



Free-form nanostructured tools for plastic injection moulding

Kafka, Jan ; Sonne, Mads Rostgaard; Lam, Yee Cheong; Matschuk, Maria; Pranov, Henrik; Taboryski, Rafael J.; Kofod, Guggi

Publication date:
2016

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):

Kafka, J., Sonne, M. R., Lam, Y. C., Matschuk, M., Pranov, H., Taboryski, R. J., & Kofod, G. (2016). *Free-form nanostructured tools for plastic injection moulding*. Abstract from Polymer Replication on Nanoscale, Windisch, Switzerland.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Free-form nanostructured tools for plastic injection moulding

Jan Kafka¹, Mads Sonne², Yee Cheong Lam³, Maria Matschuk¹, Henrik Pranov¹, Rafael Taboryski⁴, Guggi Kofod¹

¹ Inmold A/S, Taastrup, Denmark

² DTU Department of Mechanical Engineering, Lyngby, Denmark

³ School of Mechanical & Aerospace Engineering, Nanyang Technological University, Singapore

⁴ DTU Department of Micro- and Nanotechnology, Lyngby, Denmark

We present results on a recently developed process to provide nanostructured surfaces on curved free-form injection moulding tools. The nanostructures are prepared using a sol-gel type coating, which can be applied by various means. Nanostructures are transferred from master structures originated typically by lithography. The nanostructures are imprinted by means of flexible stamps. After imprinting, nanostructures in the sol-gel are cured by baking, by which the material is converted to a quartz-like substance. Line patterns with depths up to about 500 nm and aspect ratio of up to 1 have been realized and successfully transferred to plastic parts during injection moulding.

As an example, we present theory and results regarding the imprint of pillar nanostructures on a semi-spherical mold surface, followed by injection molding of the same. The deformation of the flexible stamp is characterized by measurement of inter-pillar distance on various points on the sphere, and compared to predictions provided by a geometrical model. Moulded plastic parts show good replication of the pillar structure.

There are various practical advantages to the new process: the application of the coating is possible on both flat, single-curved and double-curved surfaces; the coating and the baking step is compatible with typical steel types in common usage for injection moulding; the coating is conformal with a relatively high surface roughness up to $R_a \approx 100$ nm, accommodating several surface finishing methods such as fine milling and diamond polishing; the coating has slightly insulating properties, which improves the nanostructure transfer properties compared to metal nanostructures; several durability studies have shown that the nanostructures on the injection moulding tool surface are unaffected for at least 100.000 injection moulding cycles; the imprinting of nanostructures has been successfully attempted with several types of thermoplastic polymer, including PS, ABS, PE, PP, COC (Topaz), and PA (Nylon), showing that most polymers are compatible, while some may require an increase in mold temperature for full transfer of nanostructure depth.

In conclusion, the process for nanostructured surfaces on double-curved or free-form injection moulding tools relies on flexible stamps, giving rise to predictable deformation of the pattern. The sol-gel process provides for a durable tool with accommodation of imperfect injection tool surface.