N86-29399

SILICON SHEET SURFACE STUDIES

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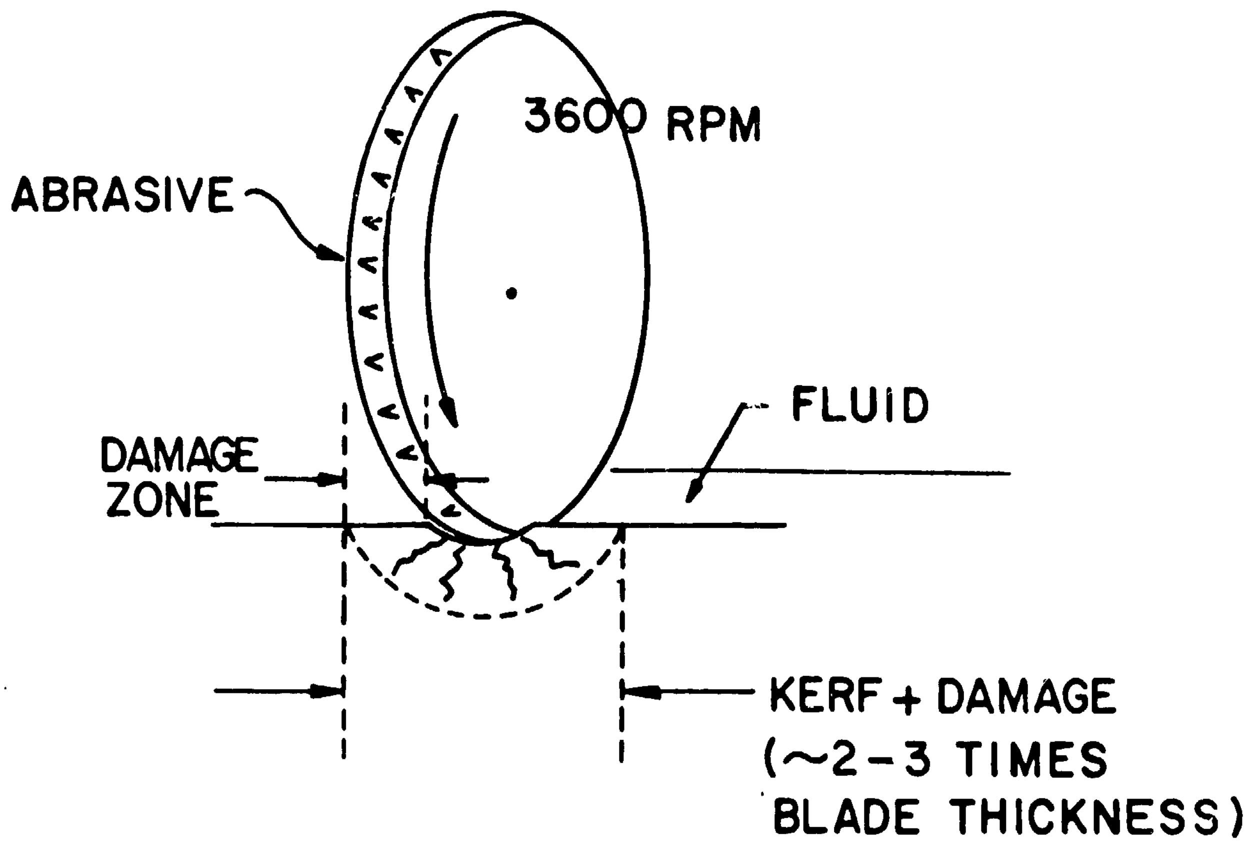
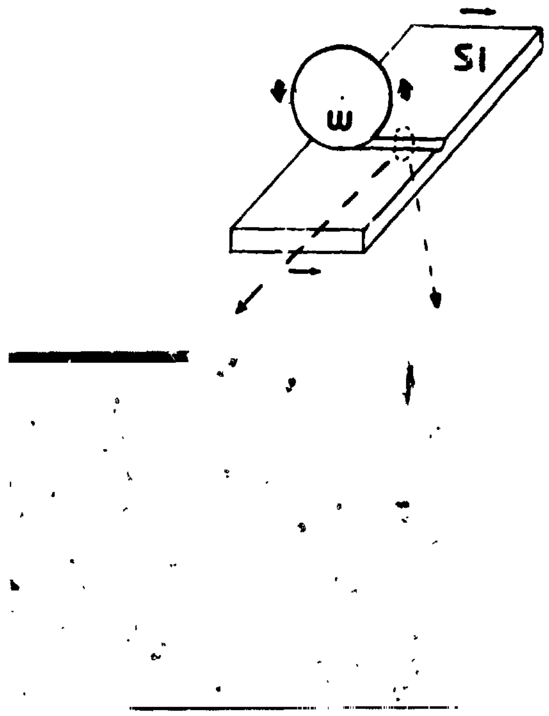
Abrasion and Wear of Silicon in Fluids	Measure Wear Rate (in fluids) Determine Mechanism of Wear Develop Model
Non-destructive Determination of Residual Stresses in Sheet Silicon	Develop experimental technique Perform Analysis Determine σ_{RS} in WEB, EFG sheet

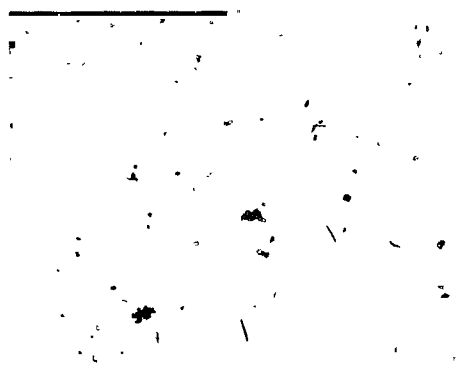
OD Sawing (Dicing)



