Assessment of injection moulded nano-patterned surfaces

Menotti, Stefano; Bissacco, Giuliano; Hansen, Hans Nørgaard

Published in:
Proceedings of the 14th euspen International Conference

Publication date:
2014

Assessment of injection moulded nano-patterned surfaces

S. Menotti, G. Bissacco, H.N. Hansen

Dep. of mechanical engineering, Technical University of Denmark, Denmark

S. Menotti *steme@mek.dtu.dk*

Abstract

Deterministic and random nano-patterned surfaces have received increasing attention in the recent years due to their ability to enable different functionalities. Deterministic nano-patterned surfaces can be used for instance for data storage, while random nano-patterned surfaces can be used for tissue engineering applications and tailoring of wettability.

In applications where polymer substrates are suitable, components carrying such surfaces can be mass produced by means of micro and nano injection moulding. A critical aspect is to ensure high quality of the nano pattern transfer from the mould to the polymer part during injection moulding.

Replication quality at nano scale is strongly influenced by the mould temperature. Therefore an embedded mould induction heating system has been developed and its performance validated through replication tests using a specific nano-patterned surface as reference. Such pattern was obtained on a nickel mould insert surface by means of a process chain based on aluminum anodization and electroplating. The obtained surface consisted of a random pattern of protrusions each having a spherical profile with lateral dimension in the range between 400-600 nm and a height between 80-150 nm. Assessment of nano-patterned surfaces requires measurements with nano-metric resolution. In order to enable the optimization of the moulding process it is necessary to develop a robust method for quantitative characterization of the replication quality of random nano-patterned surfaces which is compatible with the limitations introduced by the applicable measuring instruments.

In this work two different methods for quantitative characterization of random nano-patterned surfaces were compared and assessed. One method is based on the estimation of the roughness amplitude parameters Sa and Sz on the replicated surfaces for a direct comparison with the reference mould surface. This simple approach is based on the consideration that higher values of roughness amplitude parameters correspond to a better replication quality, while at the same time their maximum values are defined by those of the mould surface. The second method is based on pore and particle analysis using the watershed algorithm for feature recognition and gives a quantitative output consisting of the statistical distribution of the relevant measures of the surface features such as diameter and height. To compare the methods, the mould insert and a number of replicated nano-patterned surfaces were measured on nominally identical locations by means of an atomic force microscope mounted on a manual CMM. Location recognition was obtained through reference marks embedded in the mould insert and replicated on the polymer parts. The results of the comparison show that the first method is strongly affected by local variations of the surface and therefore requires the ability to locate exactly the area for comparison on each replica and on the mould surface. By contrast the second method is implicitly more robust and the output is more directly correlated with the dimensional characteristics of the features to be replicated and therefore allows a more explicit assessment of the quality of replication.