Progress Toward Fabrication of Aspheres Using Precision Multilayer Deposition

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Extreme ultraviolet lithography (EUVL) requires the design and fabrication of multiple element, all reflective optical systems that operate at the diffraction limit over field sizes of order 103 mm2. The large field size requires that the imaging systems be multiple element with aspheric surfaces. Diffraction limited performance implies that the total wavefront error of the imaging camera be of order l/4. For example, the individual multilayer (ML) coated optics of a four element reduction camera operating at 13 nm. must have a figure errors less than 0.8 nm. These requirements are pushing the state of the art in optical fabrication and coating technology.

Requirements for efficient radiation transport in large field EUVL systems has necessitated the use of laterally graded period ML coatings. We have recently developed a novel deposition method that utilizes controlled variation of the substrate velocity as it transits the deposition source boundaries to effect the spatial gradation of the coating1. It enables fabrication of laterally graded, axially symmetric thin film coatings without modification of the deposition system hardware and offers significant advantages over conventional approaches which require installation of customized "uniformity" masks2. The technique is best suited for producing slow gradients, i.e. graded period ML coatings with lateral gradients, D, in the range of 0 <= D <= 0. 2 nm/cm, and a demonstrated precision of better than 0.3%.

The precision ML deposition capability in combination with recent advances in interferometry3 permit an iterative, additive approach to the problem of fabricating aspheres. Mo/Si MLs provide appropriate additive material since they can be grown to a thickness of several microns with negligible increase in surface roughness; however, the relatively large compressive stress of magnetron sputtered Mo/Si coatings can produce substrate deformation which must be accounted for in achieving the desired surface profile.

The capabilities of the deposition method in providing tailored ML reflectance profiles for EUVL optical components is illustrated and the status of aspheric fabrication will be presented. The test asphere mimics the design of the M3 optic of the 5x reduction camera under development at Sandia National Laboratory4 - hardware limitations prevent fabrication of the "true" M3 in our magnetron deposition system; therefore, a subaperture of M3 is being fabricated. The optic is a radially symmetric asphere 100 mm in diameter with an aspheric departure of 0.6 mm. The starting surface is a superpolished concave spherical surface with a radius of curvature of 0.6 m accurate to l/200 @ l=633 nm, and an RMS surface roughness of less than 0.2 nm as determined from scanning probe microscopy measurements of the figured surface over 2mm fields.

1 S.P. Vernon et. al., OSA proceedings on Extreme Ultraviolet Lithography 23, pp. 33-40 (1995).

2 D.L. Windt et.al., SPIE Proceedings on Multilayer Optics for Advanced X-Ray Applications 1547, pp. 144-158 (1991).

3 G.E. Sommargren, Technical Digest of the OSA Annual Meeting, September 1995.

4 D. A. Tichenor, et. al. Proc. of the SPIE Symposium on Electron-Beam, X-Ray, and Ion-Beam Submicrometer Lithographies for Manufacturing V, 2437, pp. 292-307 (1995).