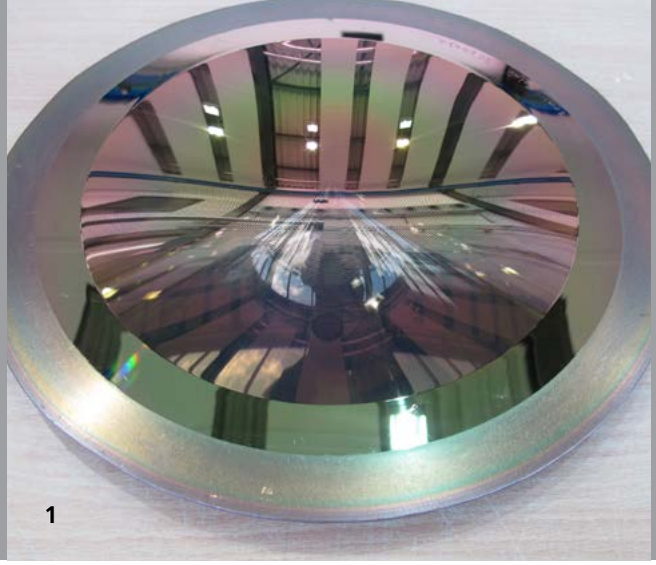

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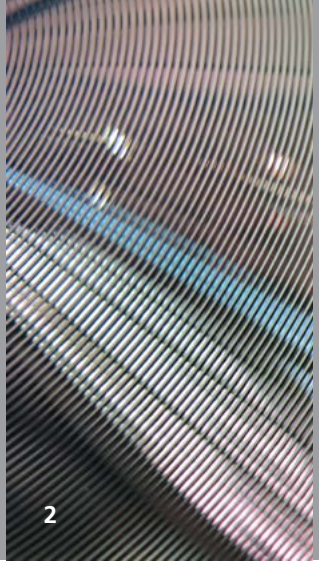

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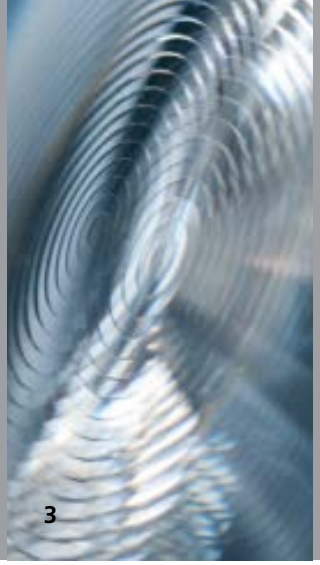


3

ANTI-ADHESIVE COATINGS WITH HIGH CONTOUR FIDELITY FOR PLASTIC MOLDING

Plastic products with defined and complex shapes and structures can be produced by injection-molding and hot-embossing methods. For the efficient production of large quantities, short cycle times are required. The tendency of many polymers to adhere to the mold surface does however restrict production as it makes demolding the plastic parts more difficult. This results in longer cycle times, compromises in process control and limited design options for feasible structures and surface finishes. In many cases release agent must be used in order to facilitate demolding or even allow it at all. External release agents are applied to the mold between cycles thereby increasing the cycle time. Internal release agents are added to the polymer and can adversely affect material properties and also represent a considerable cost factor. Furthermore, in some cases no suitable release agents are available for special molding compounds. The Fraunhofer IST is here working on cost-effective coating solutions which reduce cycle times, facilitate demolding and increase quality.

Optimized non-stick coatings for structured molds

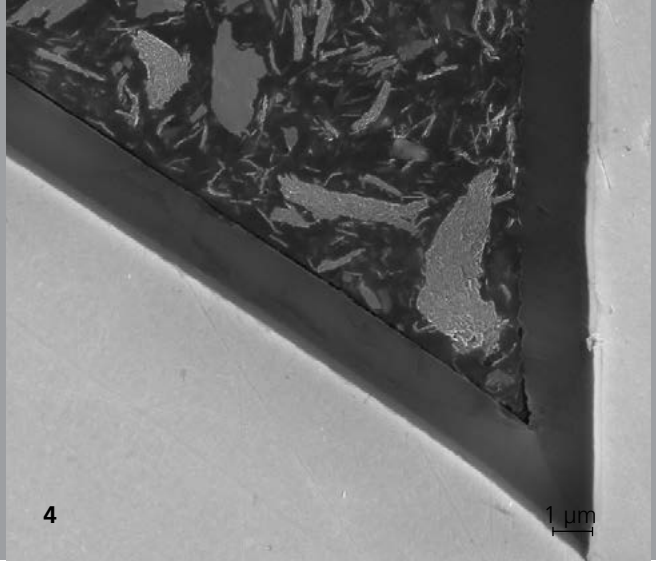
The basis of the alternative solution proposed by the Fraunhofer IST are wear-resistant, anti-adhesive coatings which are applied to the mold surface. The coatings may not only develop low adhesion forces in interaction with the polymer, but must at the same time offer good durability for use on the mold. An additional challenge in the coating of complex shapes is their contour fidelity.

Microstructures with steep edges and high aspect ratios are increasingly required for medical and optical components. For example, fine microfluidic channels need to be molded in the production of lab-on-a-chip systems. Flat and compact optical components such as are used for head-up displays or concentrator solar cells can be fabricated with so-called Fresnel structures on the mold. For the function and efficiency of these and many other components made of plastic, precise replication of the finest structures is necessary. Moreover, the anti-adhesive coating must follow the mold contours if the tight manufacturing tolerances are to be complied with.

From development to industrial practical trials

Within the framework of the AiF project "Contour-accurate anti-adhesive coatings for microstructured molds for efficient plastic molding processes" the Fraunhofer IST has developed PACVD processes for coating complex structured molds with high contour accuracy. The basis for this is constituted by modified DLC coatings (a-C:H:X, X = O, Si, F) with low surface energy. Subsequent investigations of these coatings carried out at the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt demonstrated that a SICON® coating (a-C:H:Si:O) enables demolding forces in the injection molding of polycarbonate to be reduced by up to 90 percent. The first industrial practical trials on structurally

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany



adapted modified DLC mold coatings conducted in collaboration with the ORAFOL Fresnel Optics company have already produced some promising results. With these innovatively coated molds, Fresnel lenses can even be made from a special polymer whose marked tendency to adhere prevents processing in the conventional way. Optical efficiency measurements indicate that a high contour fidelity and production-level quality can be achieved with the new manufacturing approach. These development results demonstrate the high potential for application of modified DLC coatings as a mold coating in the plastics processing industry.

Outlook

These very promising coating systems and processes are being further developed for various applications in plastics processing and for additional polymer systems. Important objectives are the coating of molds with larger dimensions and the optimization of mold surfaces, including coating systems for the production of high-quality plastic products.

1 - 2 *Mold coated with SICON® and used for the production of Fresnel lenses.*

3 *Fresnel lens made of plastic, produced with a coated mold.*

4 *Structure-adapted SICON® coating on a mold.*

CONTACT

Dr.-Ing. Christian Stein
Phone +49 531 2155-647
christian.stein@ist.fraunhofer.de

Dr.-Ing. Martin Keunecke
Phone +49 531 2155-652
martin.keunecke@ist.fraunhofer.de