Hyper Precision Diffractive-Optical Devices for High-Energy Applications

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Based on research at MIT, LumArray has developed a maskless-photolithography writing system that addresses the unique needs of high-energy applications such as short-wavelength monochromators and spectrometers. In these applications, diffractive-optical devices, such as variable line-space (VLS) gratings, require extremely tight spatial-phase coherence (i.e., line-placement-error specifications) over grating lengths of 100 mm and larger. Extreme flatness requirements demand substrates 10-40 mm thick. This combination of requirements is incompatible with existing lithography tools designed for the semiconductor industry. Ruling techniques can be extremely slow and have difficulty meeting line-placement specifications on VLS-gratings.

LumArray's ZP-150 maskless photolithography system is capable of patterning arbitrary diffractive optics at >1000 lines/mm over an area of 150mm x 150mm within a few hours. Grating substrates up to 15mm thick are accommodated, with thickness up to 35mm available soon. Using differential interferometry at the Advanced Light Source, absolute line-placement error <20nm peak-to-peak has been demonstrated on linear gratings (Fig. 1), with expectations to soon demonstrate <10nm.

The principles of LumArray's zone-plate-array lithographic writing are described along with software correction of systematic errors. The combination of hyper-precision and an ability to write arbitrary geometries, including diffractive-focusing elements, will open opportunities for new modes of research at synchrotron and free-electron-laser facilities. Holographic references with extreme accuracy can also be patterned to meet the metrology challenges of beam-line optics.

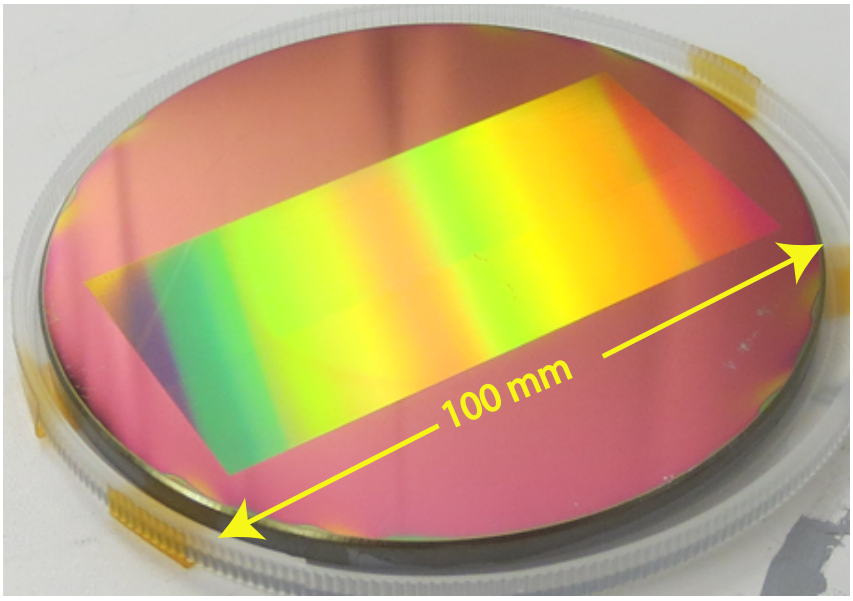

Figure 1: *Photograph of a grating written on LumArray's ZP-150 and analyzed at the Advanced Light Source using differential interferometry.*