BOOK OF ABSTRACTS

High Aspect Ratio Micro-Structure Technology

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Improvement in Cost-effective X-ray Mask Fabrication

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Abstract
The mask fabrication is the key technology in the fabrication of HARMS through X-ray lithography. Mask membrane for X-ray lithography may include polyimide, diamond, silicon carbide, silicon nitride, boron nitride, silicon, titanium, graphite or beryllium. Various mask fabrication techniques have been developed for LIGA technology [1]. For these different membrane materials, titanium and silicon compound membranes are just a few micrometers and have a high X-ray transparency but are expensive and difficult to handle. Beryllium is the most favorable material due to the high X-ray transparency but the potential toxicity is a limitation. At BESSY, we have developed the technologies which use the graphite, glass carbon or glass as the membrane material to fabricate the X-ray masks.

In this paper, the fabrication capability of X-ray masks at BESSY is demonstrated for different membrane materials (Figure 1); the main part of the paper concerns the improvement in cost-effective X-ray mask fabrication using graphite/carbon substrates and the analysis of the characteristics of various masks which is carried out based on the substrate topography experiments and deep X-ray lithography experiments. The improvement includes that using the polished graphite substrate as membrane to reduce the surface roughness of the membrane, coating a thin layer of resist on graphite substrate to overcome the shortcoming of high porosity of the graphite (Figure 2), using a new glass-like carbon substrate to replace the graphite substrate as membrane material for eliminating the striations on the sidewalls of the resist structures (Figure 3). A new approach to make X-ray masks with alignment marks on it for multiple alignment exposures will be present, too. The novel point in this approach is to use the thin glass as membrane and deposit indium-tin-oxides (ITO) thin film which is conductive and optic transparency as plating base.

For these three different membrane X-ray masks, graphite membrane masks are cost-effective and easy handle in fabrication [2] but the high roughness on sidewalls of the patterned resist structures limited its application in high precision structures; glass carbon membrane has not only the same advantages as graphite but also overcome the disadvantage regard of the roughness on sidewalls of the resist structures (Figure 3); glass membrane is thin and fragile and difficult handle, but its optic transparency provides the advantage in making X-ray masks with alignment marks, especially with conductive and transparent ITO film as plating base.

Reference

1. Yohannes M. Desta, Bernd Loechel, Jost Goettert; "X-ray Masks for the LIGA Process", submitted to HAMST 2003, Monterey, California, USA.
2. Yohannes M. Desta, Jost Gottert, Linke Jian, Georg Aigeldinger, Michael C. Murphy, Phil Coane(2001), Graphite Membrane X-ray Masks for Rapid and Inexpensive Prototyping of LIGA Structures, HAMST'01, Germany

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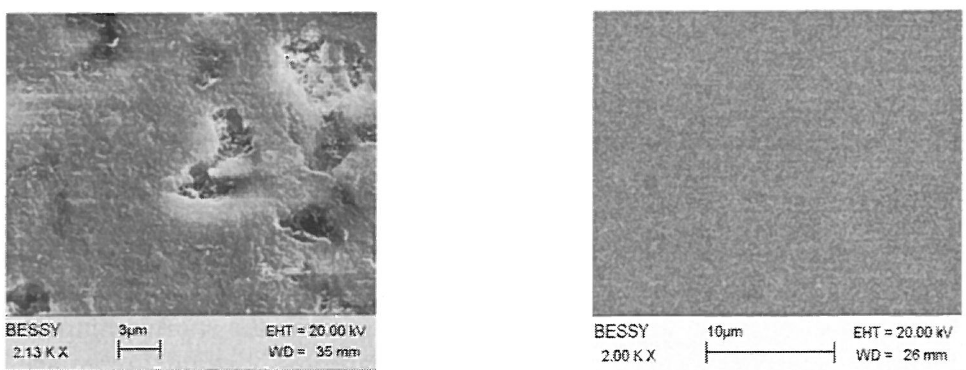
(a)Graphite membrane supported by stainless ring

(b)glass membrane supported by glass ring, the two optic transparency windows used for alignment marks

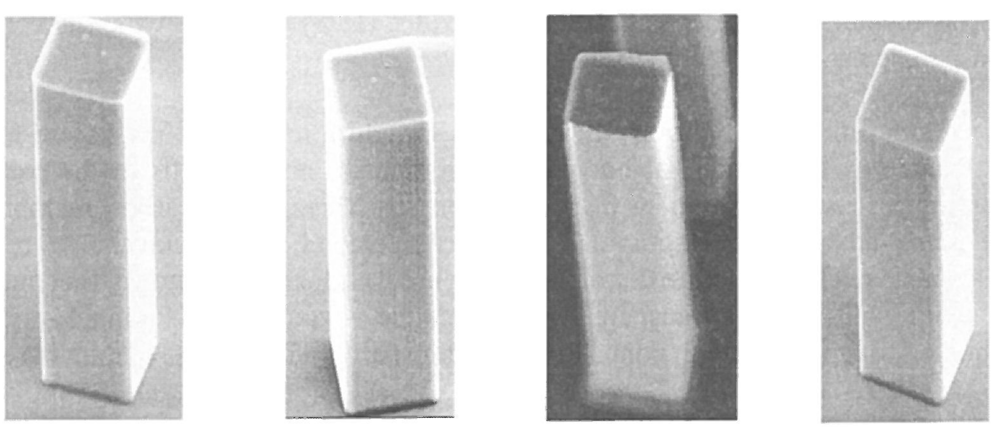
FIGURE 1 Examples of x-ray masks made in BESSY



(a) Surface appearance of the graphite substrate

(b) Surface of the graphite substrate with coated thin resist layer

FIGURE 2 Coating a layer of resist to improve the surface quality of the graphite substrate



(a) **(c)** **(d)**

FIGURE 3 200 µm SU-8 posts fabricated by x-ray exposure with different membrane masks, (a) 2.2 µm Ti membrane, (b) 200 µm graphite membrane, (c) 30 µm glass membrane, (d) 200 µm glass carbon membrane