First Results of the Development of Freestanding Copper Antiscatter Grid Using Deep X-ray Lithography

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Introduction

Mammography is the principal method of breast cancer detection using x-rays with energy in the range of 28 kVp, produced from a focal point 60 cm above the image receptor, centered at the chest wall. The antiscatter grid is placed above the image receptor to minimize the amount of scatter reaching it. For mammography, the typical ratio of scattered radiation to primary radiation at the image receptor ranges from 0.3 to 1.0. A large amount of scattered radiation reduces the signal-to-noise ratio and the contrast, and contributes to poor diagnostic quality.

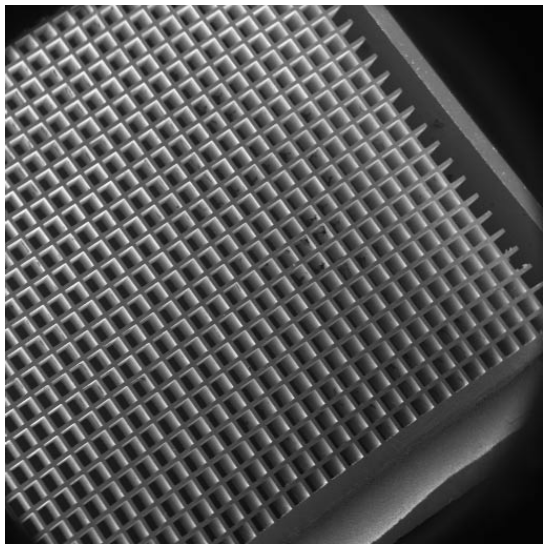

FIG. 1. Freestanding copper grid.

We are developing x-ray anti-scatter grids with the following properties: (1) air core, (2) lamella walls focused to the x-ray source, (3) square-shaped lamellae, and (4) thin lamellae.[1-4] This grid will provide higher transmission of primary radiation and lower transmission of scattered radiation than conventional grids. For the first stage of our work, experiments were performed to optimize substrate preparation, exposure dose, and parameters of copper electroplating. The work was conducted at the Advanced Photon Source (APS) at Argonne National Laboratory.

Method and Materials

Commercially available (poly)methylmethacrylate (PMMA) sheets of 1 mm thickness were used as a thick resist layer. Silicon wafers coated with Cr/Au or Ti/Cu/Ti films, and rigid graphite carbon foil were used as plating bases. Prepared silicon wafers and rigid graphite were spun-coated with a PMMA resist layer. A 1-mm-thick PMMA sheet was solvent bonded on top of a PMMA layer using methylmethacrylate. The deep x-ray exposure was performed at the APS 2-BM beamline, using a 1 mm C filter and a 0.15ºC grazing incidence Cr mirror for selecting the beam spectrum. An Au/Si grid mask for deep x-ray lithography was used for patterning. Exposed PMMA was developed by immersion into agitated solutions of GG developer and rinse at 25ºC. Copper electroforming was performed using copper sulfate plating solution

Results and Discussion

Achieving good adhesion of the resist to the plating base is critical for the process. Various substrates have been used and commercially available rigid graphite films were found to provide the best adhesion.[5] The conductivity of carbon is sufficient to deposit copper and it served as a good electroplating base. Another advantage of using graphite is the simplicity of releasing the metal microstructure from the substrate by abrasion.

A test mask with grids of 100-mm-thick lamella and a 500 mm period was used for the exposure of a 1.2 mm PMMA sheet bonded on graphite substrate. The dose value of 10 kJ/cm^3 was deposited on the top of the resist. Copper electroplating was used to form the metal in the exposed regions of the resist removed by development. A uniform low-stress, fine-grain copper deposition has been obtained.

Figure 1 displays a SEM image of a 20 x 20 mm^2 freestanding copper grid polished on both sides.

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References

[1] C.-M. Tang et al., Microsystem Technol. **4**, 187-192 (1998).

[2] C.-M. Tang et al., Chicago 2000 World Congress on Medical Physics and Biomedical Engineering, Jul. 23-28, 2000.

[3] K. Fischer et al., Proc. SPIE **4145**, 227-234 (2000).

[4] C.-M. Tang et al., Proc. SPIE **3977**, 647-657 (2000).

[5] D. C. Mancini et al., to be presented at HARMST 2001.