Replicative Manufacturing of Glass Optics with Antireflective Microstructures

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Abstract

The cost-effective manufacturing of highly precise infrared (IR) lenses is the enabler for a broad usage of optical systems such as night visions, thermal imaging or laser-based sensing. As most infrared glasses (e.g. chalcogenide glasses) suffer from high transmission losses due to their high refractive index, the integration of an anti-reflective (AR) function is necessary. While AR-coatings are state of the art, a promising new way is the implementation of moth-eye microstructures onto the lenses' surface.

Precision Glass Molding (PGM) is a replicative method for manufacturing highly precise glass optics, which is able to carry out macroscopic molding and the integration of microstructures simultaneously. Whereas alternative manufacturing methods for glass optics with AR function need several additional process steps, after PGM the optic is ready to use.

The PGM process development starts out with numerical simulations as an efficient approach to design mold shapes and molding process. A multiscale modelling is essential to deal with the microstructure of the molded optics and the overall tool geometry. Based on the simulation results, the molding tools are manufactured in two steps. First, the masters are made. While ultra-precision technologies such as diamond turning or grinding are used for macroscopic shaping, the microstructures are brought into the surface by lithographic processes. Second, the masters are electroplated with nickel to receive the actual molds as nickel-shims. In order to avoid glass adhesion within the molding process protective coatings are applied. As the microstructures dimensions are in the same range as the layer thickness, the optimization of the coating system becomes especially important to remain the original structure geometry. Afterwards, the molding is conducted by molding a heated glass preform in between the precisely manufactured molds into the desired lens shape. To archive a complete macro- and microgeometric cavity filling an extensive investigation of the molding process parameters is necessary.