Injection moulding of microfeatured parts

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INTRODUCTION

- There is a growing market for polymer components with micro- and nanofeatured surfaces, e.g. in microoptics based sensors and lab-on-a-chip devices for medical diagnosis.
- This poster reports on the moulding of a diffractive optical element (DOE), which is an essential component of a low cost IR spectrometer, used to identify different polymer types in a recycling centre (see picture).
- The objective of our project is to contribute to a fundamental understanding of the moulding process for such parts, including investigating alternative materials for improving mechanical properties and reducing thermal expansion, while retaining adequate replication ability.

EXPERIMENTAL

- Mould with microstructured insert: A nickel shim with the negative DOE structure was made by electroplating a resist structured by electron beam lithography, and this nickel shim was clamped in a modular mould.
- DOE structure: An irregular grating with height 0.5 µm, wavelength 3 µm and total structured area 10 mm x 10 mm.
- Injection moulding machine: Servoelectric Battenfeld EM 50/120 with maximum clamping force 500 kN and screw diameter 25 mm.
- Processing conditions: Mould temperature, injection speed and holding pressure were varied.
- Characterisation of parts: White light interferometry, AFM and SEM.

A FAST AND ACCURATE METHOD FOR MEASURING THE DEGREE OF REPLICATION

- Step 1: Topographies of a certain area of the moulded part and the mould insert are characterised by white light interferometry.
- Step 2: Power spectral densities (PSD) are calculated, and the degree of replication is calculated from the relative intensities of the main PSD peak.
- This measure of replication correlates well with AFM measurements.

CURVATURE (WARPAGE) OF MOULDED PART

- In order to satisfy the optical specifications of the DOE, the deviation from a plane must be less than 10 µm (over 10 mm, see figure).
- The curvature decreased with increasing holding pressure.
- Two PC grades were compared, and the one with the highest molecular weight gave the smallest curvature.

CONCLUSION

- The DOE structure could be well replicated, also with a polymer having rather high viscosity (and better mechanical properties and lower warpage).
- The degree of replication vs. processing conditions and material properties was analysed in terms of the effects enabling and resisting replication.

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