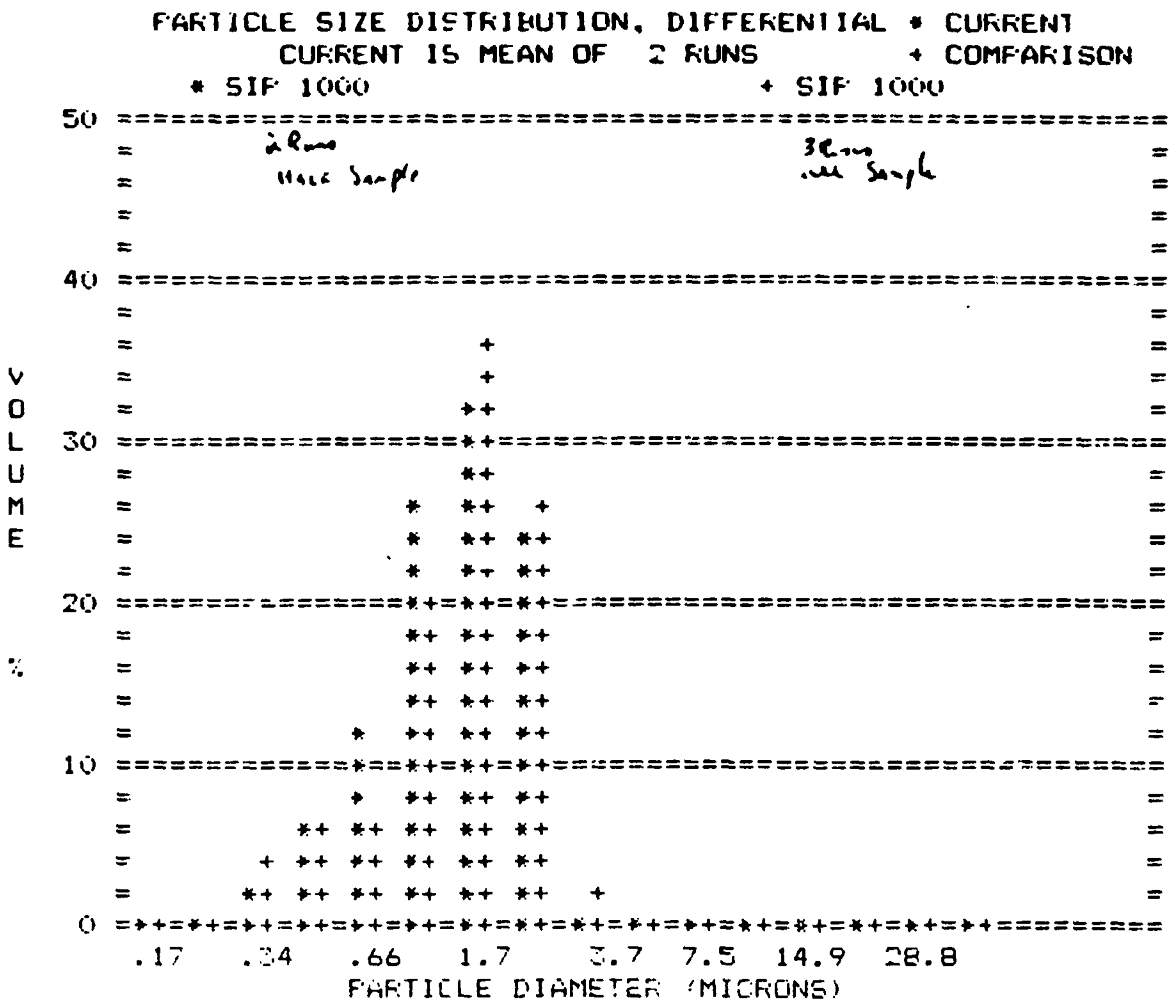
Grinding of Silicon Single Crystal



(a) P type (100), RPM: 1000, Depth of cut: .002", Feed rate: .7"/min., Blade thickness: .0010"



(b) Higher magnification of (a)

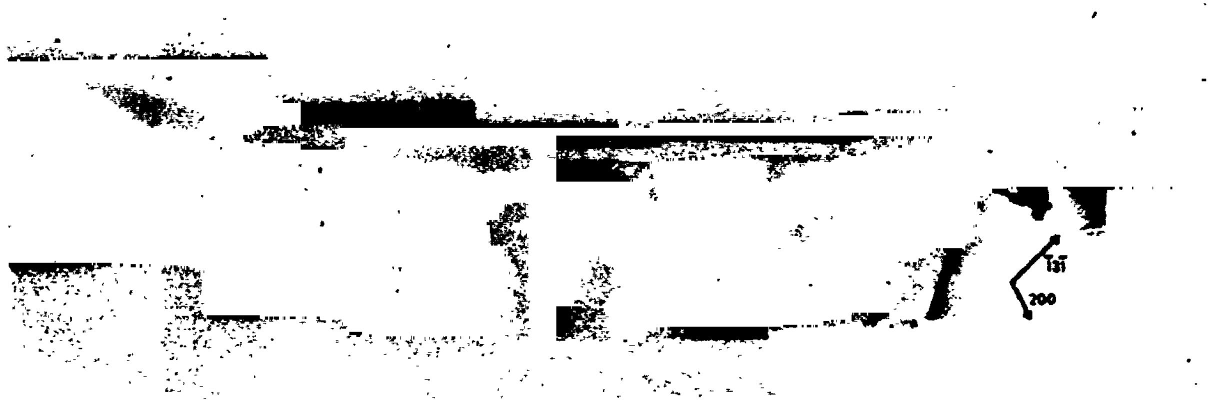


* Grinding condition of silicon

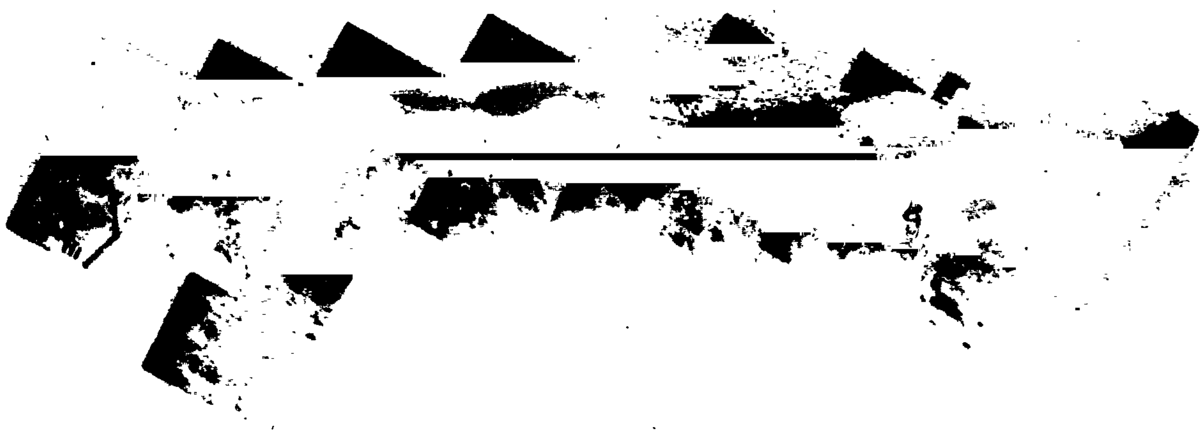
rpm : 1000, depth of cut : .005", feed rate : 1.5"/min.

