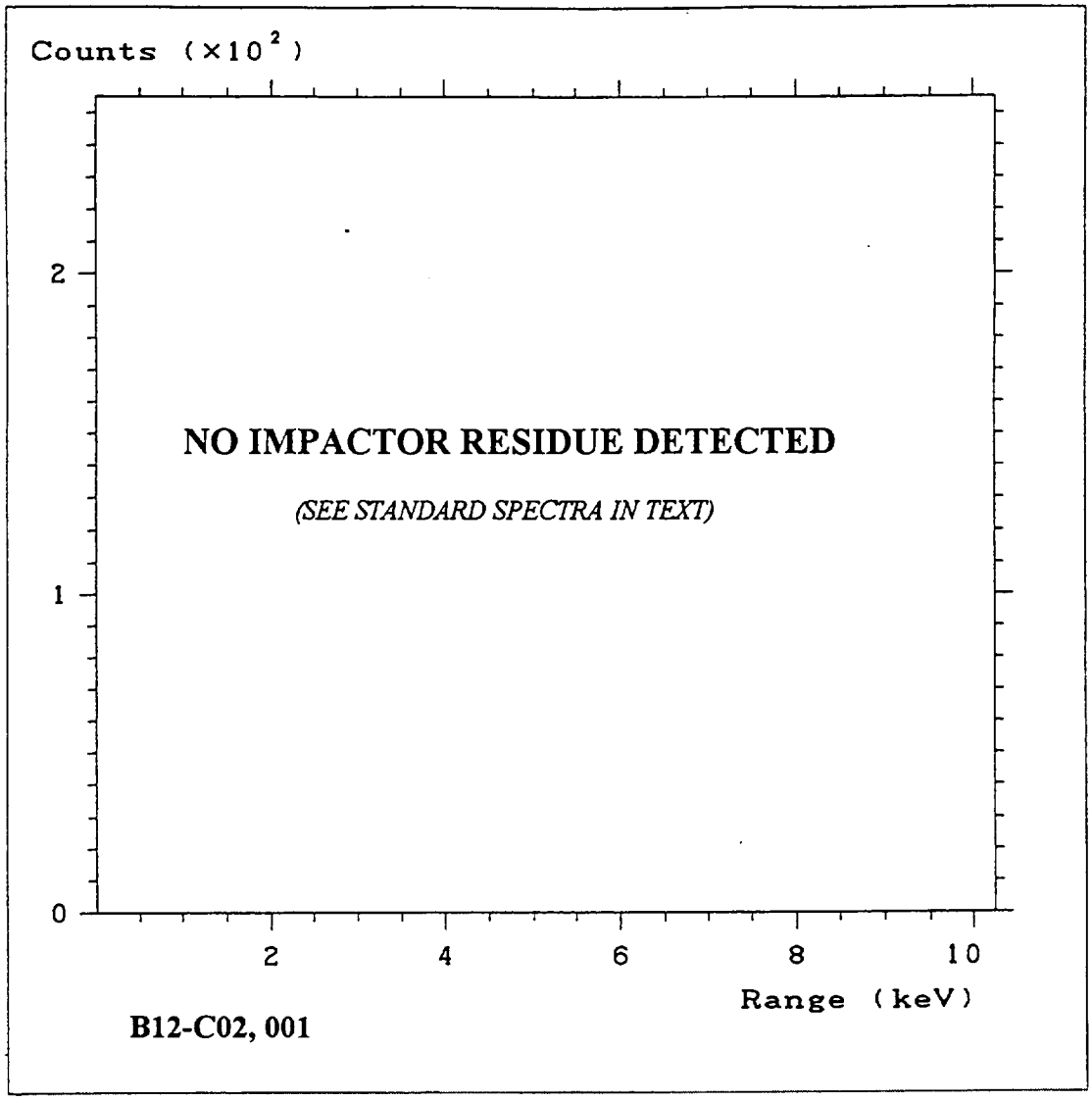

25kv 0.55kx 18.0μ 101

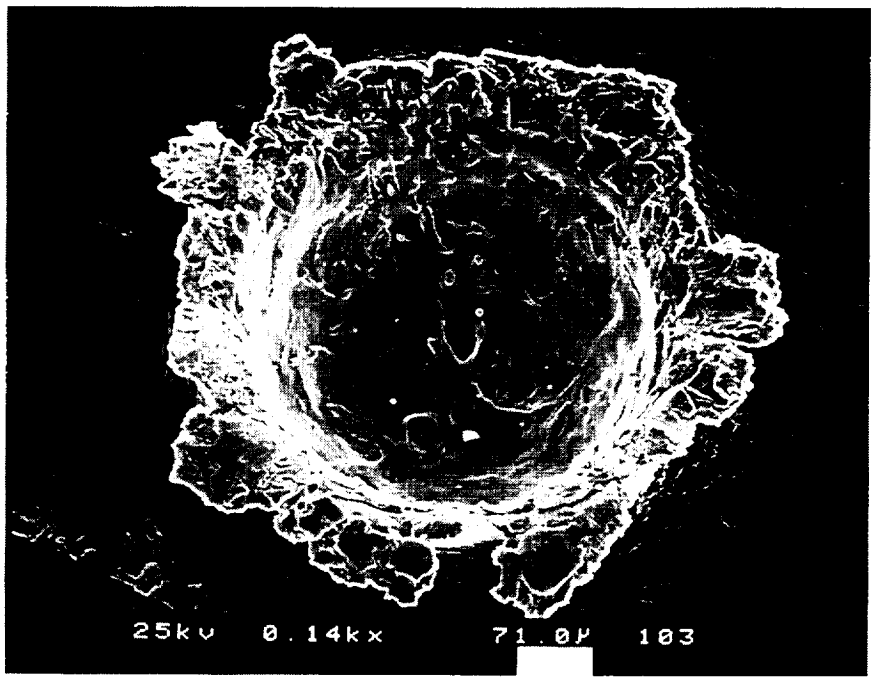
B12-C01 009

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B12-C02	001	55	4	600	UNKNOWN
	002	118	5	150	MICROMETEORITIC
	003	23	29	70	MICROMETEORITIC
	004	71	29	320	PAINT PATCH
	005	120	24	300	UNKNOWN
	006	43	48	60	UNKNOWN

