Hydrophobic hierarchical structures on polypropylene by plastic injection molding

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Introduction

Materials properties can be taylored by texturing their surfaces with custom designs of repeated patterns. Interesting properties like self cleaning, anti-reflection, hydrophobicity or diffraction colours can be obtained by means of particular surface motifs. In this work, simulations and experiments have been performed to study the replication of sub-micron patterned structures at low cost using plastic injection moulding. Hydrophobic surfaces onto metallic plastic injection moulds were fabricated by laser texturing and then these surfaces were replicated on polypropylene plastic parts.

Mould texturing

The mold shown in Figure 1 was textured with a femtosecond (350fs) laser source (lambda=1030 nm). Micro holes further show sub-micron structure clearly observed in the SEM micrograph of the mould surface (Figure 1).

Injection

The effect of Temperature, Pressure and Time on Polypropylene injection was investigated following a 2^3 design of experiments. Temperature levels: 230 and 270 ºC; Pressure levels: 80 and 100 bar; Pressure application time: 5 and 15 seconds.

Plastic parts

Figure 2a shows the contrast between patterned (bright) and non-patterned areas (dark). Quantitative image analysis of this surface allowed us to determine the quality of the replicated pattern. Figure 2b shows the contact angle measurement of a hydrophobic plastic surface. Contact angles between 95 and 135º were obtained.

Results

Figure 3 shows the influence of each parameter on the final quality of replication. Larger cycle times and higher temperatures yield higher replication quality.

Replicated percentage and contact angle are compared in Figure 4. Values range from 0 % replication (polished surface) to 80% replication. There is a relationship between the copied percentage and the water contact angle above 50% replication. Below this value, hydrophobicity is that intrinsic to polypropylene (reported contact angle 97.15º).

Conclusions

- Sub-micron patterned polypropylene surfaces can be obtained by plastic injection moulding using laser textured moulds.
- Temperature and injection cycle time play a key role in the quality of replication.
- Further work is needed to achieve complete replication of sub-micronic patterns fabricated by laser texturing.

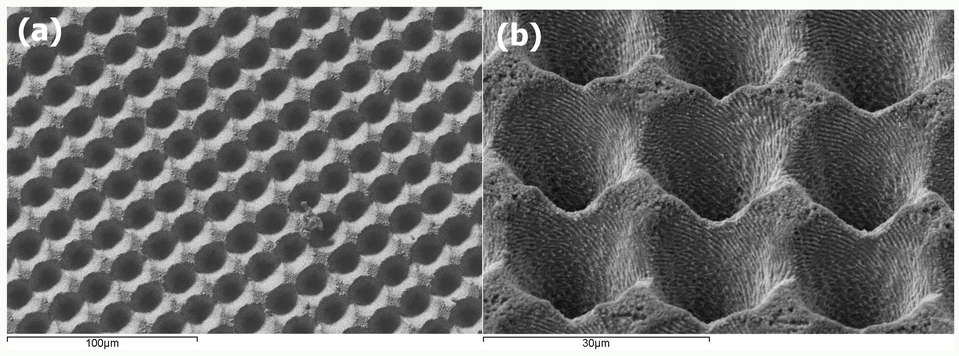

Figure 1. SEM micrographs of the mould (a) Top view (b) 40º Tilt.

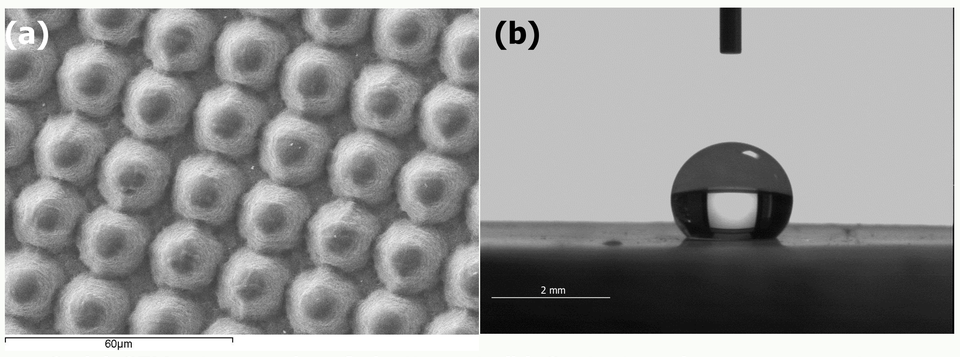

Figure 2. (a) SEM micrography of plastic part. (b) Contact angle measurement

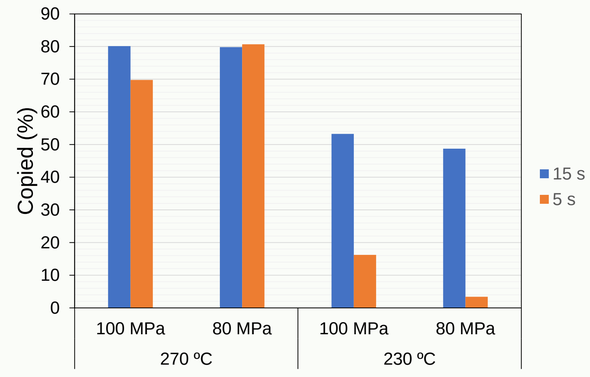

Figure 3. Copied quality vs. temperature, cycle time and pressure

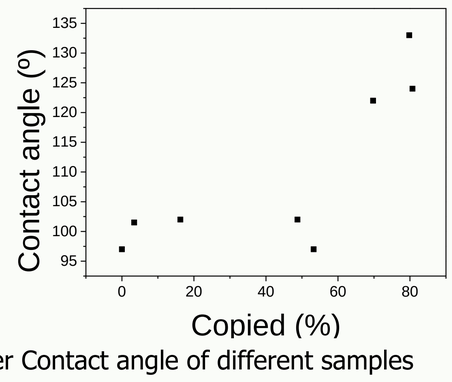

Figure 4. Water Contact angle of different samples

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