Progress in fabrication of free-standing gold gratings for phase contrast X-ray microscopy

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High-resolution, x-ray phase contrast microscopy, a key technique with promising potential in biomedical imaging and diagnostics, is based on narrow-slit high-aspect-ratio absorption gratings. The challenge is the fabrication of large-area, fine slit, and support-free gratings to reduce X-ray absorption in the grating itself, as well as reduce radiation dose in the investigated sample, which is essential for biological and medical applications.

We previously reported the development of a free-standing grating fabrication process based on gold electroplating into a silicon mold coated with various thin films to form a voltage barrier, plating base, and sacrificial layer, followed by mold removal to obtain the gold membrane with void slit apertures. The first grating prototype - a 10-µm-thick gold membrane with an array of micrometer-wide and 400-micrometer-long void slit apertures with 7.5-µm periodicity has been fabricated and an aperture-driven spatial resolution has been demonstrated using an incoherent, rotating anode X-ray tube.[1]
Here, we present the progress towards a refined process allowing to obtain submicron aperture slits (700 nm) and to substantially improve gold membrane flatness (bellow 200 nm over the entire 4 mm x 4 mm area) for higher X-ray imaging resolution. Figure 1 shows SEM and optical microscope images of the gold membrane grating with parallel void apertures. Confocal microscopy flatness measurement of the freestanding gold grating is shown in figure 2.

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[1] O.V. Makarova, R. Divan, N. Moldovan, D.A Czaplewski, M. Esposito, M. Endrizzi, C-M Tang, J.D. Ferrara and A. Olivo, Nanotechnology 2023, 34, 045301.

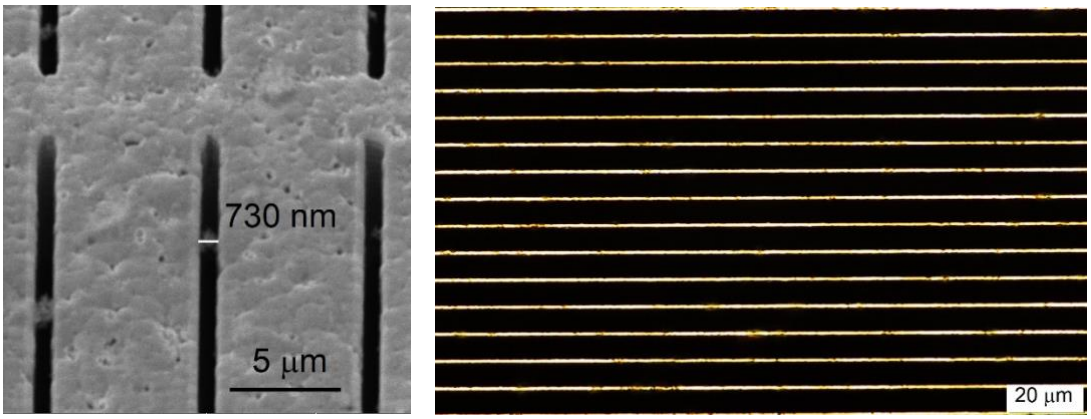

Figure 1: SEM and optical image taken with back illumination show parallel 0.7 µm-wide-void apertures of the gold membrane gratings.

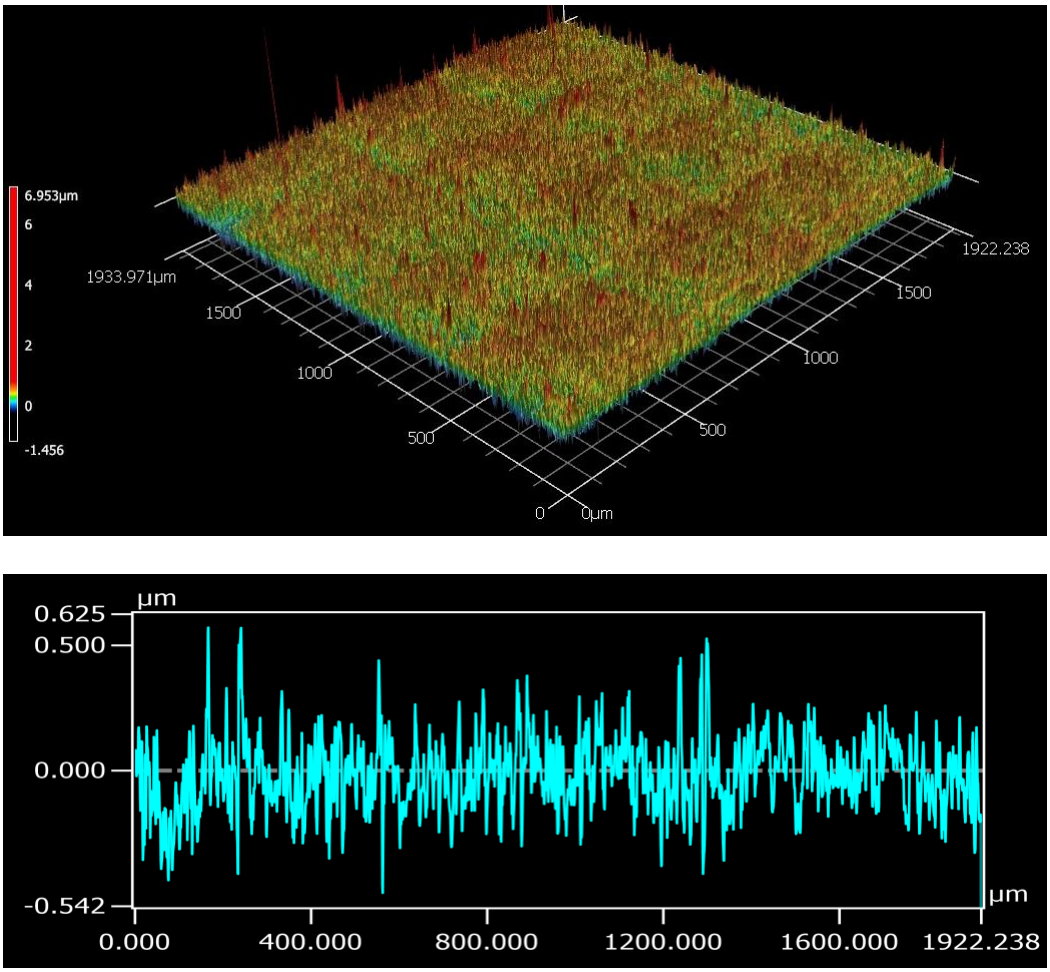

Figure 2: Optical flatness measurements of the free-standing gold grating performed with a laser confocal microscope. a) 3D profile of a portion of 1.9 mm x 1.9 mm of the grating area, with the Z-axis expanded 100 times compared to lateral coordinates showing a flatness equal to the gold roughness. b) line scan normal to the grid lines showing flatness deviations from the ideal planar shape below 0.2 µm.