High Aspect Ratio HSQ Structures for X-Ray Optics

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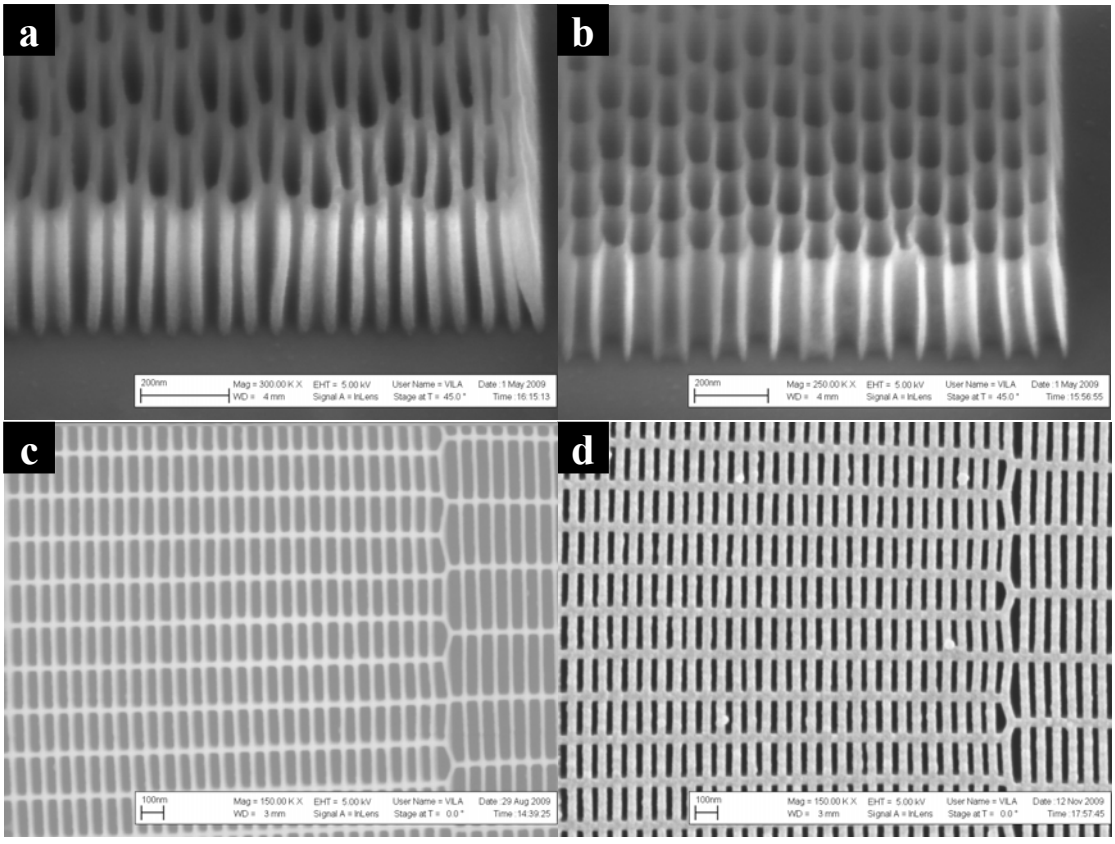
High aspect ratio structures are essential for a good performance of X-ray Fresnel zone plates, as the resolution of these devices scales with the line width of structures and their diffraction efficiency depends on the height of the structures. We have investigated the writing of dense high aspect ratio hydrogen silsesquioxane (HSQ) structures by 100 keV electron beam lithography. After the exposure the samples were developed in a sodium hydroxide (NaOH) buffered solution and supercritically dried in carbon dioxide (CO_2). Gratings with line widths down to 30 nm with 60 nm pitch were patterned in 350 nm thick resist layers (figure a). To further improve the performance of the X-ray optical devices, we have also produced semi-dense diffracting structures and 20 nm lines with 80 nm pitch were obtained in 350 nm HSQ thickness (figure b). By reducing the resist thickness to 250 nm, it was possible to write 15 nm line width at 60 nm pitch (figure c). Subsequently, the HSQ gratings were coated with Iridium by atomic layer deposition to create an effective period of 30 nm (figure d). Fresnel zone plates made this way showed excellent performance in for scanning X-ray microscopy at 1.0 keV photon energy.



a) 350 nm thick HSQ grating with 30 nm lines/spacings. b) 350 nm thick HSQ grating with 20 nm lines and 80 nm pitch. c) 250 nm thick HSQ grating with 15 nm lines and 60 nm pitch. d) The structure in c) after coating it with iridium by atomic layer deposition. The resulting structure is a 250 thick iridium grating with 15 nm lines/spaces.