Multi-Scale Modeling of Micro Injection Moulding – Case Studies With Experimental Validation

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Abstract

The implementation of micro Injection Moulding (µIM) process technology is in continuous growth. To shorten the time that undergoes from product conceptualization to manufacturing, simulation and modelling of the µIM process were developed and adopted from the conventional IM. Since the challenges that arise when scaling from meso- to micro-scale are known for more than a decade, the usability of different models or approaches for µIM simulation requires experimental validation for each case or application. This work presents a collection of case studies, including both single 3D micro parts and samples featuring micro surface structures. Commercially developed and available models based on the Finite Element Method (FEM) and on the generalized Navier-Stokes equations are employed for the analysis. Different modelling approaches and purposes are conducted. At first, virtual Design of Experiments studies are used for the prediction of micro dimensions (diameter of a micro ring) and micro defects (flash formation on a micro cap). Secondly, different multi-scale meshing solutions are presented for the analysis of the filling behaviour of micro structured products for optical applications. In one case, the prediction focuses on the evaluation of fill-time depending on microstructures orientation. In another study, the analysis converges on the filling behaviour of micro-features of a Fresnel lens. The results presented in this research find a meaningful impact on the wide case implementation of µIM simulation process technology.

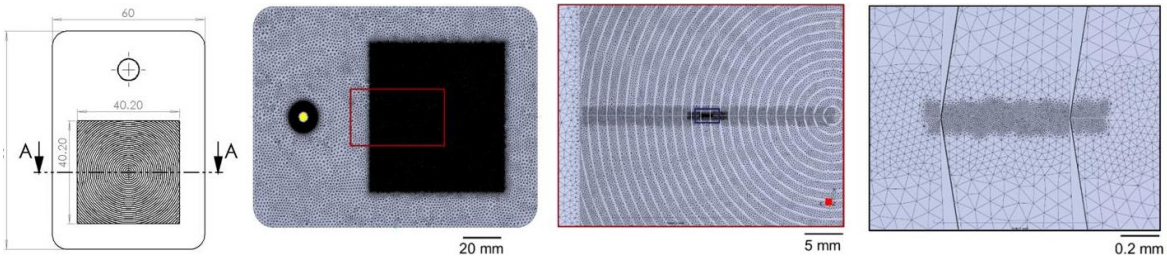

Figure 1: Multi-scale meshing for the modelling of a microstructured optical component [1].

[1] Loaldi, D.; Regi, F.; Baruffi, F.; Calaon, M.; Quagliotti, D.; Zhang, Y.; Tosello, G. Experimental Validation of Injection Molding Simulations of 3D Microparts and Microstructured Components Using Virtual Design of Experiments and Multi-Scale Modeling. Micromachines, 2020, 11(6), 614.