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Roll-to-roll extrusion coating (R2R EC) is a well-established and well-studied process in the field of the packaging industry. Within the last 5 years a new field of study has occurred: adding molds to the cooling process allows a successful replication of micro- and nano-sized structures in several thermoplastic polymers [1-3].

The replication fidelity has been analyzed with respect to the different extrusion parameters for the nano-sized pillars by Murthy et.al. [1], nano-grass by Telecka et.al. [2] and for the micro-sized pillars by Okulova et.al. [3]. An interesting inconsistency occurs for the influence of the line speed during this process: the nano-sized structures seem to replicate best at the higher line speeds and the micro-sized structures seem to replicate best at the lower line speeds. A comparison of the filling for the two structure sizes is shown in Figure 1.

The main objective of this study is the investigation of the pattern replication for hierarchical structures, where the micro pillars are supplied by the nano-grass structures. In Figure 2, an SEM image of the structures produced by DRIE process in Si are shown in a and b. An electroformed Ni mold is used for the extrusion coating. In Figure 2c the replicated pattern in PP is presented. The produced structured foils show a superhydrophobic behavior.

Some of the interesting applications of such superhydrophobic foils are self-cleaning surfaces, as well as anti-icing and protection against corrosion. For most of the superhydrophobic surfaces the contact and roll-off angles are measured in order to prove the superhydrophobicity. This study goes beyond the rolling droplet and examines an impacting droplet (Figure 3), that is a better model for a raindrop.

Later-time dynamics (the cotact angles and the maximum spreading ratio of the droplet diameters) of the impacting droplets are measured for different Weber numbers. The maximum spreading ratios as a function of the impact Weber number found in experiments are then compared with simple analytical estimates of the maximum spreading diameter by Wildeman et.al. [4].

This high-speed and low cost method looks very promising, however further material and hydrodynamic investigation will be carried out before this product can be available on the market.

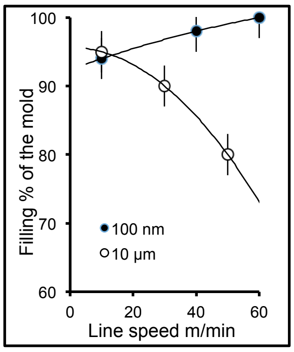

Figure 1. The fidelity of the replication process for the micro- [3] and nano-sized pillars [1]. The decreasing replication fidelity is more drastic at lower temperature in both cases, however the results presented here are obtained at 70°C, being the only comparable parameter space for the two studies.

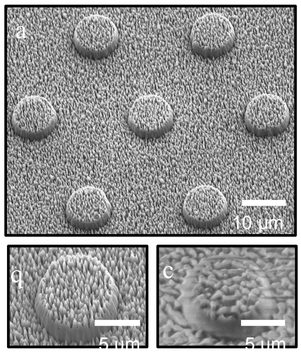

Figure 2. The original hierarchical structure on a Si master (a,b) and similar structures replicated in PP during the extrusion coating (c).

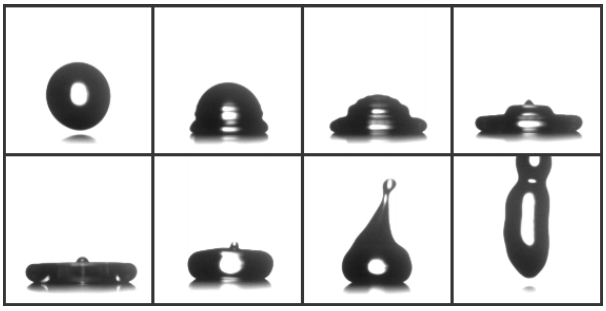

Figure 3. The droplet impact on a polypropylene surface structured using the roll-to-roll extrusion coating. The superhydrophobic structures used in this experiment are similar to the ones shown in Figure 2.

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