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Preparation of Extremely Thin Self-Supporting Metal Foils*

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Metal foils are prepared by the technique of evaporation and deposition on a plastic backing, which is subsequently dissolved in acetone. Destruction of the foils upon traversing the air–liquid interface is avoided by letting them traverse first a layer of ether which does not dissolve the plastic. During the whole procedure of fabrication the foils are never removed from the frame upon which the plastic layer is originally mounted. Foils have been prepared of the following metals: copper, gold, nickel, silver and tin. Thicknesses as low as 8 $\mu g/cm^2$ (76 Å of Ag) have been obtained.

IN the course of an experiment for the determination of atomic stopping powers of different metals for a proton beam at energies between 25 and 250 keV,[1] we have succeeded in fabricating with relative ease very thin metal foils without backing and without the use of a supporting mesh. These foils have the dimensions and thicknesses given in Table I. The thicknesses obtained are sensibly lower than those reported in several earlier articles on the subject.[2–4] In what follows we give a brief step-by-step description of the procedure. For the sake of completeness we also include well known steps.

I. PREPARATION OF PLASTIC SUBSTRATE

(1) A mixture of approximately 92% distilled water–8% pure ethyl alcohol is prepared in a dish-type beaker.

(2) A droplet of a plastic solution[5] is gently deposited on the water–alcohol mixture, which upon spreading should not touch the rim of the vessel. Thus a thin, uniform plastic film is obtained.

(3) The film is lifted with the special plate (Fig. 1) which was previously placed at the bottom of the beaker with the target holders in place. It is important to perform this step about 4 sec after depositing the plastic solution to achieve a good adherence between plate and film.

(4) Film and holder have to be completely dried of water and solvent residuals.[6] (We simply placed them for about 1 h on top of a hot water radiator.)

(5) With a surgical knife the plastic film is cut in between target holders.

(6) With the special tool shown in Fig. 1 the target holders are pushed out of the plate.

TABLE I. Self-supporting metal foils; dimensions and thicknesses.

Metal	Diameter	Thickness	
Ag	5 mm	28 $\mu g/cm^2$	267 Å
	2	8	76
Au	2	25	129
Cu	2	19	213
Ni	5	18	202
Sn	2	10	137

II. EVAPORATION OF TARGET MATERIAL

The targets are placed into a conventional bell-jar evaporation chamber *with the plastic side facing the evaporation source.* The evaporation rate has to be high enough that a reflecting layer is rapidly formed on the substrate, thus preventing the plastic from being excessively heated.[6] Also increasing the deposition rate results in a dense population of nucleation centers producing small islands. This favors formation of a continuous layer at relatively low average film thicknesses.[7] If the deposition rate is too low, we found that the foils break when the plastic is removed.

III. REMOVAL OF THE PLASTIC BACKING

(1) Having deposited the metal, the target holder is tightly secured in a ring-shaped frame by means of a retaining ring, as shown in Fig. 2.

(2) The assembled targets mounted on a special frame are inserted into the device used for dissolution of the plastic backing (Fig. 3).

(3) The removal of the plastic backing is performed by dissolution in acetone according to the method described by Meckbach.[8] If the foils with their plastic backing were submerged directly in acetone, they would be destroyed by surface tension upon traversing the air–liquid interface. By letting the foils be first submerged in a layer of ether they will not break because the ether does not dissolve the plastic backing. The dissolution of the plastic is initiated when the acetone comes into contact with the foils already submerged in ether. Extreme care is to be taken to avoid

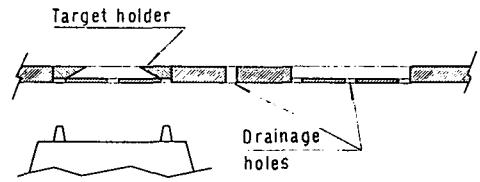

FIG. 1. Detail of the plate with target holders for lifting plastic. The holder is leveled with the upper plate surface. The tool for pushing the holders out of the plate is shown. The plate permits mounting of 25 target holders simultaneously.

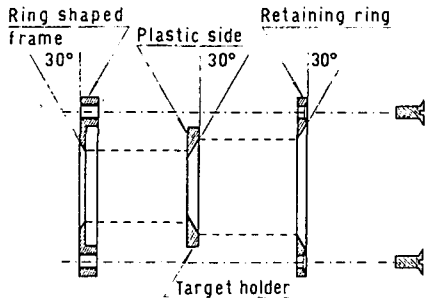

FIG. 2. Mounting assembly for metal foils. Dashed lines show relative dimensions of holes.

any sporadic movement and turbulence of the liquid during this process. Figure 3 shows the arrangement of the vessels used for the plastic dissolution procedure, which is slightly different from that used by Meckbach.[8]

IV. OBSERVATIONS

As already stressed in Ref. 8, we again emphasize that the most important feature of the present method is that the technique of dissolution of the plastic backing is performed without removing the metal foil from the frame where it was originally deposited, thus avoiding subsequent handling as, for example, floating on a liquid surface.[3,4,9–12]

The main improvement with respect to Ref. 8 resides in that the metal is deposited on the side on which the plastic film is adhered to its holder, against which the metal layer is then pressed by the ring-shaped frame. It is important that the 30° bevel in the holder and frame are carefully polished.

The efficiency of the present method is about 70% for foils of the dimensions and thicknesses shown in Table I. These thicknesses were determined by measuring the energy loss of a proton beam through the foils at about 250 keV where the stopping power in these materials is known.

The beam formed a pencil of about 0.1 mm in diameter. By changing the position of the target with respect to the beam we could check that the foil thickness was uniform within about 1%, and that the foils did not have pinholes. The foils showed good mechanical rigidity.

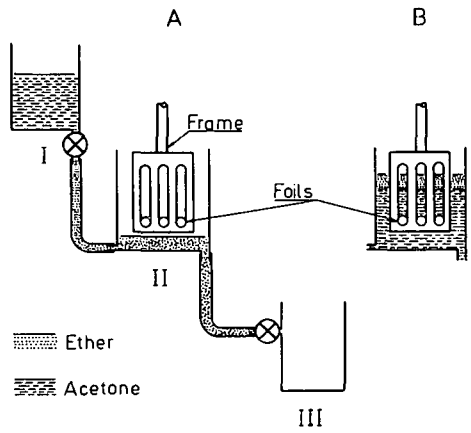

FIG. 3. Device for removal of the plastic backing of foils by dissolution in acetone. Vessel II is mounted on a vibration-free support. (A) Before dissolution, (B) during dissolution.

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