room temperature, without fluids

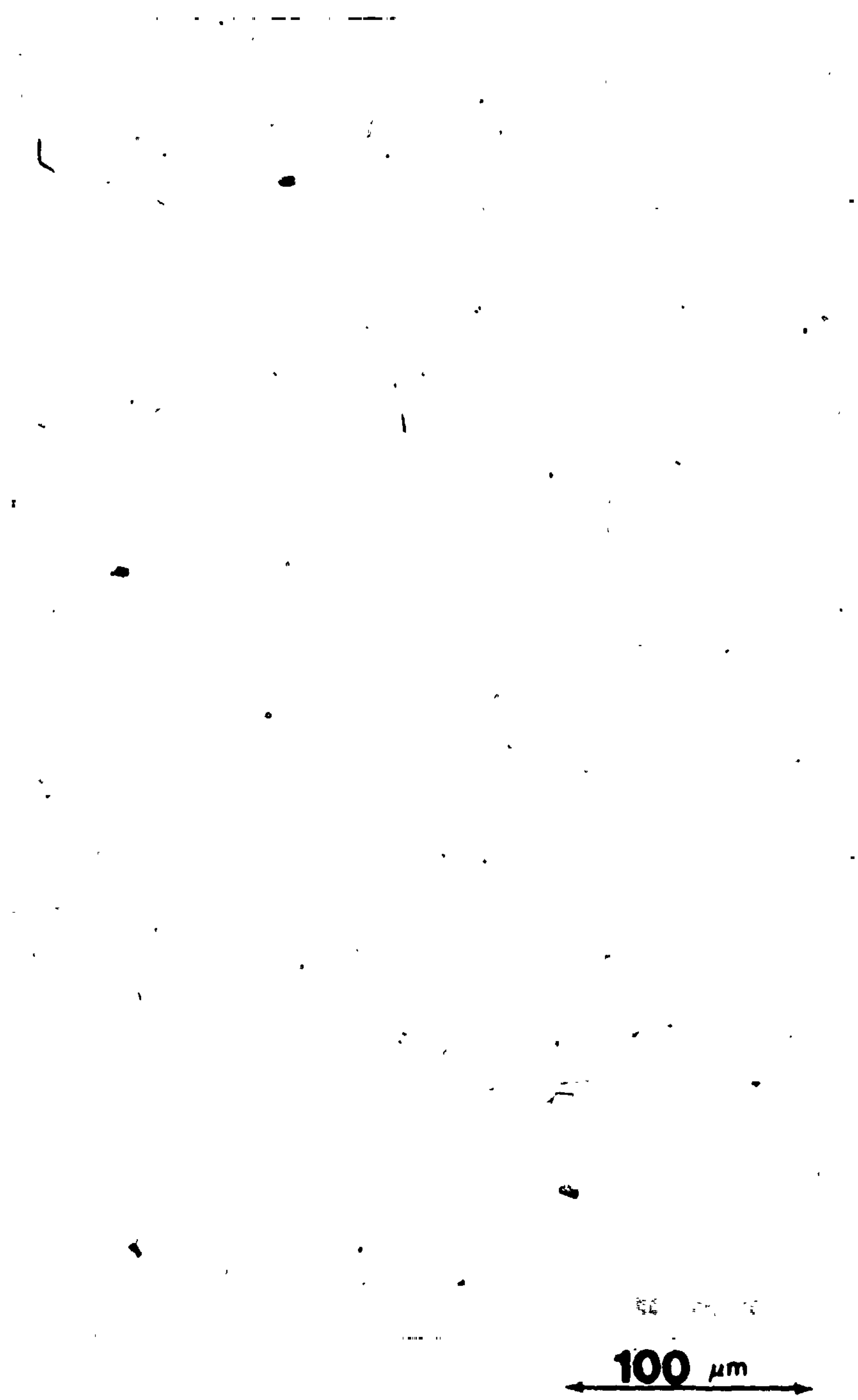
Diamond Grit of Dicing wheel, Series 401,
Micro Automation, blade thickness .0006-.0008"



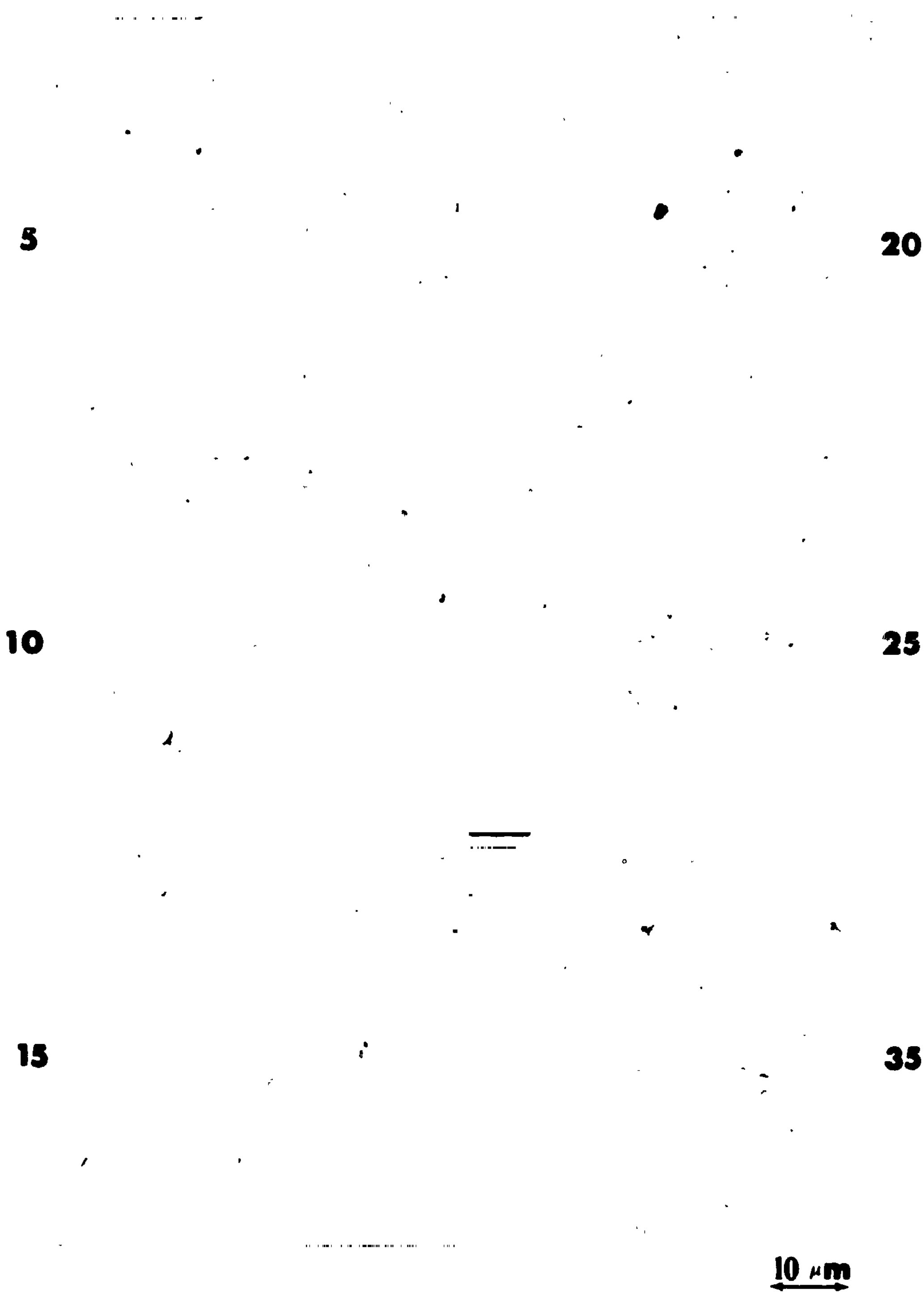
TEM micrograph of a scratch groove in p-type Cz silicon abraded in ethanol. The load on the pyramid diamond was 0.5 N and thescratching speed was 1.1 cm/s.