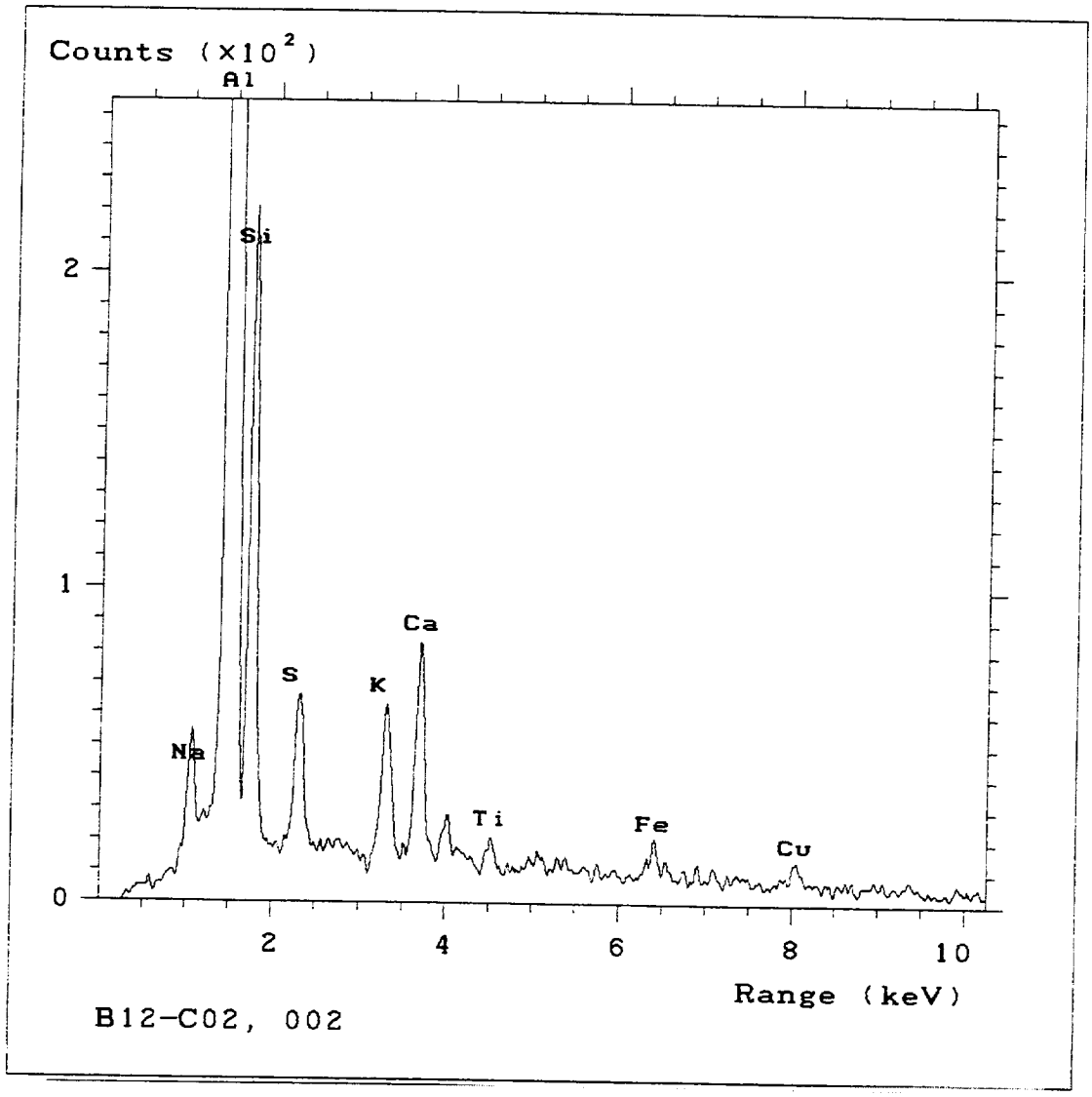


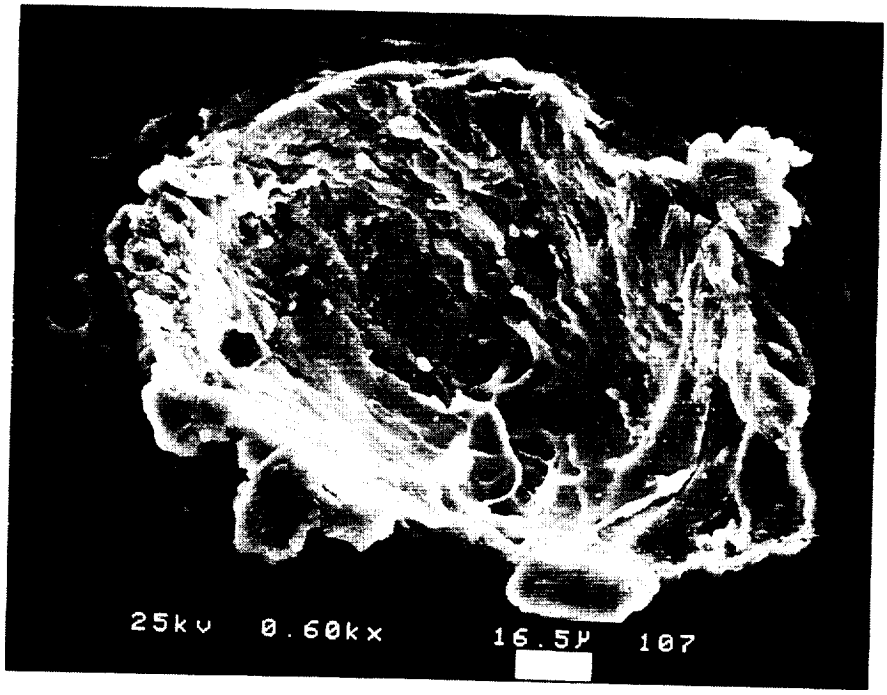
B12-C02


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C02, 001

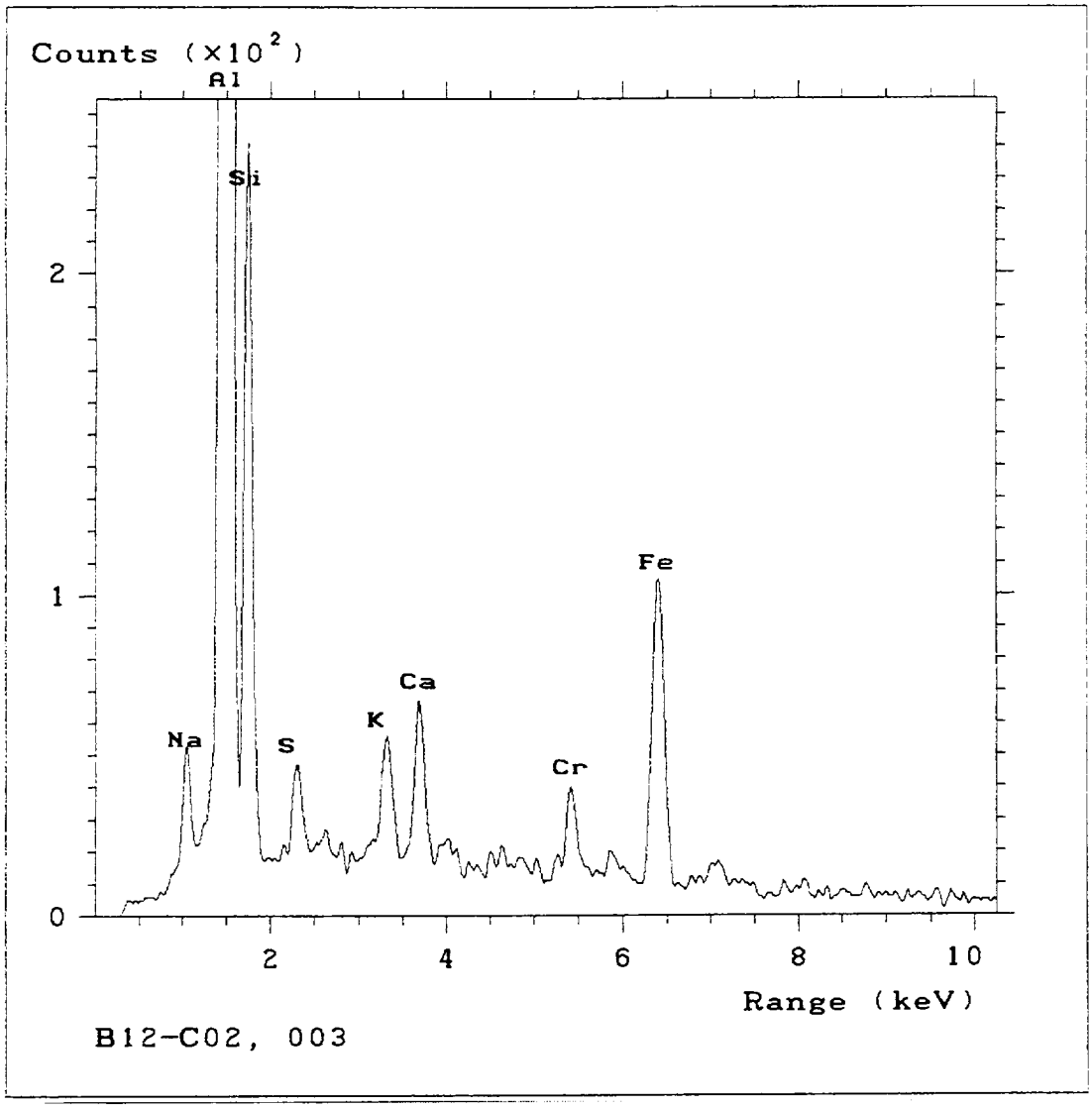

