

The use of the GUM for the expression of uncertainty in micro moulded textures analysed with product fingerprints

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Abstract

The Injection Moulding (IM) of micro/nanostructured textured components requires optimisation studies based on to find the suitable process window to maximise the replication of structures. Depending on the geometrical properties, i.e. size and the aspect ratio, a different set of parameters has to be found for the process optimisation. The quality of the various process conditions is called "replication quality" and compares the plastic replica with the mould insert geometry. The evaluation of replication often lacks a robust metrological framework, and uncertainty evaluation is often neglected. In the present study, the replication analysis is performed through the use of "product fingerprints", i.e. synthetic quantitative measurands that objectively describe microstructures. The fingerprint is defined as the root mean square amplitude error (Sq) of the residual between surface topographies sampled on the replicated plastic products and on the tool insert. By performing a full factorial design (2⁴) on the four IM process parameters (Holding Pressure, Injection Velocity, Melt Temperature, Mould Temperature), the IM process window is at first identified. The DOE is used to produce a regression model of the IM process that it predicts the Sq values based on process parameters within the analysed window. The regression equation is employed then as a mathematical formulation of the process for the use of the Guide to the Expression of Uncertainty in Measurement (GUM) method. The method allows for a comprehensive estimation of the uncertainty of a fingerprint measurement according to the selected process conditions. The analysis leads to an expanded uncertainty of 19 nm for an estimated Sq of 246 nm corresponding to 8 % of the measurand amplitude.

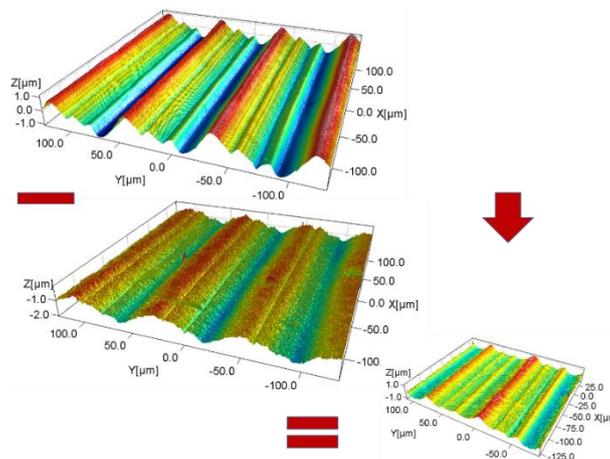


Figure 1: Analysis of the residual surface topography between textured insert and plastic replica.