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Target Thinning Using a Saddle Field Ion Source

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Abstract

A system is described for thinning films using a Saddle Field Ion Source to produce targets which are difficult to make by other means. The method used, the beam profile, and characteristics of the various targets thinned are given.

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1. Introduction

The Saddle Field Ion Source has been used for some time to produce thin films from small amounts of source material. The characteristics of this Ion Source have been described by Thomas¹⁾, Maier²⁾ and Muggleton³⁾. The system has proved to be quite stable and reliable. After making the initial adjustments on the operating parameters of the system, it can be left unattended for several hours and even overnight if necessary.

There has always been a need for targets which are too thin to be rolled and too thick for it to be practical to produce them by the evaporation method. Production of this type of target has been achieved by a two step method. The material for the target is first rolled as thin as possible and is then thinned to the desired thickness with the saddle field ion source using an ion milling technique and "sputtering" off a known thickness of material.

2. Experimental

There are two fundamental components in the experimental set up. The first is the system for doing the milling or "sputtering" and the second is that for determining the thickness of the foil.

2.1 Thinning System

The experimental arrangement for thinning by actually sputtering of particles of material from the target is shown in Fig. 1. The Saddle Field Ion Source is placed in a position 30° to the horizon. Normally the source is 5 cm from the target to be sputtered. As shown in Fig. 1, the source has been moved to a position 8 cm from the target to determine if the beam would diverge to a larger diameter at this distance. However, it was found that the source produced a very parallel beam and there was negligible beam divergence.

For these tests the target was placed on a very simple pedestal. A thickness monitor was positioned at a distance of ~ 5 cm above the target. The thickness monitor was found to be a very useful tool for determining amounts sputtered as well as rates since it is nearly impossible to determine the amount of material which has been sputtered off of the target by visual inspection. It is advisable to remove the target and measure the target thickness as each time the monitor indicates $\sim 150\text{-}200 \mu\text{g cm}^{-2}$ has been removed.

The system was first pumped to a vacuum of the order of 7×10^{-7} torr. Xenon was fed into the system until the highest usable current was obtained and the flow rate kept constant. The ion source was operated at 6 kV with 4 milliamp ion current and a beam current of ~ 2.3 milliamps. The centering of the beam on the foil can be obtained by the visual method described by Maier²⁾ or by using a test foil and observing the amount sputtered from it.

2.2 Foil Thickness Measuring System

The foil thickness measuring system is shown in Fig. 2a. It uses a ^{249}Cf source with a silicon detector. The foil to be measured is placed between the source and detector and its alpha particle energy loss is measured to determine its thickness. A Series II Personal Computer Analyzer is used for these measurements. The system has a small Sargent Welch mechanical pump having an ultimate vacuum of ~ 10 millitorr, making it quite suitable for obtaining the 100 millitorr needed in the system. The position of the detector, the ^{249}Cf source, and the foil between them is shown in Fig. 2b. The scale shown in front of the foil can be used to determine the position of either the 1, 2, 3 or 4 mm dia. aperture. The foil can be moved horizontally to measure its profile.

Two of the alpha particles from ^{249}Cf are used for calibration purposes, one at 5.812 MeV and another at 6.194 MeV. From these two it is possible to

determine the keV per channel of the analyzer. Then, knowing the channel shift of the alpha particle when the foil is in place and the nuclear and electronic stopping power, the thickness of the foil in $\mu\text{g cm}^{-2}$ can be determined.

3. Results

Several different foils have been thinned. Those thinned were samples of rare earths, with high melting points and different malleabilities. The first representative case is that of nickel as shown in Fig. 4. The original thickness was $600 \mu\text{g cm}^{-2}$ and it was thinned to $250 \mu\text{g cm}^{-2}$ and could have been made thinner. The thinnest section had a width of ~ 2 mm dia. which is consistent with that quoted in the specifications for the saddle field ion source. Notice that the thickness monitor values of $\mu\text{g cm}^{-2}$ vs time milled are nearly linear with time (Fig. 5), indicating that with proper calibration it could be used as a measure of the thickness of the foil. A third indication to note from Fig. 6 is that the amount of material sputtered from the foil is also linear with time. These three indicators when used together can be checked to monitor the thickness of the foil as it is being "sputtered" or ion milled.

Gold was used as a "target" material which is relatively simple to produce by evaporation or rolling. It was in turn easy to "sputter" or ion mill. When a thickness of $140 \mu\text{g cm}^{-2}$ was reached it could also in addition easily be verified by visual inspection. On viewing the foil against a bright light it had a pale blue translucent appearance at the thinnest position .

Platinum was chosen as a high melting point material and Gadolinium and Ytterbium were chosen as rare earths. All of these materials were found quite adaptable to the ion milling technique.

The results of ion milling these different materials are given in Table 1. Platinum was thinned from a particularly thick sample in which case it could

have been milled even thinner. The beginning materials were taken from those available at the time of the tests.

It should also be noted that a sandwich target of 50 mg cm² Pb backing, 1 mg cm² ¹⁵⁰Nd, and 200 µg cm⁻² Au cover was needed. However, due to a monitor malfunction the Au cover was much too thick. Since the ¹⁵⁰Nd used was difficult to obtain it was desirable to remove some of the Au. The Au was ion milled or "sputtered" off, using the saddle field ion source, to the desired thickness and the target was used successfully in the experiment for which it was produced.

4. Discussion

The ion milling technique using a saddle field ion source has proven quite feasible for several representative types of materials. Although this source produces only a small area of thinned material the area could be enlarged by rotating the target. Further, we have purchased a new wide beam saddle field ion source which it is felt will produce a beam of ~1.25 cm diameter. The technique of ion milling which has been used successfully for sometime should be quite useful in the future for thinning targets using a saddle field ion source.

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References

- [1] G.E. Thomas, Proc. Workshop of the International Nuclear Target Development Society, 1983, ANL/PHY-84-2, p. 249.
- [2] H.J. Maier, Nucl. Inst. and Meth. A303 (1991) 172.
- [3] A.H.F. Muggleton, Nucl. Inst. and Meth. A303 (1991) 157.

Figure Captions

Fig. 1. Photograph of the target thinning mechanism showing the saddle field ion source, the target being thinned and the thickness monitor.

Fig. 2a. Overall view of the target thickness measuring system showing the measuring system itself as well as the computer set up for taking the measurement.

Fig. 2b. Target thickness measuring containment cell showing the alpha source, the target, the silicon detector and the position for the filter.

Fig. 3. Nickel foil profile, in the x-direction, of a target thinned using a saddle field ion source.

Fig. 4. Thickness monitor values ($\mu\text{g}/\text{cm}^2$) as a function of time for a nickel foil which has been thinned by a saddle field ion source.

Fig. 5. Target thickness of a nickel foil as a function of time using the thickness measuring system shown in Fig. 2a.

Fig. 6. Gold foil profile, in the x-direction, of a target thinned using a saddle field ion source.

Table 1. Thinning Results of Various Foils

Foil Material	Beginning Thickness	Thickness
	$\mu\text{g}/\text{cm}^{-2}$	after Thinning $\mu\text{g}/\text{cm}^{-2}$
Ni	600	250
Gd	980	320
Au	930	140
Pt	2300	900
Yb	1400	408

Fig. 1

Fig. 2a

Fig. 2b

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

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