Zone-Plate-Array Lithography:
Enabling Nanotechnology from Research through Production.

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Presentation

Abstract: Increasing interest in micro- and nanofabrication technology for applications outside of the traditional semiconductor industry has highlighted the limitations of current lithographic techniques. Mask-based optical projection lithography, exemplified by steppers and scanners, is magnificently adapted to the specific needs of semiconductor manufacturing but high-cost and lack of flexibility limit its utility in other arenas. Electron-beam lithography (EBL) offers high resolution but severely limited throughput. Systems of various architectures employing a multitude of parallel electron-beams are currently under development with the expectation of solving the well-known problem of low throughput in EBL, however this approach often overlooks other problems of EBL, notably pattern-placement accuracy. Between these two alternatives, innovation is hindered as researchers and entrepreneurs struggle to find an affordable patterning solution that combines the simplicity and throughput of optical patterning with the flexibility and resolution of an electron-beam.

We present zone-plate- array lithography (ZPAL) [1] as an alternative approach for high-speed maskless lithography utilizing a massively-parallel array of photon beams rather than electron beams. The ZPAL technique uses an array of high-numerical-aperture diffractive lenses, known as zone-plates, to create an array of focal spots on the substrate. Patterns of arbitrary geometry are created in a dot-matrix fashion as the substrate is scanned across the focal plane. Incident light to each lens is modulated synchronously with the scan using a spatial-light modulator upstream of the zone-plate array.

In this paper we present system-level design and lithographic results from the ZP-150 alpha-tool. The ZP-150 has been designed with emphasis on flexibility for low-volume manufacturing, prototyping and R&D. Tool design for pattern-placement accuracy is discussed in relation to electron beam systems. Proximity-effect correction (PEC) for improving fidelity is demonstrated, and the role of PEC in maskless lithography is discussed. Lithographic results from the ZP-150 alpha tool will be shown demonstrating the viability of ZPAL for direct-write and mask making with resolution down to 150nm. Absorbance-modulation [2] will be introduced as a technique with the potential to achieve ~20 nm resolution, comparable to an electron-beam while retaining all the benefits of optical lithography.

References:

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