25kv 0.14kx 71.0µ 103

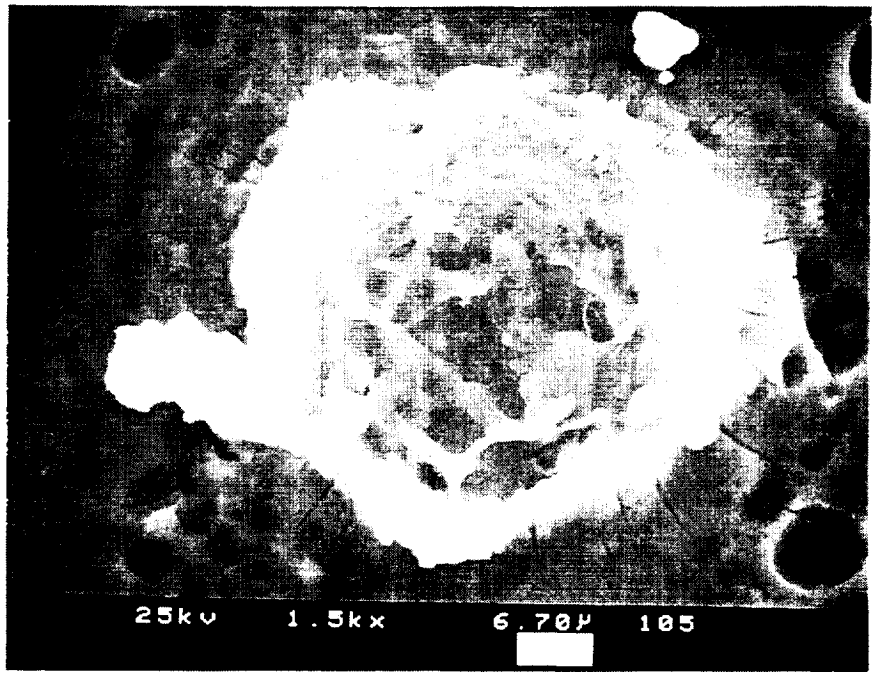
B12-C02 001



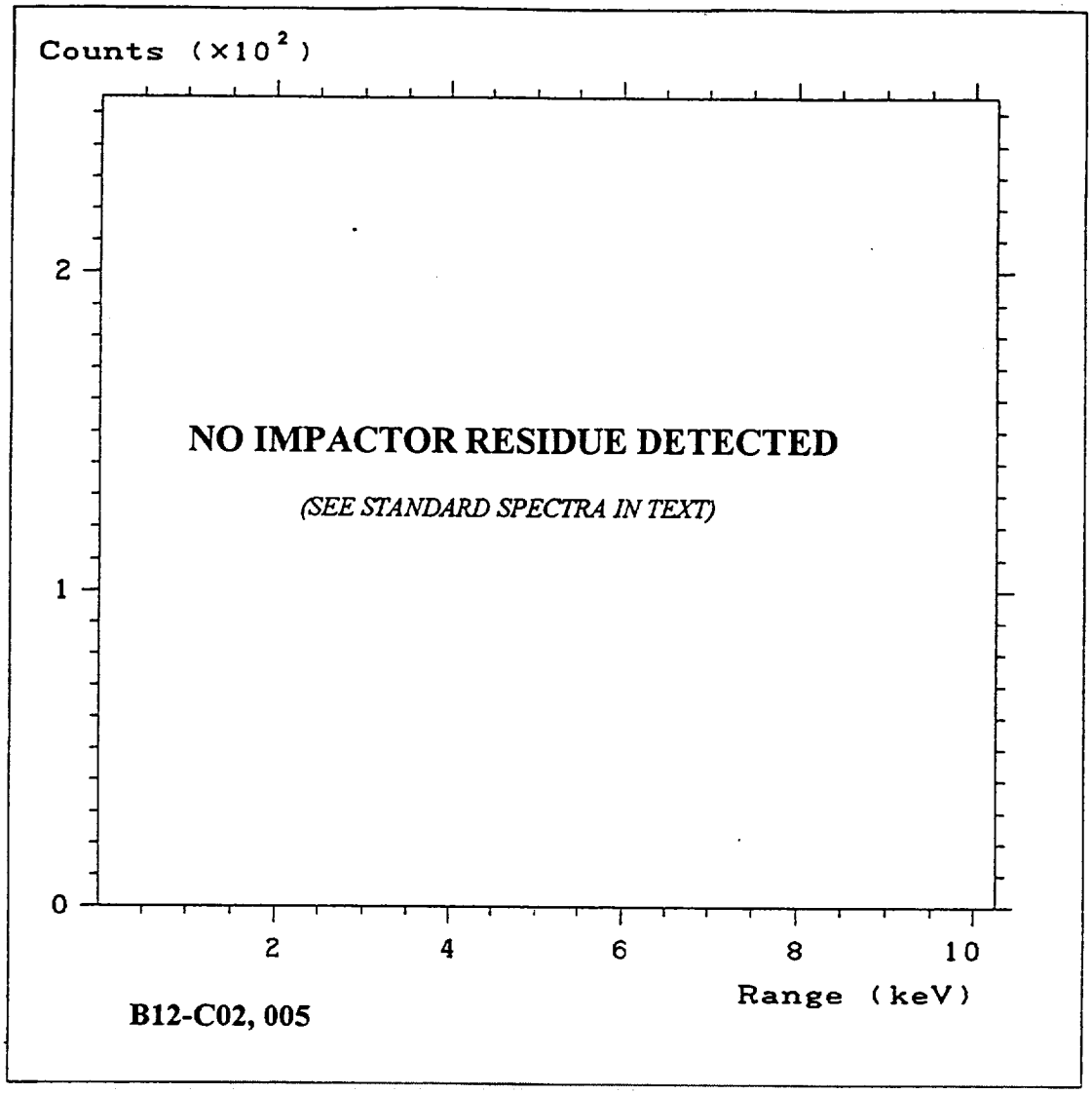


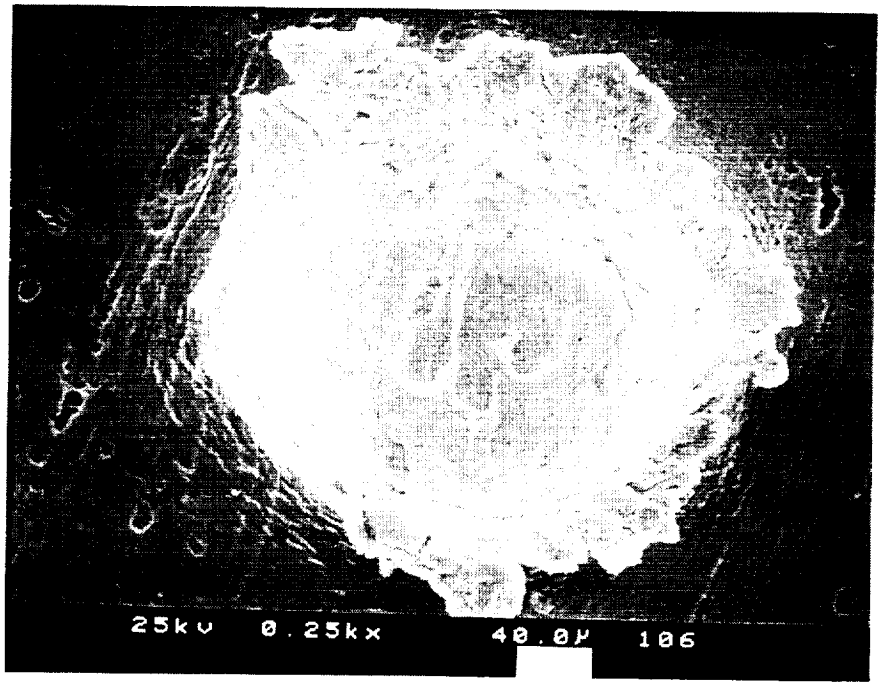
B12 - C02 002 mm



