Creating superhydrophobic textures for microfluidic applications through a combination of femtosecond laser ablation and polymer injection moulding

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Superhydrophobic surfaces enable us to precisely control the fluid flow in microfluidic applications such as lab-on-chip devices where various laboratory functions can be performed in different microchannels within a single device. By introducing micro and nano-scale textures to alter the surface topography within microfluidic channels, superhydrophobicity can be achieved, thus enabling functional capabilities such as hydrophobic valves. In scientific literature, it is noted that superhydrophobicity can be achieved by the integration of dual-scale hierarchical textures, wherein nano textures are positioned on top of micro textures. These micro and nano-scale textures can be made with chemical etching, photolithography, and micro-milling. Yet, making dual-scale hierarchical textures through these means can be laborious and intricate. A suitable alternative lies in the utilization of femtosecond laser surface texturing, which can create hierarchical textures in a single-step process. Additionally, realizing such features on polymeric microfluidic products directly through laser texturing lacks efficiency in terms of mass production. This limitation can be addressed by creating the negative of desired features on the surface of the mould with femtosecond laser ablation, which can be replicated using polymer injection moulding.

Owing to the extremely small dimensions (in the order of hundreds of microns) of microchannels in lab-on-chip devices, textures are needed with a small distance (called “pitch”) between the features. This study focuses on the creation of the negative of desired hierarchical micro textures on a mould surface which upon replication on polymer via injection moulding are expected to generate micro-textures that not only are superhydrophobic but also have minimum pitch so that they can be incorporated in the narrow microchannels.

In the first step, micro textures are fabricated on a flat steel mould insert using a femtosecond laser, by varying the pitch and number of pulses and keeping the other parameters constant. Subsequently, the textures are replicated onto polypropylene through injection moulding, resulting in the formation of hierarchical micro bumps with conical shapes. The wettability of the replicated textures on polypropylene is analyzed by assessing the contact angle, using a drop and surface analyzer (DASA).

This establishes a relationship between the micro-texture design parameters (shape and pitch), laser scanning parameters, and the hydrophobicity of a replicated surface. This knowledge will be crucial when in the future the micro-textures will be incorporated within narrow microfluidic channels.