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MeV ION-BEAM ANALYSIS OF OPTICAL DATA STORAGE FILMS

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OBJECTIVES

Our objectives are threefold: 1) to accurately characterize optical data storage films by MeV ion-beam analysis (IBA) for ODSC collaborators; 2) to develop new and/or improved analysis techniques; and 3) to expand the capabilities of the IBA facility itself.

Using $^{1}H^{+}$, $^{4}He^{+}$ and $^{15}N^{++}$ ion beams in the 1.5 MeV to 10 MeV energy range from a 5.5 MV Van de Graaff accelerator, we determine film thickness (in atoms/cm^2), stoichiometry, impurity concentration profiles and crystalline structure by Rutherford backscattering (RBS), high-energy backscattering, channeling, nuclear reaction analysis (NRA) and proton induced X-ray emission (PIXE). Most of these techniques are discussed in detail in the ODSC Annual Report (February 17, 1987), p. 74. The PIXE technique is briefly discussed in the ODSC Annual Report (March 15, 1991), p. 23.

PROGRESS

Film Characterization

From March 1, 1992, to March 1, 1993, we provided a total of 214 equivalent backscattering analyses of thin films provided by ODSC collaborators. Table 1 indicates the distribution.

Table 1. Number of analyses of thin films for ODSC.

Period	Falco	Mansuripur	Zelinski	Armstrong	Totals
3/1/92 - 6/1/92	10	22	---	2	34
6/1/92 - 9/1/92	27	50	21	---	98
9/1/92 - 12/1/92	31	8	6	---	45
12/1/92 - 3/1/93	19	---	18	---	37
3/1/92 - 3/1/93	87	80	45	2	214

For Falco (with Engel, Van Leeuwen, Wiedmann and Yu), we provided channeling analyses of Pd/Co multilayers, backscattering analyses of PdCu, MnSb, NbCuMn, PdCoAu, and CoAgIr films and PIXE analyses of several films containing adjacent mass elements (such as Pd and Ag).

For Mansuripur (with Wu and Shieh), we provided backscattering analyses of 3-layer (and 4-layer) SiN/TbFeCo/SiN/(Al) films to determine stoichiometry and "thickness."

For Zelinski (with Vogt and Weisenbach), we performed channeling studies of $SiO_2/TiO_2(Zn)$ waveguide films to provide stoichiometry, "thickness" and impurities.

For Armstrong (with England), we provided two backscattering analyses of SnS_2 films.

Technique Development

We have continued to develop techniques for increasing sensitivity for quantifying light elements in/on heavy matrices. In this connection: 1) We have published measured ^{4}He-^{10}B, ^{4}He-^{11}B backscattering cross sections for incident ^{4}He energies 1 MeV to 3 MeV (see publications). 2) We have published details of a technique for quantifying ^{10}B and ^{11}B in films using (α,p) nuclear reactions for incident ^{4}He energies near 3 MeV (see publications). 3) Work involving use of (α,p) reactions to quantify ^{14}N has been submitted for publication (see preprint, Appendix A, ODSC Quarterly Report, December 15, 1992). 4) Work involving use of ^{4}He and ^{1}H non-Rutherford backscattering to quantify ^{9}Be in thin films will be reported at the 11th IBA Conference in Hungary, July 1993. 5) We are continuing work on using (α,p) reactions to quantify Al and Si in films. 6) We have recently developed a technique to accurately determine the stoichiometry of SiC films on single crystal Si substrates. The technique uses channeling with incident 3776 keV ^{4}He ions to reduce the Si substrate signal and enhance the C signal. The ^{4}He-C cross section is about seven times Rutherford for this ^{4}He energy. The hydrogen content of the films is determined by the elastic recoil detection (ERD) technique. 7) The PIXE technique is now fully developed. It has been used to analyze more than 2500 samples during the past year. Most of these samples are of biological interest; we have used the PIXE technique on 10 films for ODSC to separate adjacent-mass film components.

Facility Development

We are continuing to work on installing the nuclear microprobe. The goal of this project is to produce analysis beams (^{1}H or ^{4}He) of about 1 μm diameter. This microbeam will be rastered over the sample to determine the lateral distribution of trace elements in features more than a few microns in size. The beamline is nearly complete; we have actually run a beam through the entire length of the apparatus. We have not yet finished installing two high-vacuum pumps. An extended period of testing will follow. We hope to be in operation in late spring 1993. This project is a collaborative effort involving Q. Fernando (University of Arizona, Department of Chemistry) and is partially supported by funds from an NIH Superfund grant (see the ODSC Quarterly Report, September 15, 1997, p. 27).

PLANS

During the next year, we plan: 1) to continue characterizing optical data storage films for ODSC collaborators; 2) to continue our program for developing techniques for quantifying light elements in/on heavy matrices; and 3) to complete construction and testing of the nuclear microprobe.

PUBLICATIONS

1. L.C. McIntyre Jr., J.A. Leavitt, M.D. Ashbaugh, Z. Lin, and J.O. Stoner Jr., "Cross Sections for 170.5° Backscattering of ^{4}He by the Isotopes of Boron for ^{4}He Energies Between 1.0 and 3.3 MeV," Nucl. Instr. Meth. **B64,** 457 (1992).

2. L.C. McIntyre Jr., J.A. Leavitt, M.D. Ashbaugh, Z. Lin, and J.O. Stoner Jr., "Determination of Boron Using the $B(\alpha,p)$C Nuclear Reaction at Incident Energies Near 3 MeV," Nucl. Instr. Meth. **B66,** 221 (1992).

3. Z. Lin, L. C. McIntyre Jr., J.A. Leavitt, M.D. Ashbaugh and R.P. Cox, "Determination of Nitrogen Using the $^{14}N(\alpha,p)^{17}O$ Nuclear Reaction," Nucl. Instr. Meth., in press (1993).