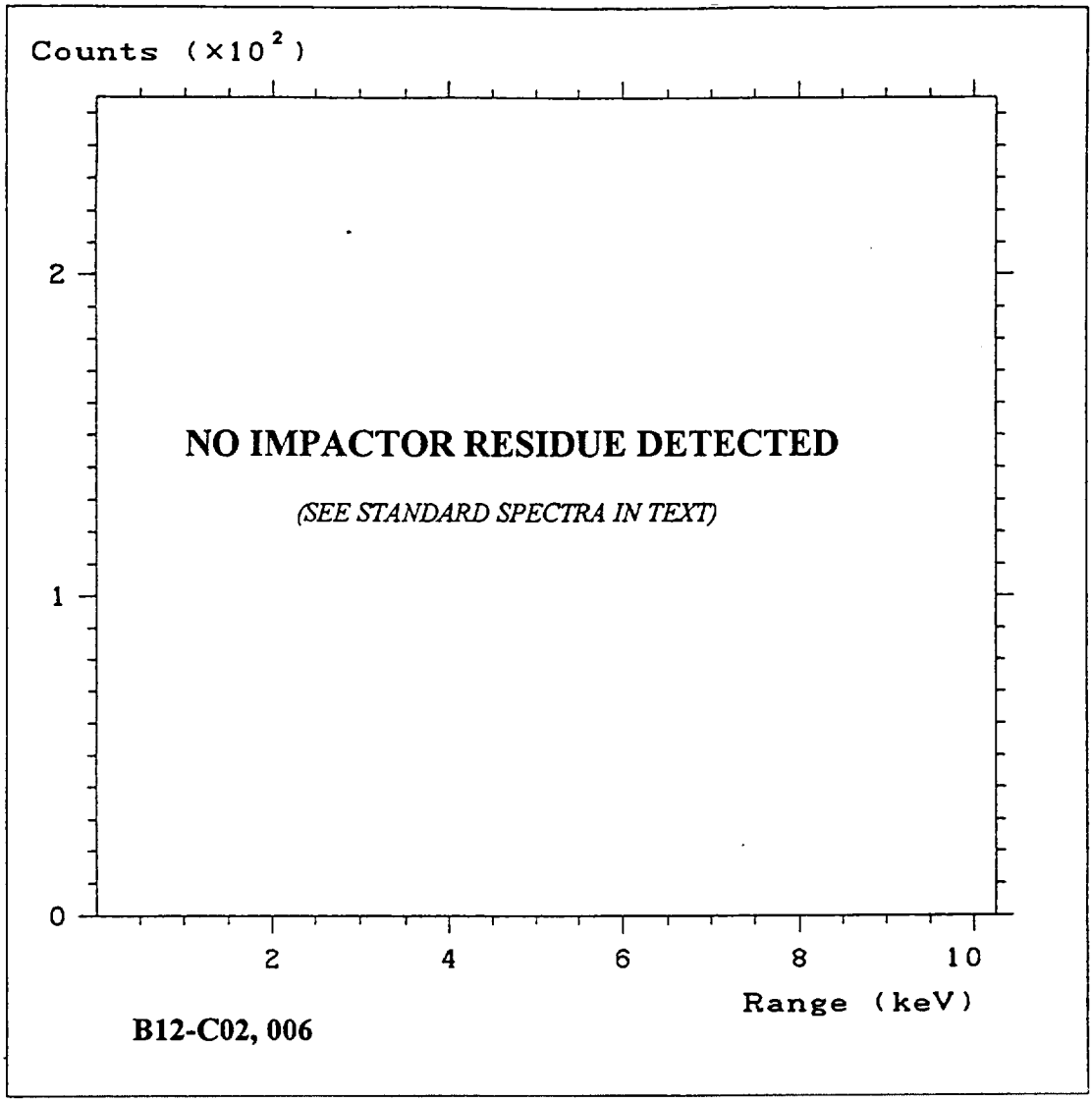


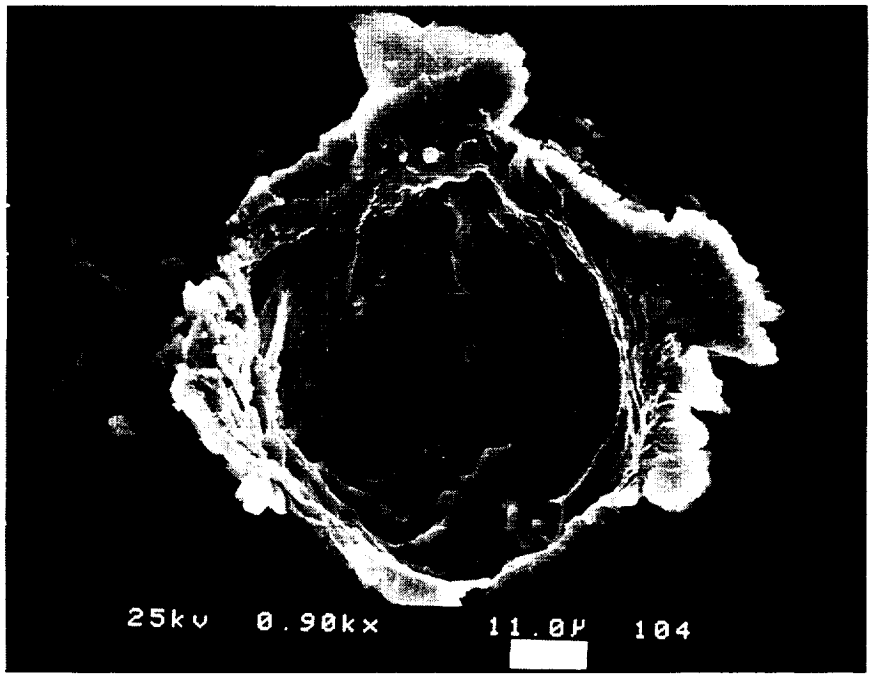
B12-C02 003 mM


Counts (×10²)
2
1
0
2
4
6
8
10
Range (keV)
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
B12-C02, 005


