Injection moulding solid microneedles using laser ablated moulds

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Abstract

Microneedles arrays are minimally invasive devices which offer a pain free, straightforward and efficient method for transdermal drug delivery. These arrays typically consist of tens or even thousands of microneedles per cm² with an individual needle length between 50 µm and 900 µm. Manufacturing these micro-systems represents a real challenge and for the technique to become economically viable, a mass production process with high volume outputs at a low cost is needed. A promising manufacturing process which fits these criteria is polymer injection moulding. By applying the negative geometry of the microneedles on a mould cavity, millions of polymer microneedle systems can be produced at a low cost. However, within the current state of the art, methods for applying the negative of the microneedles on the injection mould are limited to expensive and time consuming techniques such as micro-electrical discharge machining (µ-EDM), micro-milling, micro-drilling or micro-forging. Besides, manufacturing microneedle cavities with small tip-radii (< 15 µm) is proven to be very difficult by these techniques.

In this study, a novel manufacturing process to produce sharp-tipped solid polymer microneedle arrays using laser ablated moulds in an injection moulding process is presented. The ablation method utilizes a femtosecond laser with a cross hatching strategy. The influence of laser process parameters on the geometry of the needle cavities is evaluated by means of a design of experiments. The ablated needle cavities are characterized using micro-computed tomography (µ-CT). Finally, the attained moulds are used in an injection moulding process and the replication fidelity is assessed.