

Polarization Birefringence and Surface Roughness of XeLiF + Al Mirrors

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A new deposition method developed by Goddard Space Flight Center fluorinates the surfaces of freshly evaporated Al mirrors by exposure to XeF₂. This produces an ultrathin film of aluminum fluoride which is thought to conformally coat the aluminum. This is followed by an evaporated LiF coating to create a broadband, relatively stable mirror which is termed Al+XeLiF. This in-situ, room-temperature process produces mirrors with noteworthy environmental stability and high reflectance over a broad spectral range from the FUV to the IR, including the desirable, but hard to achieve, 100 to 115 nm range. NASA may use this approach to prepare mirrors and grating coatings for the future Habitable Worlds Observatory. To accomplish its primary mission of imaging and characterizing potentially habitable exoplanets the HWO requires total extinction of the light from an exoplanet's star to capture the light of dim exoplanets without contaminating starlight. When used with an internal coronagraph, however, surface roughness and polarization effects from the telescope mirrors could result in starlight leaking into the coronagraph's dark pit preventing clear detection and characterization of Earth-size planets in a star's habitable zone. We studied retardance and diattenuation using variable-angle, spectroscopic ellipsometry (VASE) to better understand these effects on lithium-fluoride-coated aluminum mirrors exposed to different temperature/humidity environments.

The physical evolution of roughness on deposited fluoride surfaces is noteworthy. Fluorides, particularly LiF, are observed to roughen in moist air even at relatively low humidity. Water condenses out of the air in any small defects due to Laplace pressure. Condensed water will attack the film. Then, in an Oswald ripening-type process, larger crystals form at the expense of nanometer size crystals. This creates defects even more favorable for the condensation of moisture and the eventual destruction of the film.

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