Removal of Mo/Si Multilayer Coatings on Fused Silica Substrates by Wet Chemical Etching

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Mo/Si multilayer mirrors operating in the 13-nm wavelength region can provide a high reflectivity of over 60% and have been applied in numerous imaging systems, such as extreme ultraviolet (EUV) microscopy instruments. These mirrors have a multilayer structure comprising Mo and Si bilayers on a super-polished substrate that is typically made of fused silica or ultra-low-expansion glass. An iterative and time-consuming polishing process is employed to fabricate such substrates, since the figure error must be controlled with a spatial period between several hundred millimeters and several micrometers. The surface figures in the low- and high-frequency regions are commonly controlled by either bowl-feed polishing[13)] or state-of-the-art numerical control techniques, such as magneto-rheological finishing, combined with interferometric surface figure measurements. However, these processes are both labor-intensive and expensive. One promising approach to reducing costs and labor requirements is to reuse mirror substrates, by completely removing the original multilayer coatings and depositing new ones. The reuse of such mirrors could be considered when the mirror itself shows damage, such as oxidation of the top surface layer by contact with ambient air, carbon contamination resulting from intense EUV irradiation or thermal diffusion in the periodic structure. These types of damage will eventually degrade the reflectivity of the device. During reuse processing, the multilayer coating must be completely removed while keeping the shape of the mirror substrate unchanged, and several studies have examined techniques for removing Mo/Si multilayer structures with surface oxide layers or carbon contamination. However, to the best of our knowledge, there have been no reports concerning techniques for removing the entire multilayer structure from the substrate. In the present work,[1)] we demonstrate a novel method for completely removing Mo/Si multilayer coatings, based on wet chemical etching. This research examines an etchant capable of dissolving both Mo and Si at a sufficiently high etching rate with little effect on fused silica (SiO_2) substrates. Specifically, a Mo/Si multilayer mirror was immersed in an alkaline solution containing potassium ferricyanide ($K_3Fe(CN)_6$) and sodium hydroxide (NaOH), which was found to remove the entire coating. The surface shape of the substrate was then evaluated using an optical profiler to confirm that the etching process did not increase the surface roughness.

Reference:

1. Mitsunori Toyoda et al., Appl. Phys. Express 14 052003 (2021).