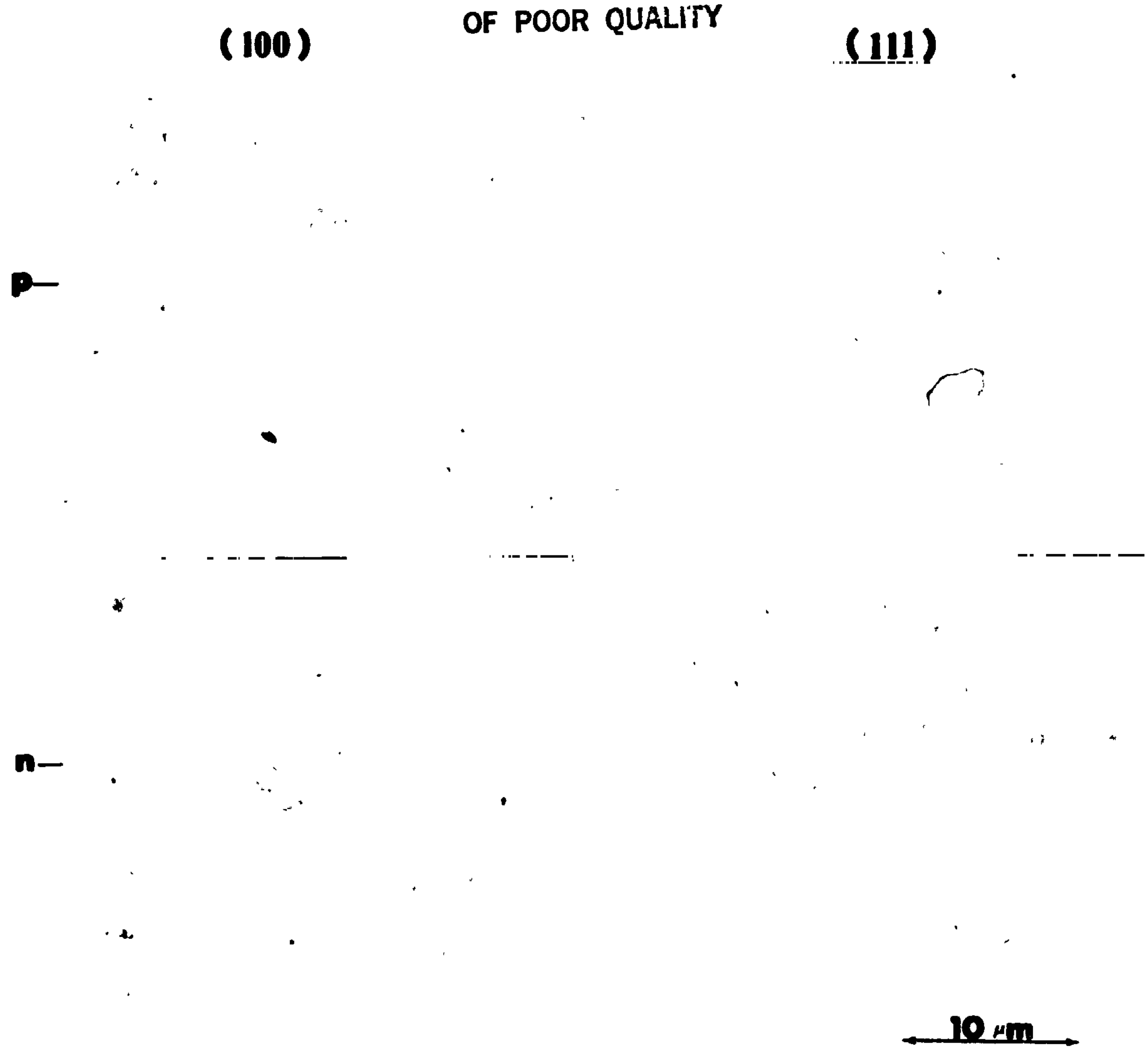
TEM micrograph of a scratch groove in p-type Cz silicon abraded in de-ionized water. The load on the abrading pyramid diamond was 0.5 N and the scratching speed was 1.1 cm/s.



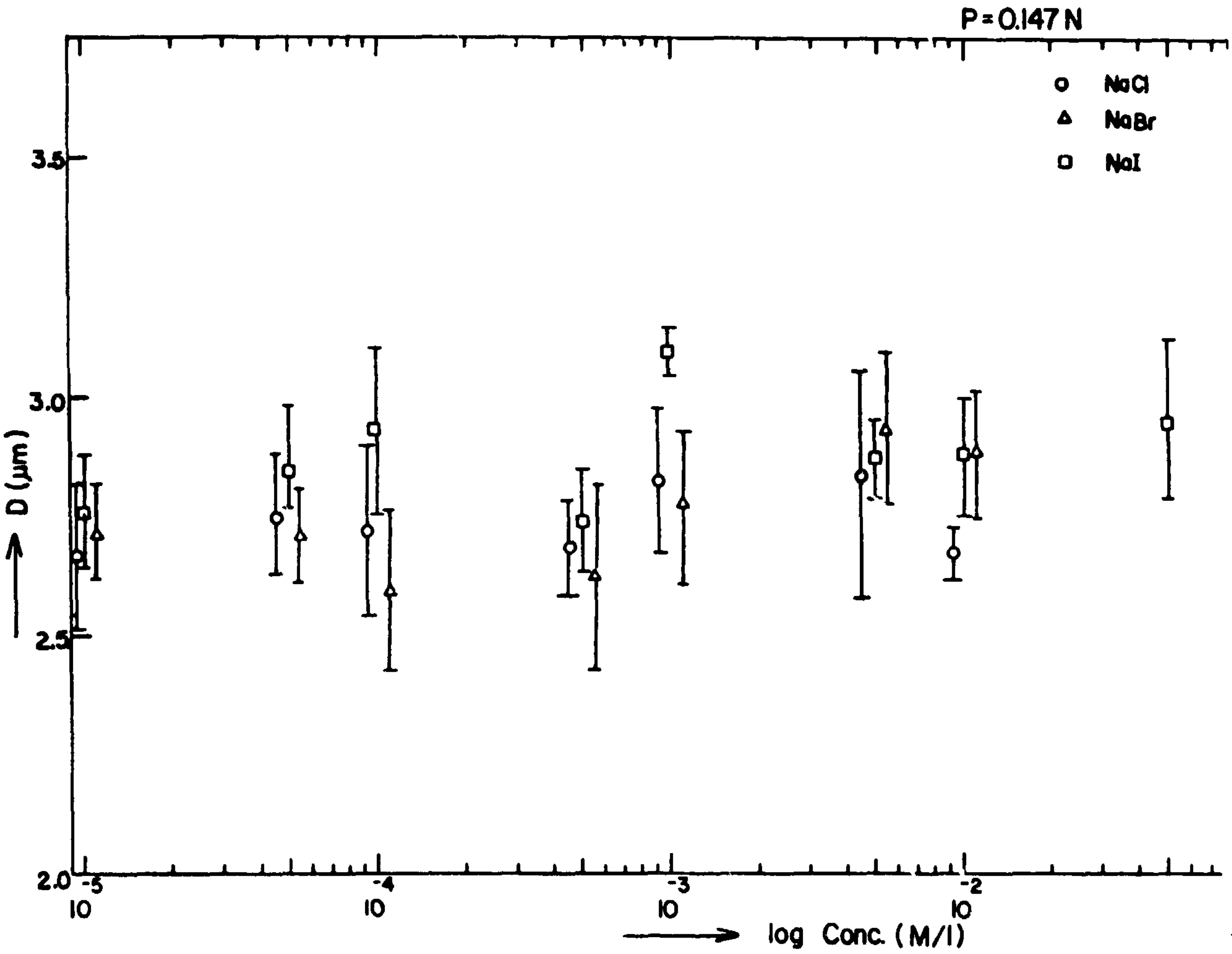
(A) Secondary electron image (SEI) and
(B) electron beam induced current (EBIC) image
of a pyramidal indentation in a (100) n-type silicon.
The indentation load was 9.8N.