25kv 0.25kx 40.0μ 106

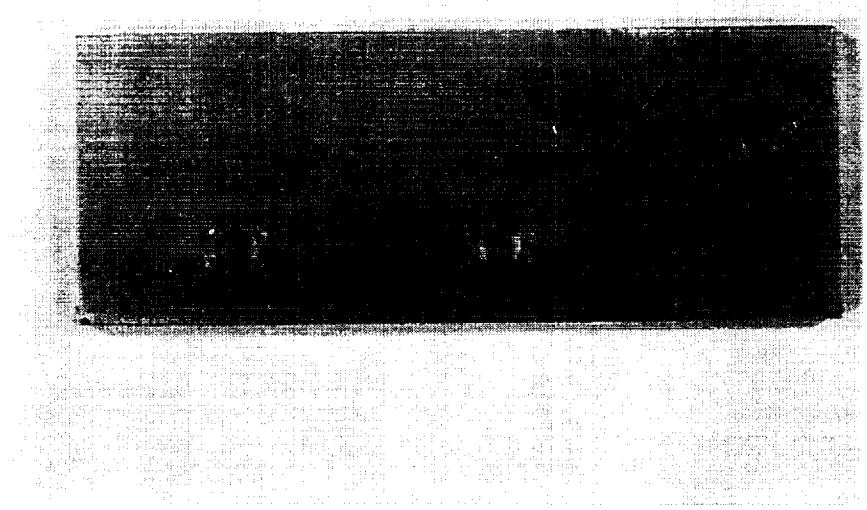
B12-C02 005


Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C02, 006

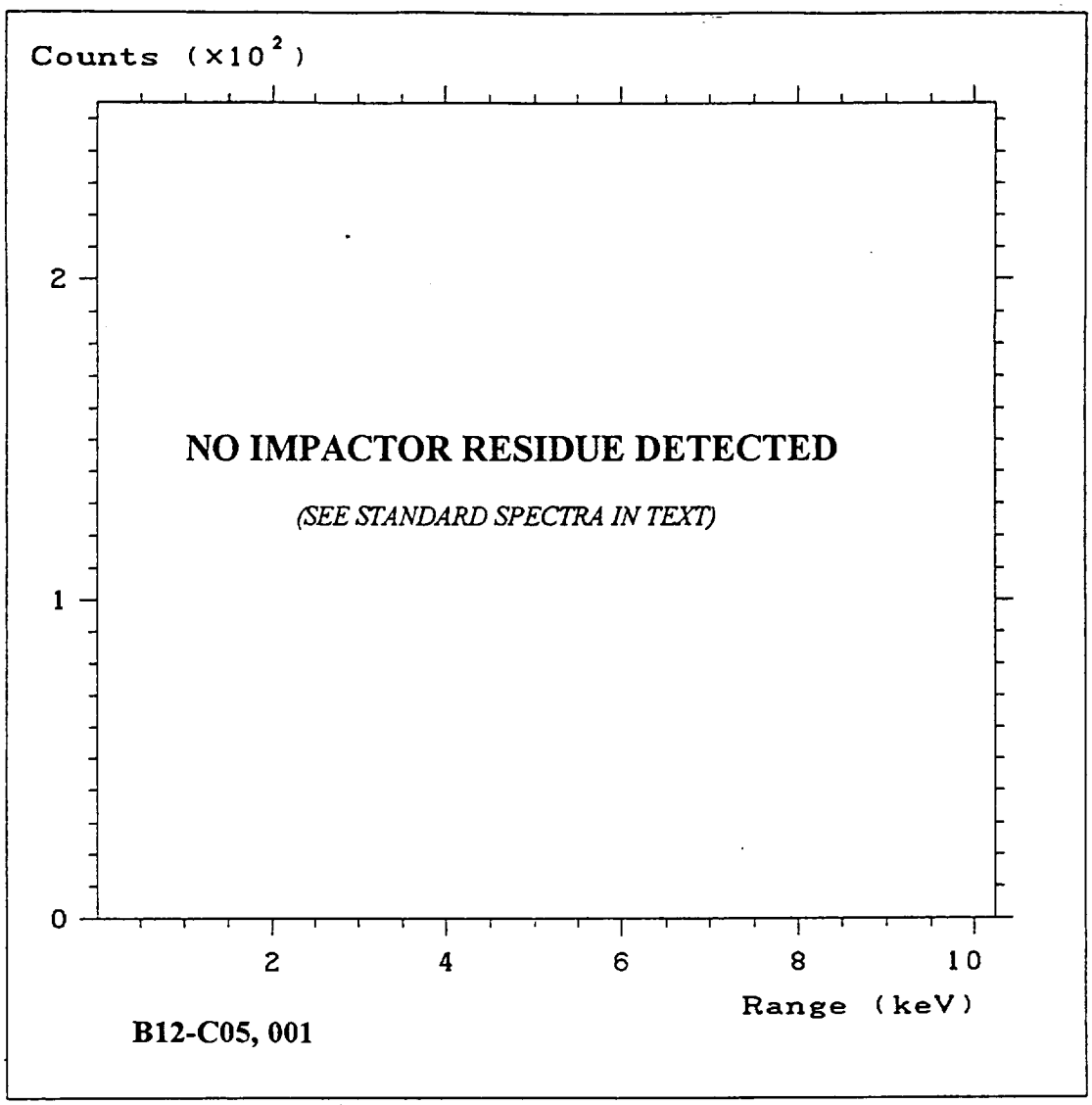

25kv 0.90kx 11.0μ 104

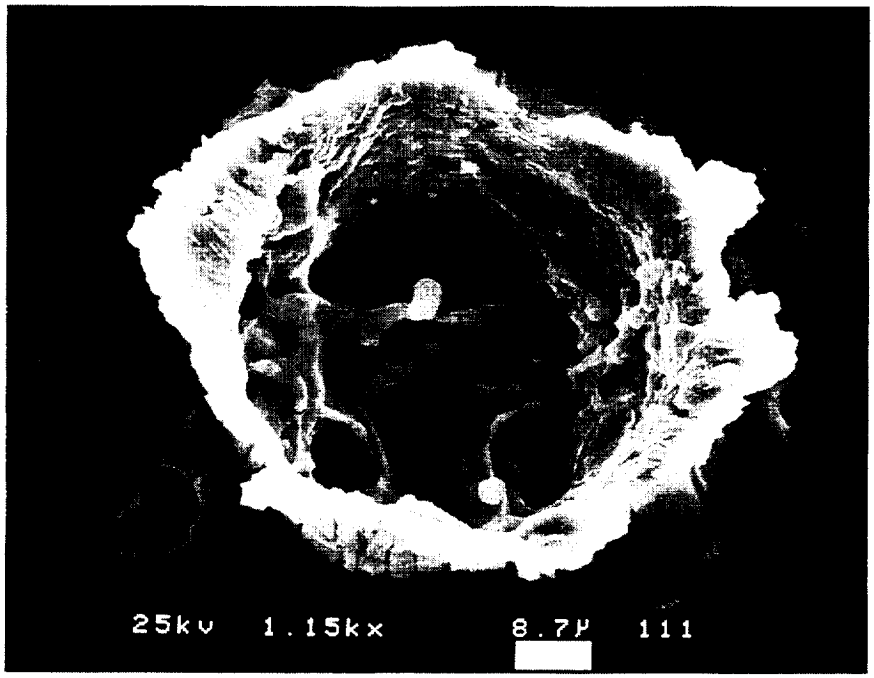
B12-C02 006

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B12-C05	001	80	16	60	UNKNOWN
	002	54	21	180	MICROMETEORITIC
	003	69	27	230	MICROMETEORITIC
	004	117	46	110	UNKNOWN

