

## NRAO Electronics Division Technical Note No. 194

# Fabrication of Small Metal Parts by Electroforming Through a Photomask

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Small, flat metal parts are often made by photofabrication (chemical milling). However, when the dimensions are not very much larger than the metal thickness, electroforming through a photomask can give better results. This method was used by Towne Technologies Inc. [1] to fabricate waveguide probes for the ALMA Band 6 LO couplers described in ALMA Memo 432 [2]. The probes were made of gold plated nickel in two sizes: 0.011" x 0.004" x 0.001" and 0.012" x 0.004" x 0.001". A total of 3600 were made, 1800 of each size, sufficient for all the Band-6 receivers. They were fabricated and delivered on a single 5" x 5" sheet of 0.005" copper. The total cost was \$1000 (= \$750 (tooling) + \$250 (fabrication)), or ~\$0.28 per probe. Fig. 1 shows photographs of a typical probe.

Removal of the probes from the copper substrate required some experimentation. Initially, we immersed the substrate in ferric chloride solution until the copper had dissolved. However, in many of the probes the ferric chloride had penetrated the gold plating and dissolved the nickel, leaving just the gold shell. A copper etch less reactive with nickel than ferric chloride is ammonium persulfate. On our first attempt using ammonium persulfate, the etchant attacked the bond between the gold and nickel, causing de-lamination if the probe was stressed or bent — this is shown in Fig. 2.

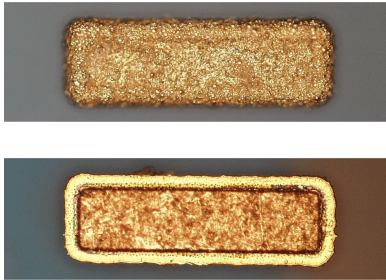


Fig. 1. Top and bottom views of a typical 0.012" x 0.004" probe.



Fig. 2. De-lamination of the gold and nickel after protracted immersion in ammonium persulfate etchant.

To reduce unnecessary exposure of the probes to the etchant, the probes were covered with G-wax (glycol phthalate, MP 100°C) during etching. The following procedure was used:

- 1) A small rectangle of the copper substrate bearing the probes was cut from the 5" x 5" substrate. The sample was placed probe side down on a heated microscope slide covered with melted G-wax, then another slide placed on top and pressure applied during cooling.

- 2) The copper substrate, attached to the microscope slide, was immersed in a saturated solution of ammonium persulfate until the copper substrate had dissolved completely (about six hours). The probes then remained attached to the slide by the G-wax.
- 3) The probes were released from the G-wax with acetone, then rinsed twice in clean acetone.

## **Results**

Measured dimensions of a random selection of the 0.012" probes gave the following results:

Length	$0.01215" \pm 0.00005$	(nominal 0.0120")
Width	$0.00410" \pm 0.00005$	(nominal 0.0040")
Thickness	$0.00080" \pm 0.00000$	(nominal 0.0010")

(The measurement resolution was 50  $\mu$ -in.)

## **References**

[1] Towne Technologies, Inc., 6 - 10 Bell Ave., P.O. Box 460 Somerville, NJ 08876 USA, Phone: (908) 722-9500 (Contact: Sal LoSardo). <http://www.townetech.com>

[2] A. R. Kerr and N. Horner, "A Split-Block Waveguide Directional Coupler," ALMA Memo 432, National Radio Astronomy Observatory, Charlottesville VA 22903, USA, Aug 2002.