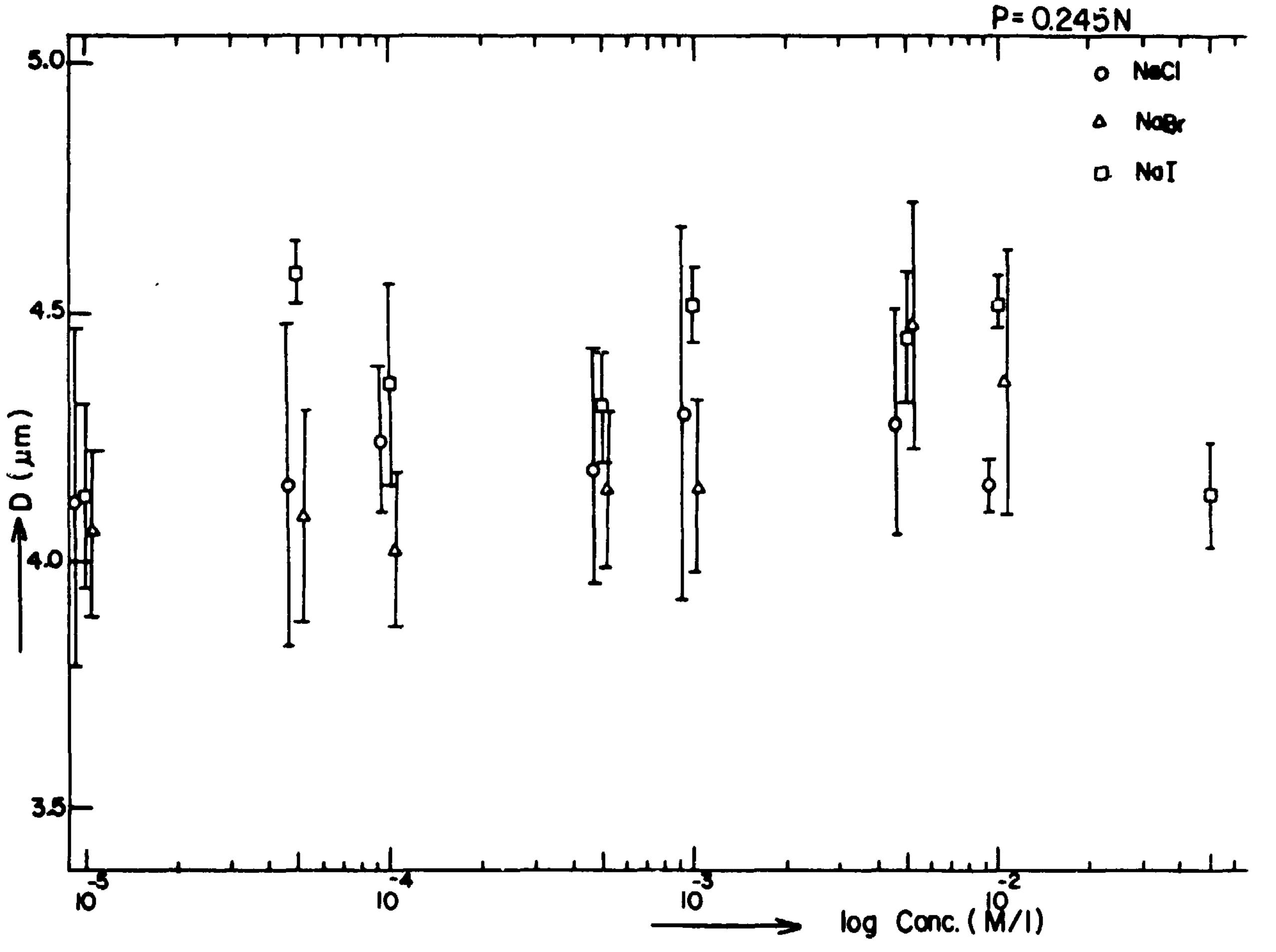


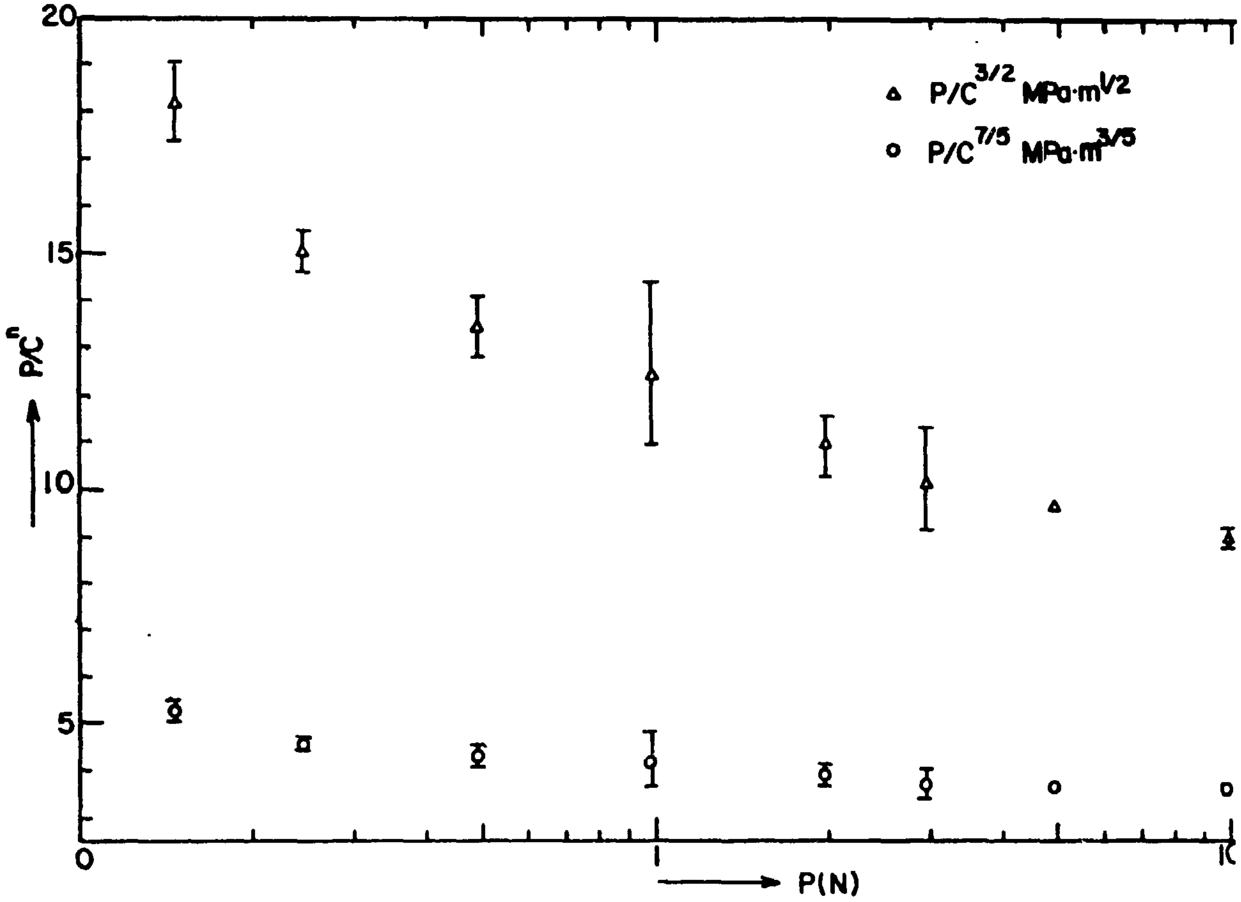
SEM micrographs of indentations as function of Sirtl etching time(s). The indentations of (100) n^- type Cz silicon were made in 10^{-3} M/I NaI.