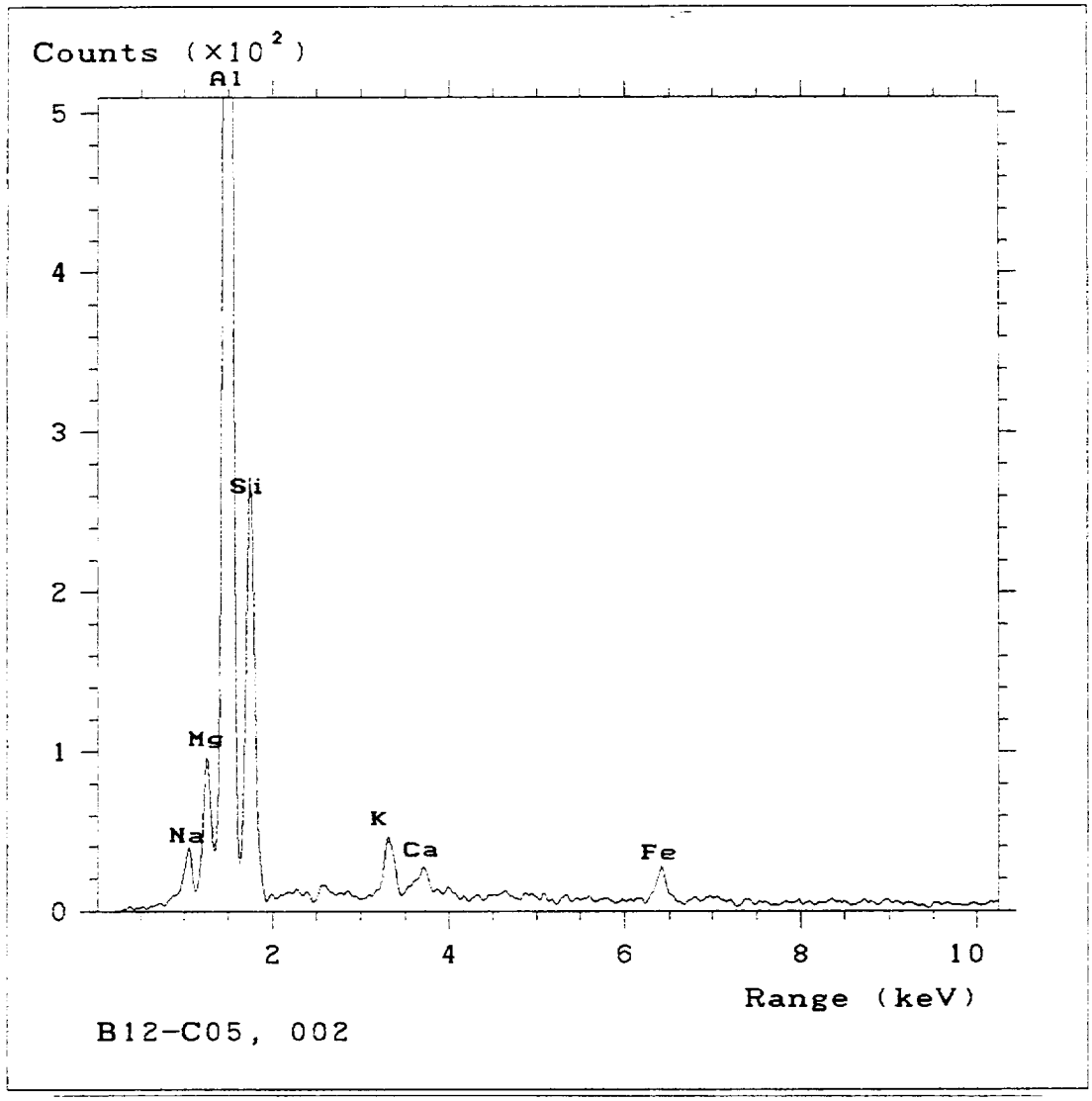


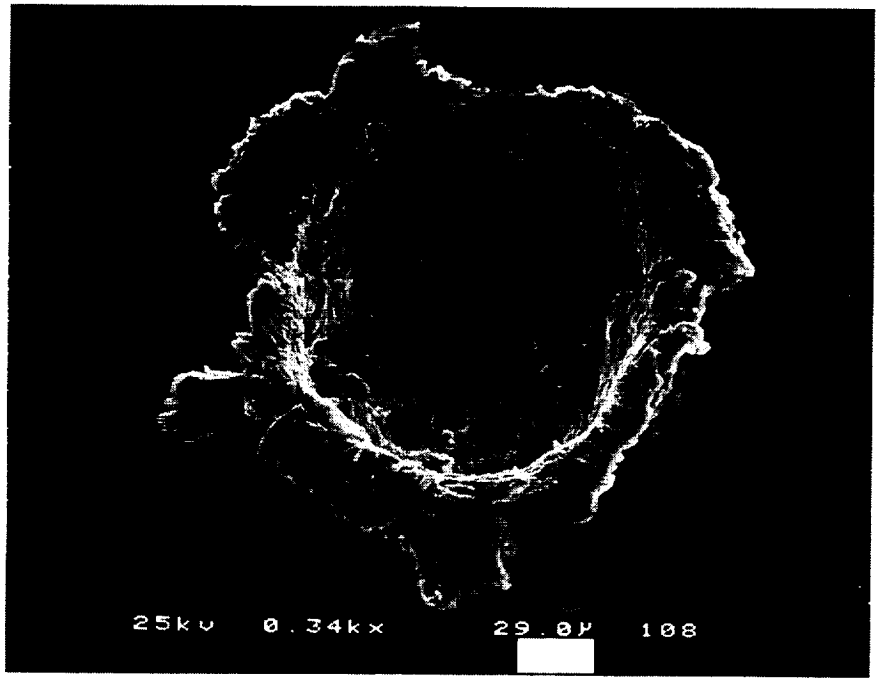
B12-C05


Counts (x10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C05, 001

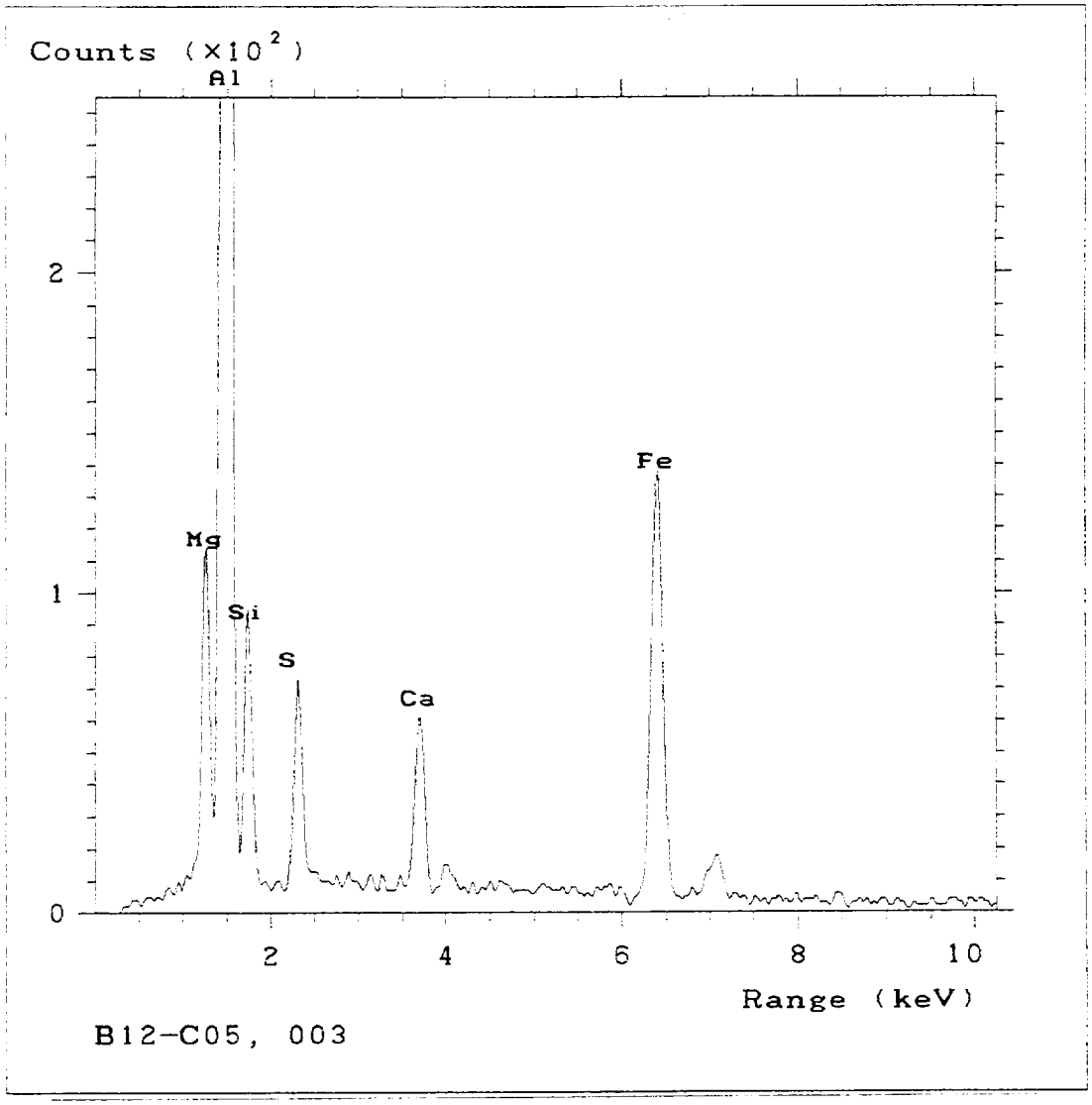

25kv 1.15kx 8.7μ 111

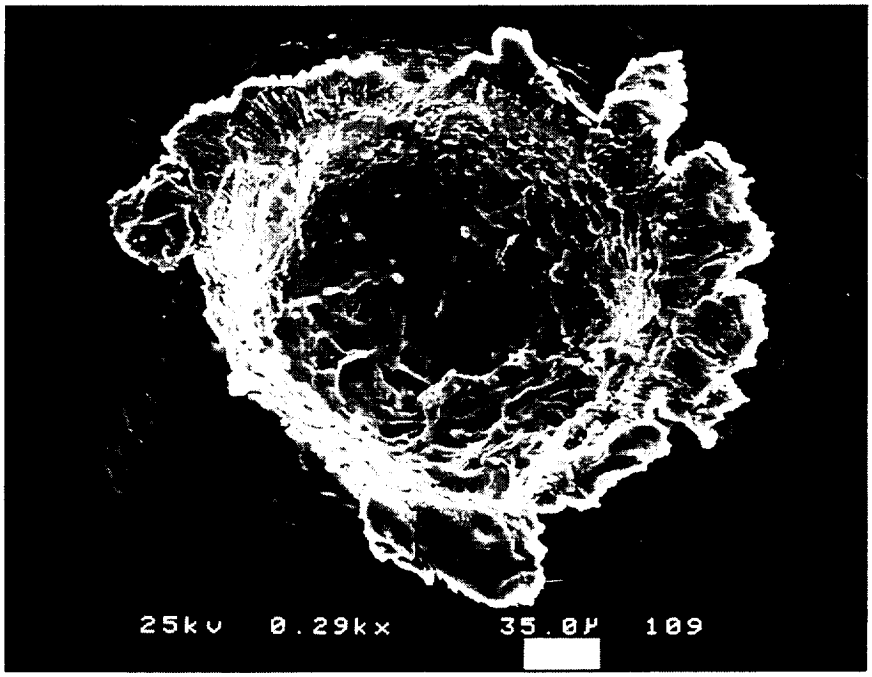
B12-C05 001



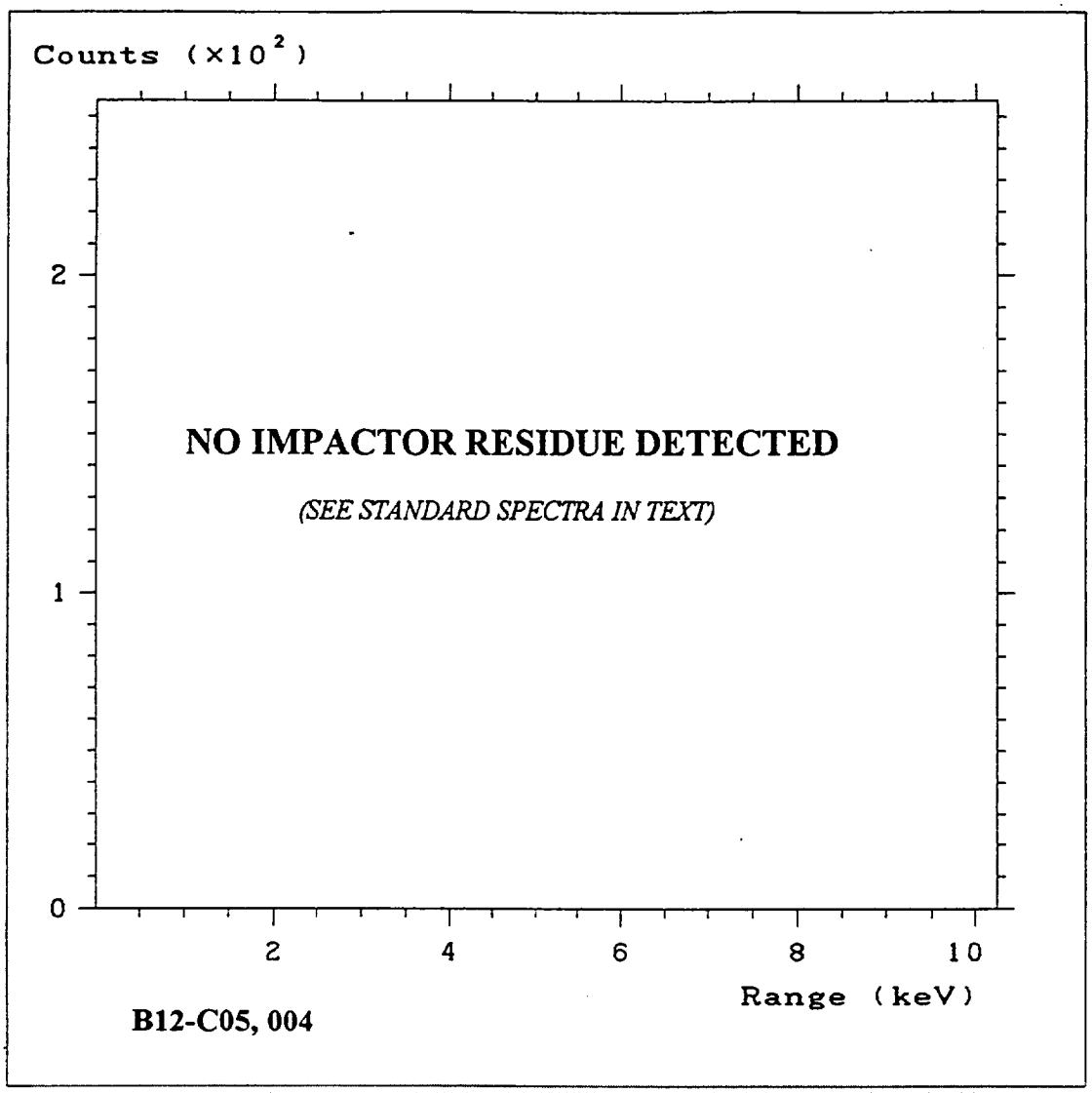


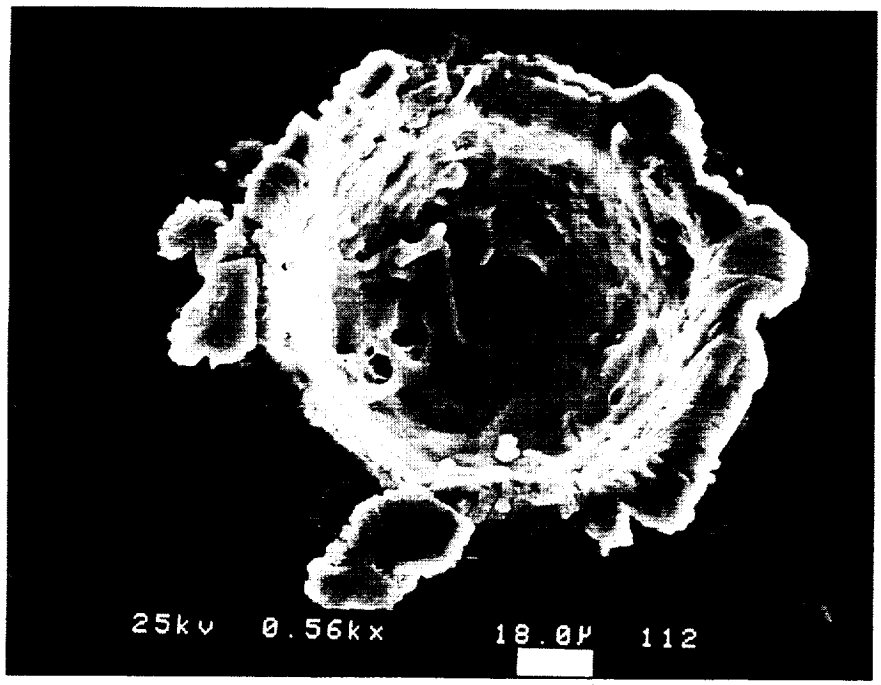
B12-C05 002 MM





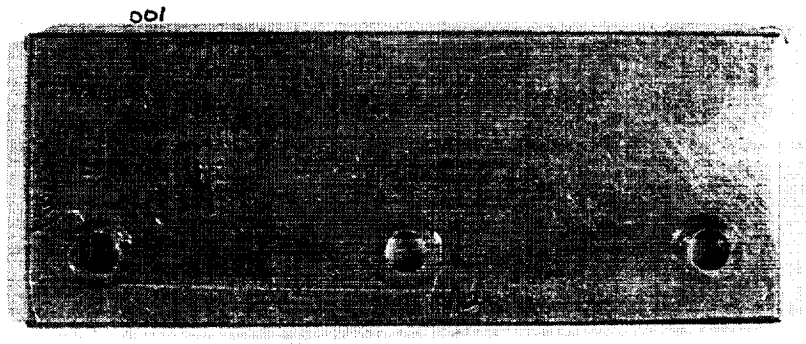
B12-C05 003 mm


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C05, 004

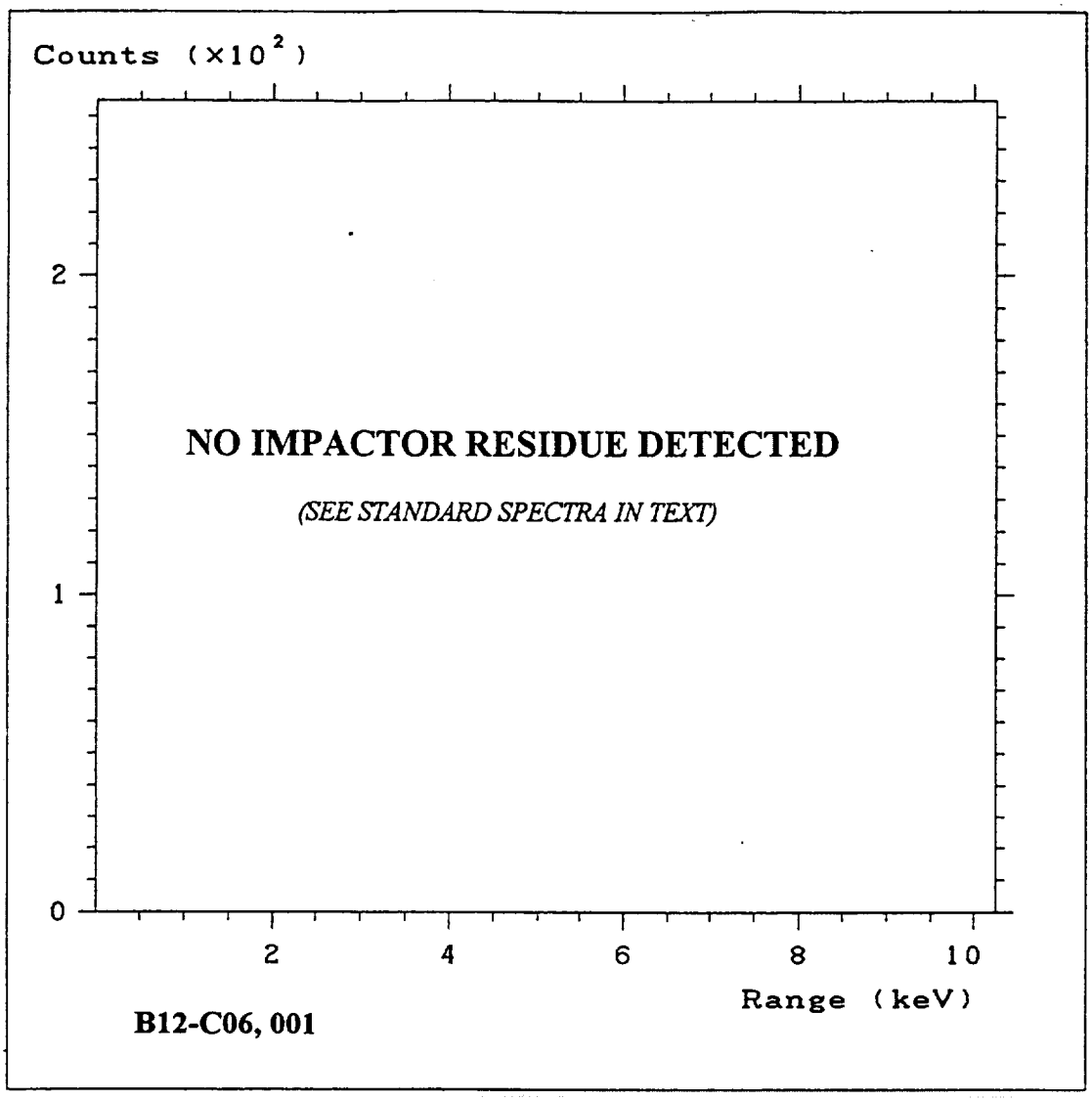

25kv 0.56kx 18.0μ 112

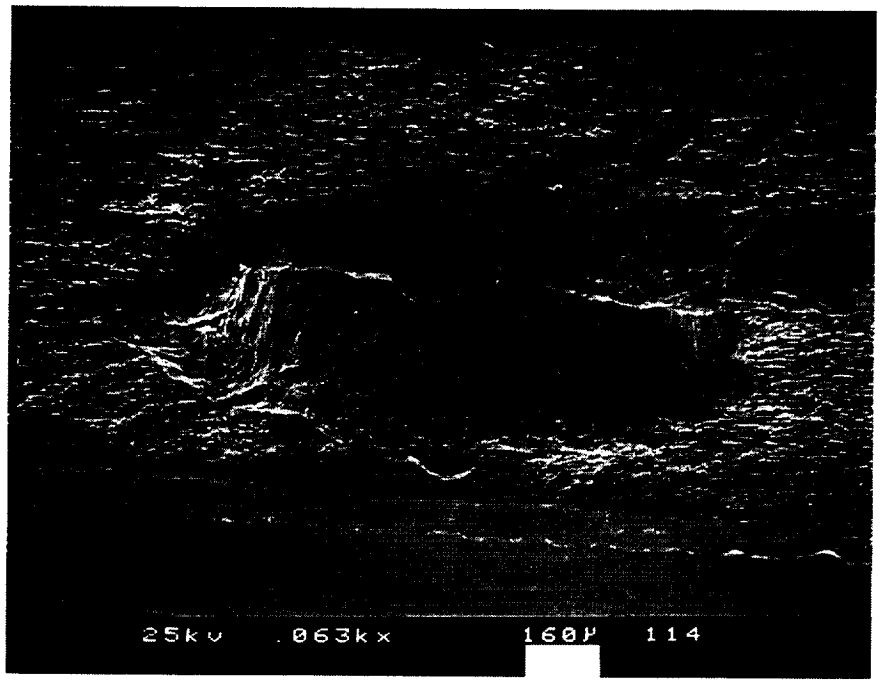
B12-C05 004

CLAMP NO.	IMPACT NO.	XCoor (mm)	YCoor (mm)	DIAMETER (µm)	COMMENTS (origin)
B12-C06	001	20	49	600	UNKNOWN
	002	70	7	360	MICROMETEORITIC
	003	0	16	200	NOT AN IMPACT

