Friedrich-Alexander-Universität
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Polymers in Optical Systems

Motivation

Optical lenses often exhibit large varying component thicknesses, which is why they cannot be produced with conventional polymer processing techniques. In the standard processing methods for polymers, sink marks and internal inhomogenity such as residual stresses and density variations occur due to the simultaneous presence of the solid and the molten state during cooling (Fig. 1) and their varying coefficients of expansion. Compression induced solidification (CIS) as well as multilayer injection molding and injection compression molding provides the possibility to reduce or even avoid these undesirable component defects.

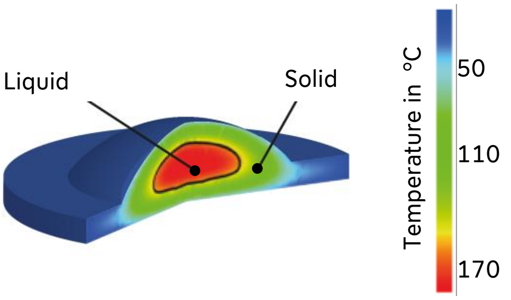

Fig. 1: *Different phases of the polymer (liquid and solid) during standard injection molding*

Application

Optical components made of polymer are becoming increasingly important in optical LED lighting, consumer electronics and laser technology. Compared to glass, polymers offer lower weight and the possibility of function integration.

CIS is based on the simultaneous solidification of the hot melt in the whole cavity solely by pressure. Thereafter, the compressed and solidified melt is cooled down (Fig. 2).

In the multilayer process, the molded optical part is injected in several layers, one after the other or simultaneously (Fig. 2). Using multiple materials, this technique can be used to produce achromatic lenses.

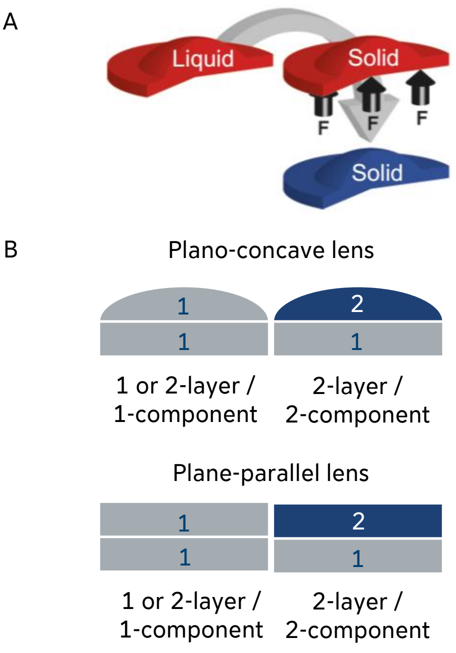

Fig. 2: *A) solidification of the melt via pressure and subsequent cooling during CIS*
B) multilayer injection molding strategies

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Research focus

As optical components often have thick-walled optical designs, the cycle time during injection molding takes several minutes to achieve the desired high quality. The different thermal expansion coefficients of the melt in the component core and the already solidified edge area leads to low dimensional accuracy as well as negative optical properties.

To ensure economical production while maintaining high precision, thick-walled optical components can be manufactured using the compression induced solidification technique or the multilayer injection molding. Hereby, the cycle time is reduced, as well as internal inhomogeneity and optical defects. For instance, by combining two materials with different dispersion, chromatic aberration can be reduced (Fig. 3).

Main research results

The CIS technique leads to better dimensional accuracy and homogeneous inner component properties, since the single-phase cooling minimizes the effects due to locally different shrinkage coefficients (Fig. 4).

Overlaying the mold heating process with the adjustment phase to mold temperature makes it possible to reduce the cycle time by up to 50 % while maintaining the properties of the compression-induced components. This has a positive economic effect compared to conventional injection molding. Cost-intensive rework grinding due to unpredictable shrinkage as well as sustainability reducing effects such as increased material consumption due to over dimensioned runner systems can be avoided.

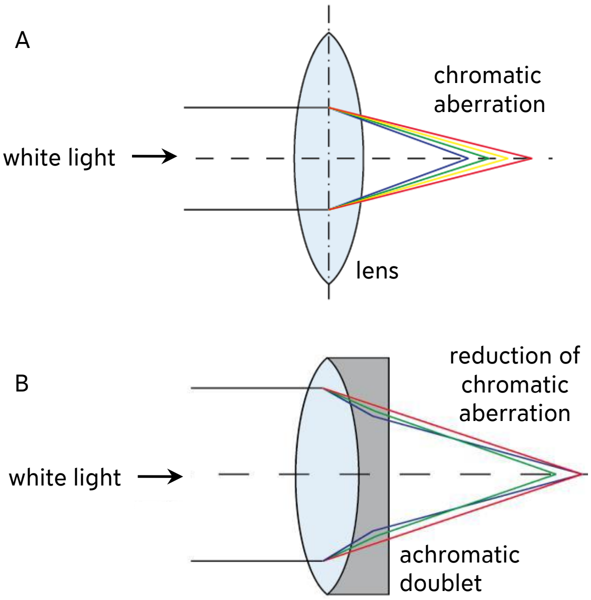

Fig. 3: *A) schematic representation of the chromatic aberration*
B) schematic representation of the optical path in an achromat

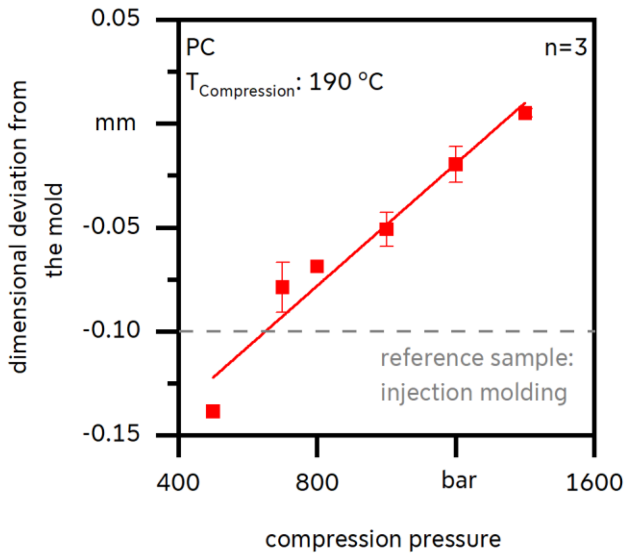

Fig. 4: *Dimensional deviation of the component from the mold*

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