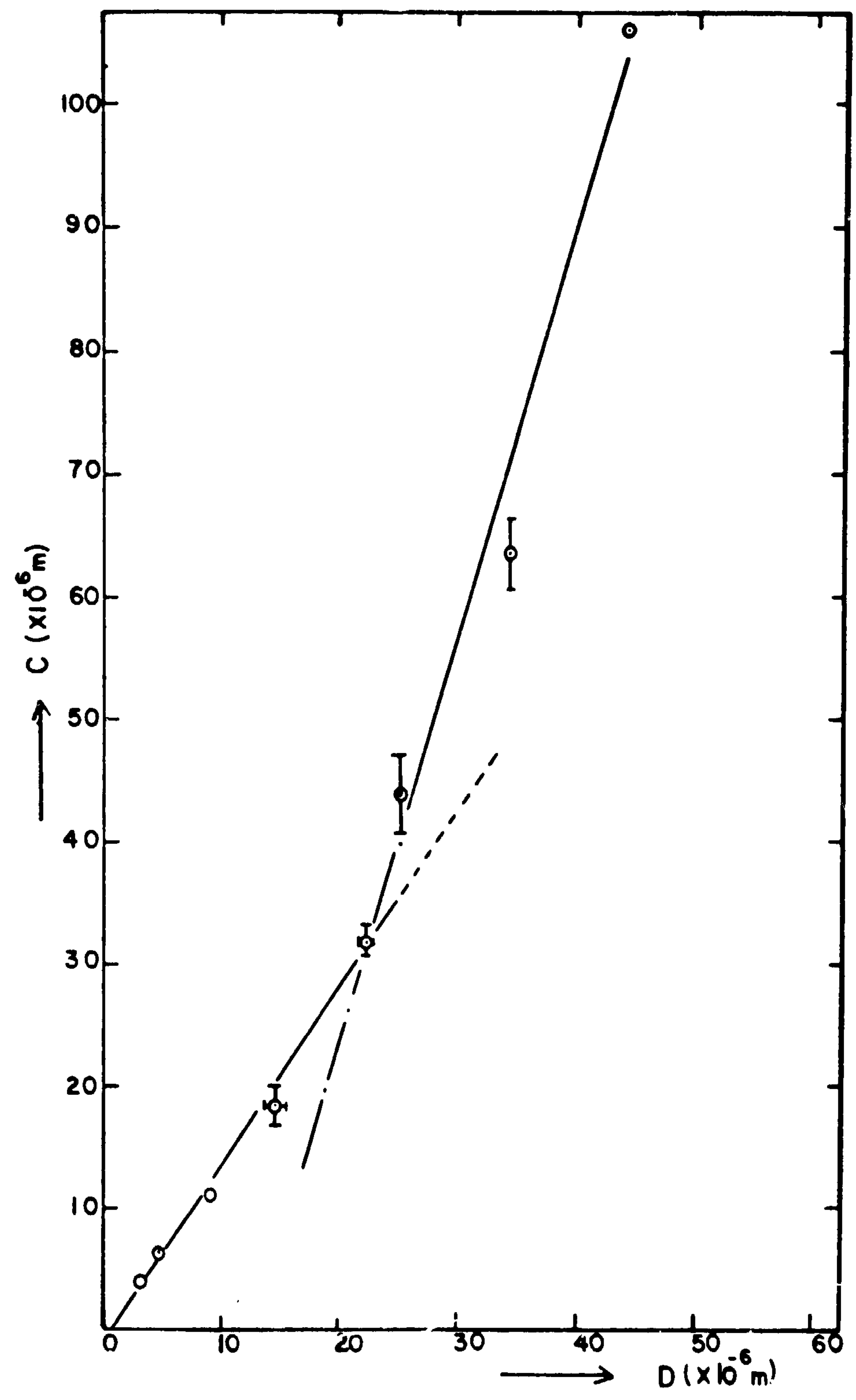
**SEM micrographs of indentations(P=0.49N, Sirtl etch for 25s.)
The indentations of (100),(111) p—and n—type Cz silicon were made in 10^{-3} M/l NaI.**

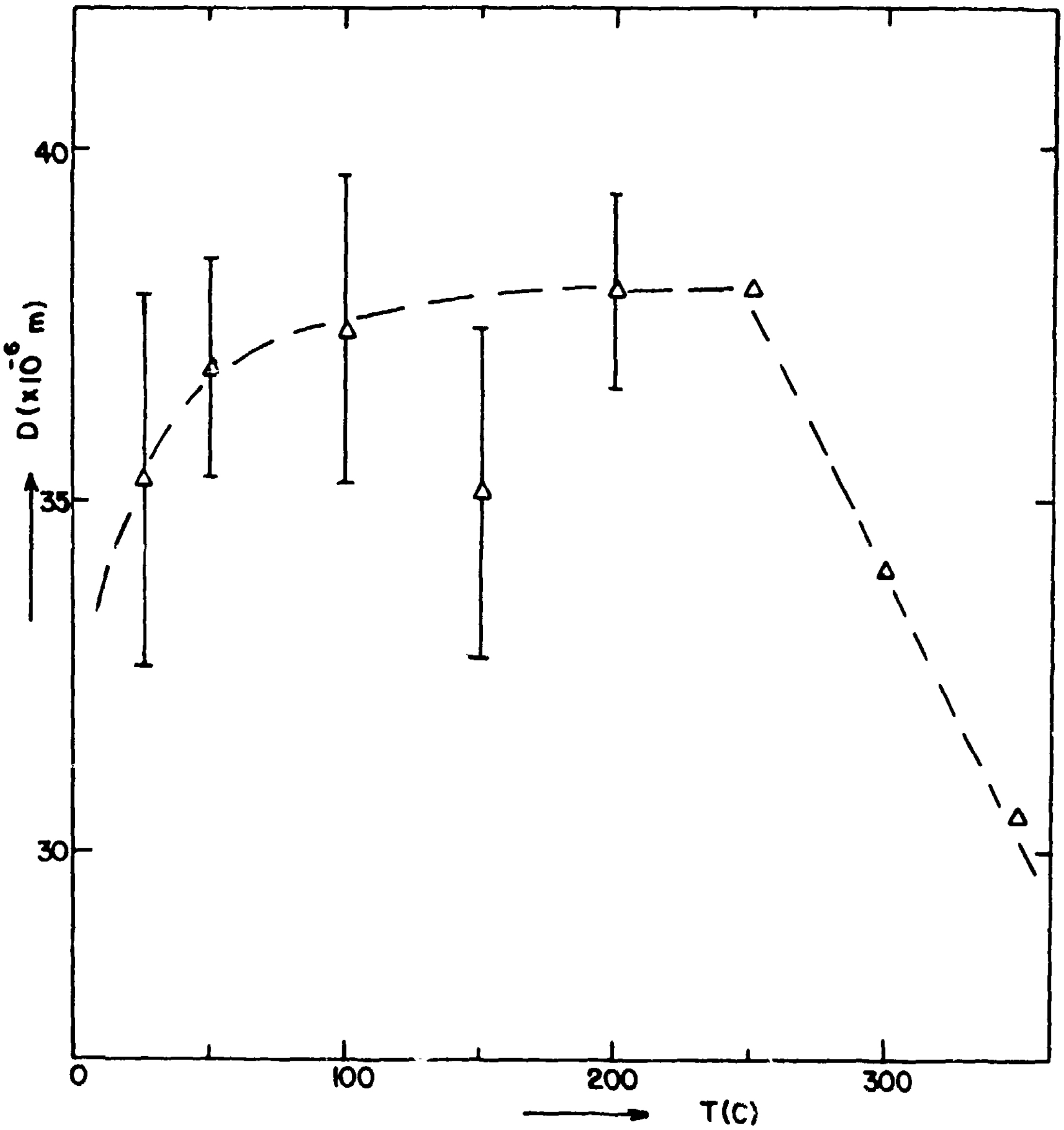

P = 0.147 N
NaCl
NaBr
NaI
3.5
3.0
2.5
2.0
D (µm)
10^-5
10^-4
10^-3
10^-2
log Conc. (M/l)