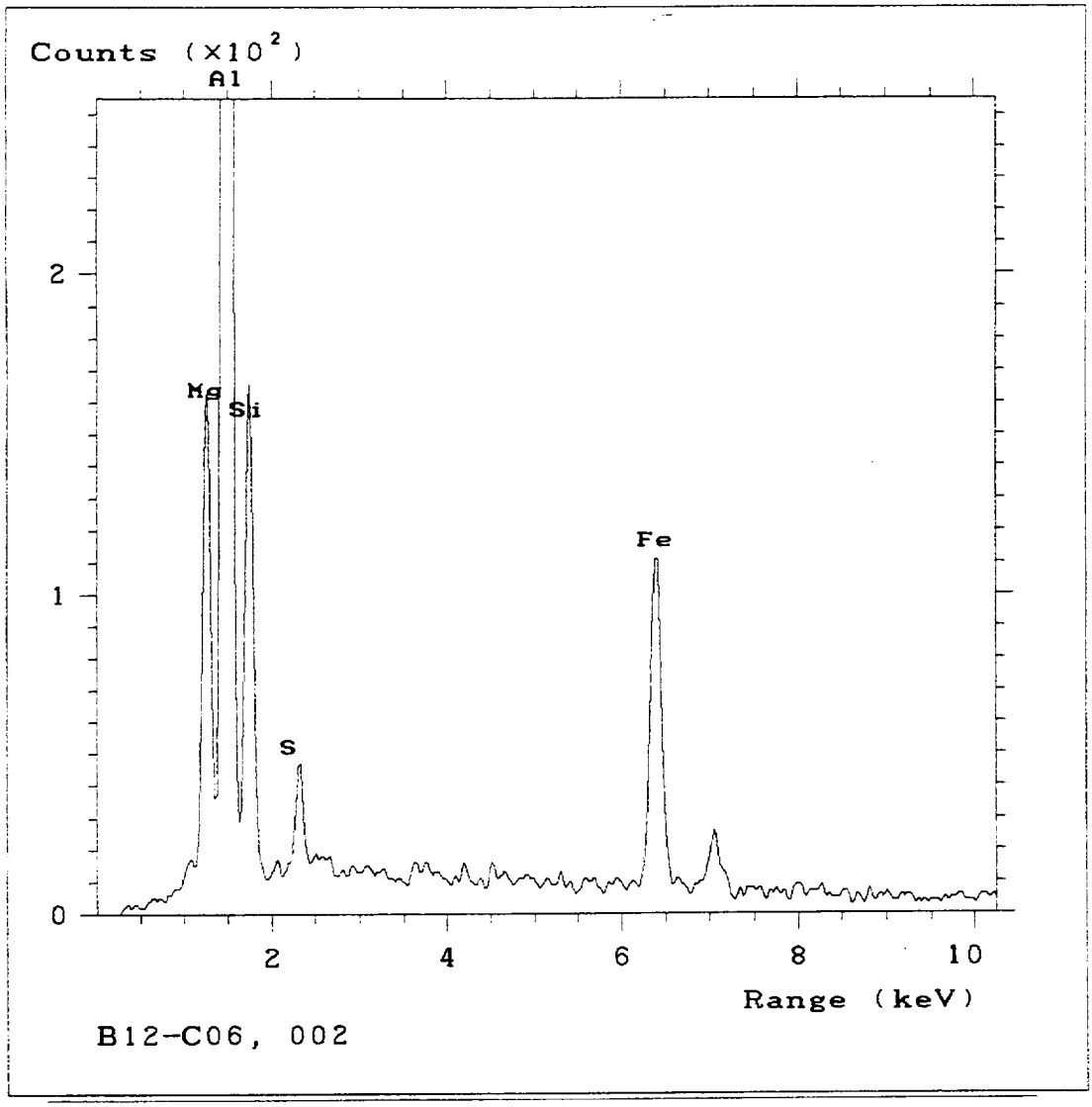


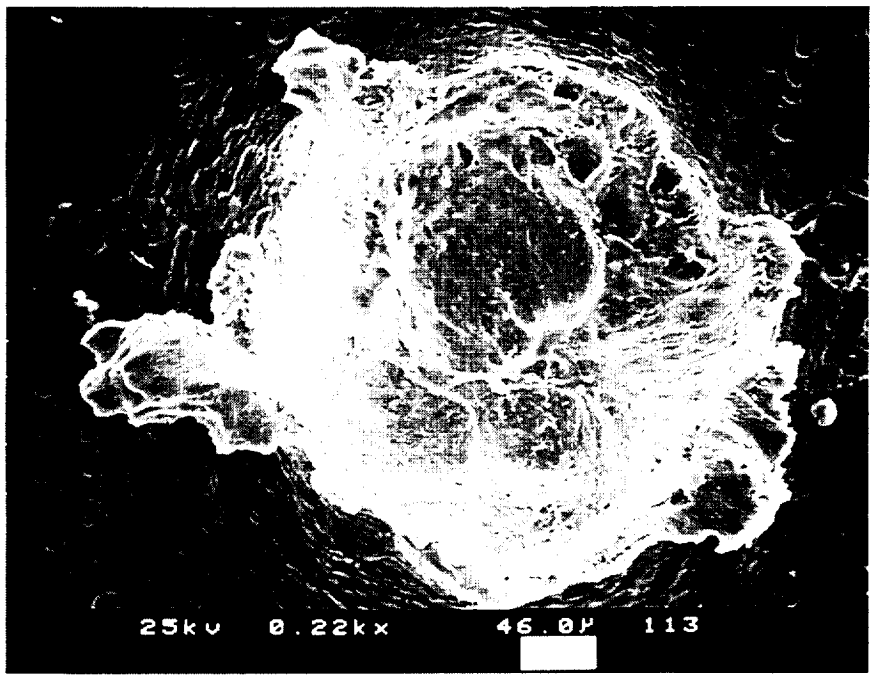
B12-C06


Counts (×10²)
2
1
0
NO IMPACTOR RESIDUE DETECTED
(SEE STANDARD SPECTRA IN TEXT)
2
4
6
8
10
Range (keV)
B12-C06, 001


25kv .063kx 160µ 114

B12-C06 001





B12-C06 002 mm

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13. ABSTRACT *(Maximum 200 words)*

The Long Duration Exposure Facility (LDEF) was placed in low-Earth orbit LEO) in 1984 and recovered 5.7 years later. The LDEF was host to several individual experiments specifically designed to characterize critical aspects of meteoroid and debris environment in LEO. However, it was realized from the beginning that the most efficient use of the satellite would be to examine the entire surface for impact features. In this regard, particular interest has centered on common exposed materials that faced in all LDEF pointing directions. Among the most important of these materials has been the tray clamps. Therefore, in an effort to better understand the nature of particulates in LEO and their effects on spacecraft hardware, we are analyzing residues found in impact features on LDEF tray clamp surfaces. This catalog presents all data from clamps from Bay B of the LDEF. NASA Technical Memorandum 104759 has cataloged impacts that occurred on Bay B (published March 1993). Subsequent catalogs will include clamps from succeeding bays of the satellite.

14. SUBJECT TERMS
Long Duration Exposure Facility (LDEF); Earth orbit, low (LEO); Meteoroids, impact damage; Debris; Clamps, holders (tray)

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