# Pathways to high reflectance Mo/Si multilayer coatings for extreme-ultraviolet lithography

C. Montcalm et al.

Lawrence Livermore National Laboratory, P.O. Box 808, L-395, Livermore, CA 94551

Present consensus designs for industrially viable extreme-ultraviolet (EUV) projection lithography systems incorporate multiple reflective optics: (1) two condenser multilayer mirrors to collect EUV radiation from the source and illuminate the mask, (2) a reflective mask consisting of an integrated circuit metalization pattern on a multilayer mirror, and (3) precision projection optics, consisting of three to four reflecting surfaces, to project a reduced image of the mask onto a resist-coated wafer.

The EUV projection lithography system throughput is therefore a strong function of the multilayer reflectance because of the six to seven reflection designs. These multilayer coatings typically consist of alternating layers of molybdenum (Mo) and silicon (Si), where the thicknesses of each layer were determined by the trade-off between maximizing the constructive interference and minimizing the overall absorption. Mo/Si multilayers have proven to be effective reflective coatings for normal incidence in 13.0–13.5 nm wavelength region with reflectances around 67% being achieved routinely. However, initial lithography system throughput analysis and cost-of-ownership estimates have led us to set goals for multilayer mirrors with 68% or higher reflectances which are stable for 3 to 5 years. Critical limitations to achieving the higher peak reflectances are the imperfection of the interfaces and the oxidation and corrosion of the top layers.

The current status of knowledge of the Mo/Si multilayer structure is presented and the limitations to achieving higher reflectances are identified. Various pathways to improve their performance are proposed and preliminary results are given.

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