P= 0.245N
NaCl
NaBr
NaI
5.0
4.5
4.0
3.5
D (μm)
10^{-5}
10^{-4}
10^{-3}
10^{-2}
log Conc. (M/l)

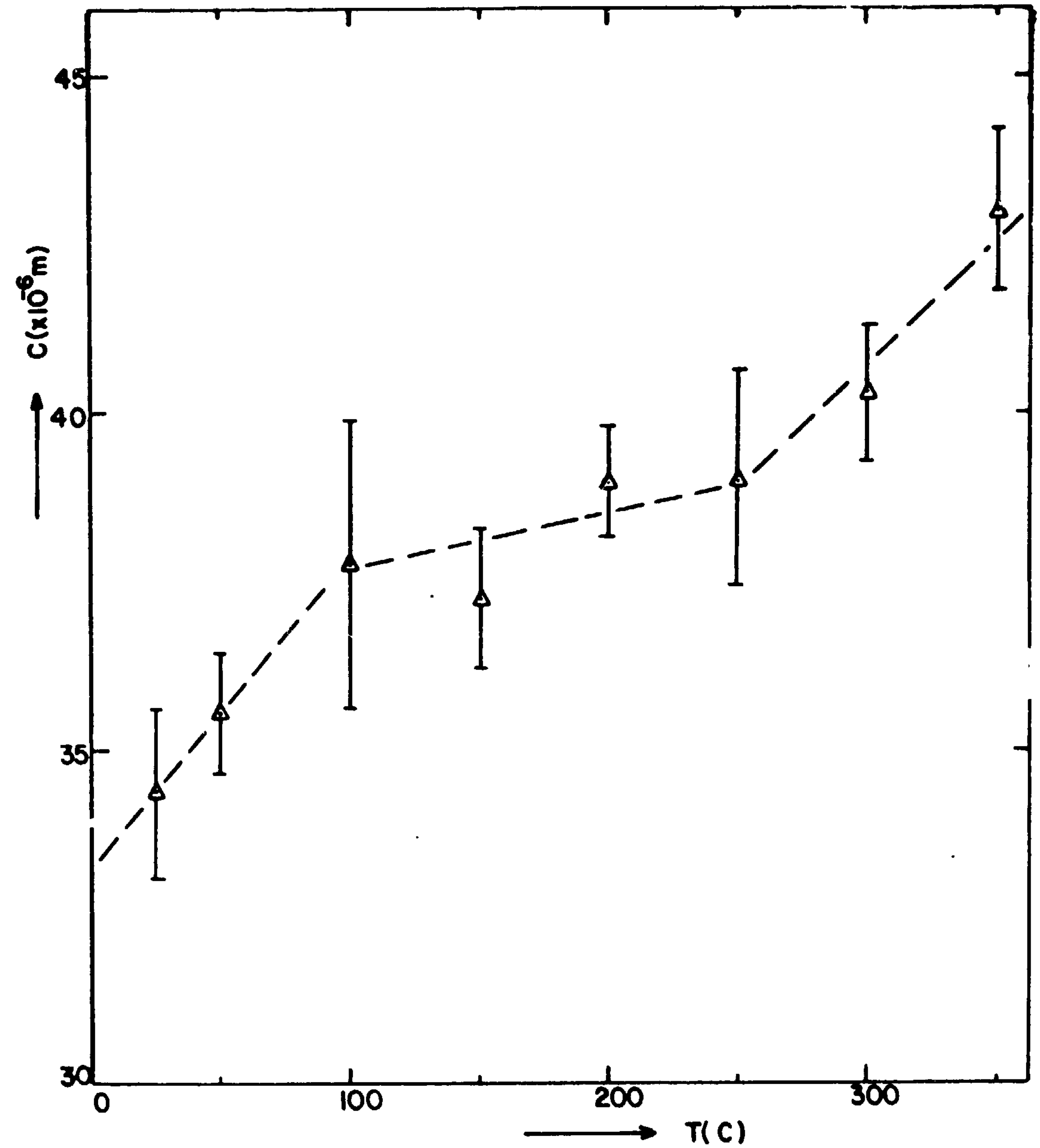

20
15
10
5
0
P/C^n
Δ P/C$^{3/2}$ MPa·m$^{1/2}$
o P/C$^{7/5}$ MPa·m$^{3/5}$
1
10
P(N)

SEM micrographs of indentation for (100) n-type silicon. The indentations were made with a load of 1.98N at 350°C, and etched in dilute Sirti solution for 15s.


C (X10^-6 m)
D (X10^-6 m)
0
10
20
30
40
50
60
70
80
90
100



Damage size as a function of temperature for (100) n-type Cz silicon under a load of 1·98N.



Radial crack length as a function of temperature for (100) n-type Cz silicon under a load of 1.98N.

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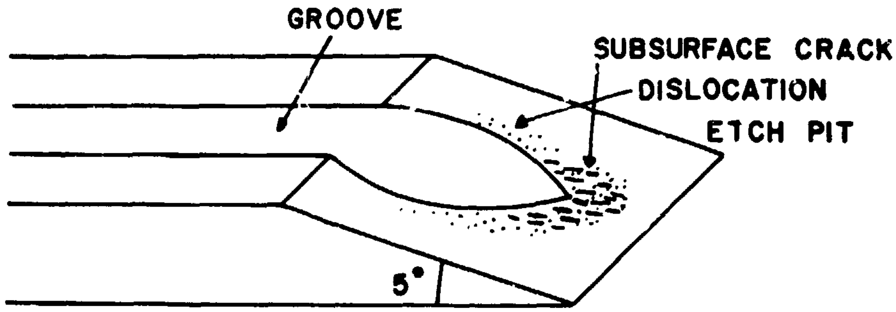
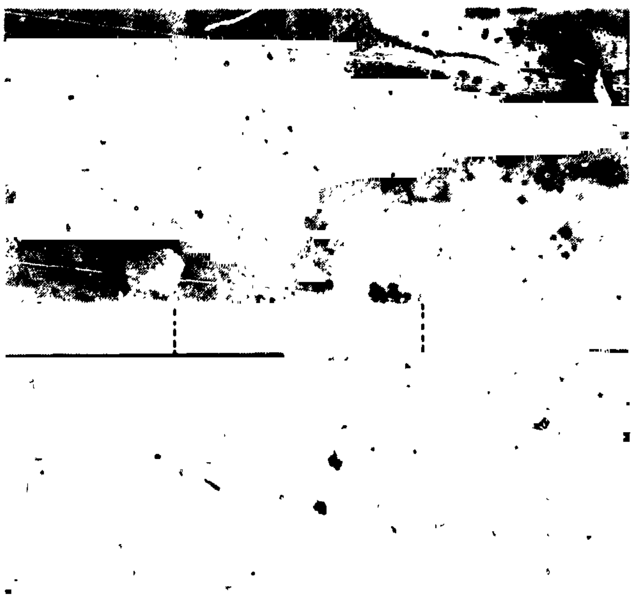
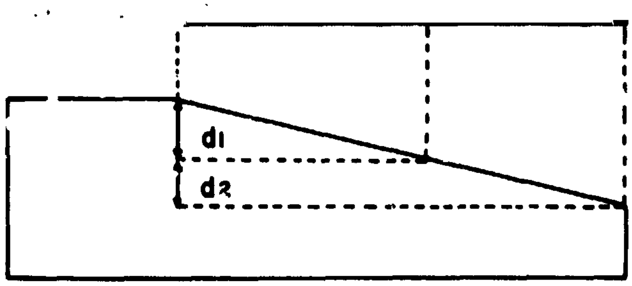


- 10 SCRATHES IN DI H_2O
- ANNEALED AT 750°C FOR 1 HR



OPTICAL

SEM
(BSE MODE)



d1 : DEPTH OF GROOVE
d2 : DEPTH OF DAMAGE

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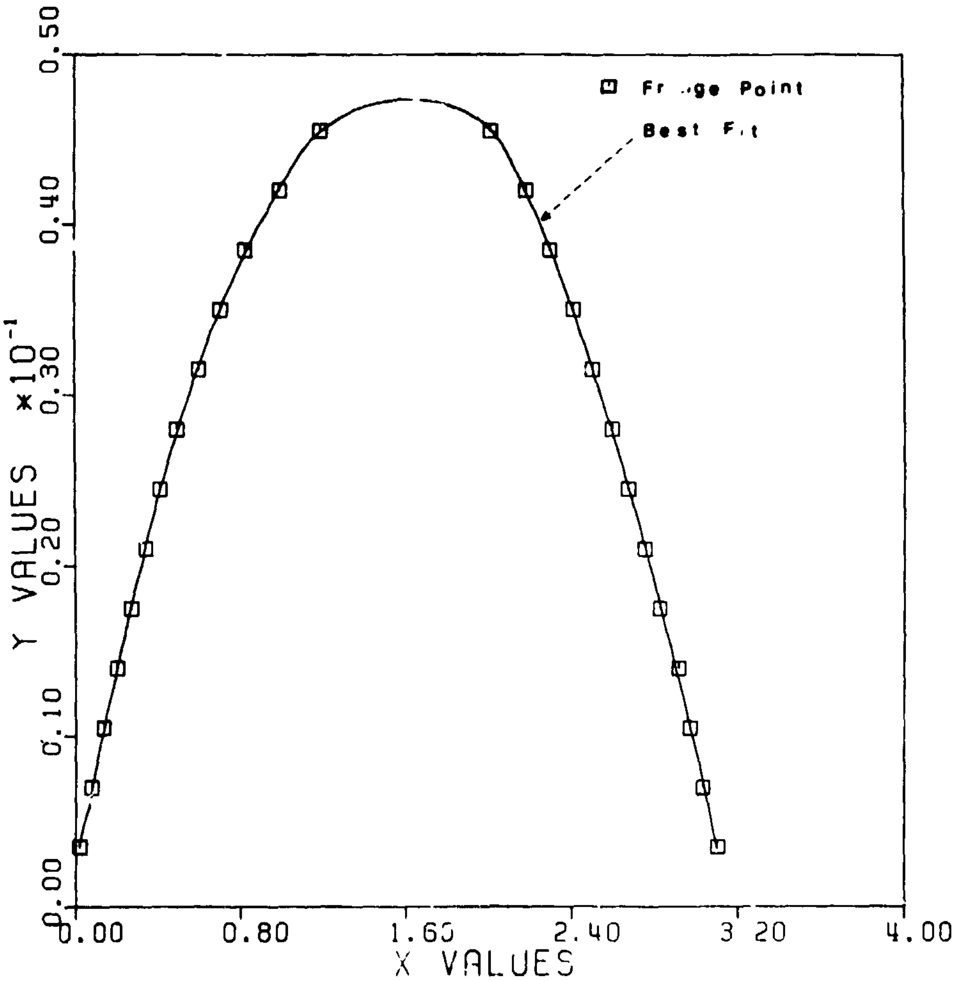
HIGH STRESS (1.4 lb)



DEFLECTION

Best Fit Polynomial

$$Y = -0.001\,X^{8} + 0.005\,X^{7} - 0.019\,X^{6} + 0.04\,X^{5} - 0.038\,X^{4} + 0.015\,X^{3} - 0.023\,X^{2} + 0.061\,X + 0.004$$

Deflection (Cubic Spline)

0.0300	0.0317	0.0319	0.0311	0.0291

Second Derivative (Cubic Spline)

0.0529	0.0363	0.0248	0.0344	0.0441

Residual Stress

-8.547	-7.720	-7.670	-7.856	-8.545

	0.6	0.8	1.0	1.2	1.4
1	-8.045	-7.694	-7.604	-7.662	-8.248
2	-8.146	-7.621	-7.628	-7.825	-8.478
3	-8.547	-7.720	-7.670	-7.866	-8.545
	-8.132	7.314	7.417	7.543	7.817
5	7.689	7.553	7.581	7.706	8.085
6	7.735	7.516	7.481	7.635	8.009
7	-8.369	-7.743	7.446	7.499	8.190
8	-8.208	-7.764	-7.540	-7.817	-8.403
9	-8.109	-7.763	-7.636	-8.265	-8.924
10	-7.801	-7.492	-7.485	-7.648	-8.250

High Stress (1.8 lb)

	0.4	0.6	0.8	1.0	1.2	1.4
1	-8.920	-7.827	-7.765	-7.791	-8.065	-8.623
2	-8.235	-7.692	7.140	7.171	7.337	-8.577
3	-8.179	-7.615	-7.527	-7.789	-7.921	-8.443
4	7.712	7.419	7.283	-8.156	-7.850	-8.407
5	8.132	7.690	7.518	7.410	7.581	7.718
6	7.969	6.470	7.413	7.433	7.673	7.465
7	8.046	7.767	7.483	7.593	7.945	8.442
8	-8.059	-7.598	-7.344	-7.389	-7.576	-8.110
9	-7.924	-7.200	-7.182	-7.592	-7.378	7.074
10	-8.780	-8.064	6.807	6.909	8.076	-9.062

Residual Stress Distribution

MODULE DEVELOPMENT AND ENGINEERING SCIENCES

Melvin I. Smokler, Chairman

M. Spitzer, of Spire Corp., described Spire progress on the development of a high-efficiency module. The effort includes development of high-efficiency cells using crystalline silicon wafers made from FZ silicon. Module-size cells, 53^2 cm in area, have been fabricated with efficiency of 18%.

R. S gimura, of JPL, reported that new materials have been developed which show promise of fabricating modules that can pass the Underwriter Laboratories Class A burning-brand test for fire-ratable solar cell modules.

D. Otth, of JPL, reviewed the development of a qualification test for modules bypass diodes. Diode junction temperature is measured, indirectly, under laboratory ambient conditions, and extrapolated to field conditions. Criteria are given for diode reliability.

R. Mueller, of JPL reported the development of the capability for measurement under global irradiance spectral distribution. He also described the status of the international round robin of reference cell measurements managed by the Commission of European Communities (CEC).

J. Lathrop, of Clemson University, discussed the work at Clemson on reliability testing of solar cells. Results are given on initial temperature and humidity tests of amorphous silicon devices.

Q. Kim, of JPL, presented results obtained in applying the unique characteristics of the solar-cell laser scanner to investigate the defects and quality of amorphous silicon cells.

D. Burger, of JPL, described the application of PVARRAY, a software program for design of PV arrays. Results of sample parametric studies on array configurations were presented.