Micromoulding facilitates the miniaturisation of medical device components in plastics

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Moulding of plastic ‘micro-scale’ components or parts that have micro-scale/nano-scale features has become increasingly possible over the last few years through developments in processing technology and in machining and mould manufacturing techniques.

Examples of micro-moulded medical components include parts featuring miniature holes and meshes, surfaces with sub-micron structures, overmoulded micro-inserts, and combinations of dissimilar materials for drug delivery devices.

Creation of micro-scale cored-holes and injection gating

The 1.5mm long through-holes in the micro-part shown in figure 1 are circular holes of diameter 0.2mm, and square holes of 0.3mm per side. The holes are cored out during the moulding process using steel pins made by advanced micro-EDM (electro-discharge machining) processes. In a similar way, moulded filters have been produced with mesh holes as small as 40 microns. At a slightly larger scale, the part shown in figure 2 features a 0.320mm dia hole, 7mm long, that runs through the clip at a compound angle and is used for fluid injection during surgery.

Gates for micro-moulds can be less than 60 microns in diameter. This is important to minimise the gate vestige left on micro-parts and to allow automatic de-gating in the process via 3-plate mould designs. Examples of microparts moulded using auto-degating include bio-resorbable staples and x-ray opaque probes with tip diameter of 0.15mm.

Sometimes it is beneficial to leave micro-parts on the runner for assembly purposes, but direct gating has the additional advantage of minimising the feed system, so the amount of polymer material used can be reduced. With bio-compatible materials being expensive, this helps to keep part cost lower.

Fig 1: Micro-moulded fibre optic connector with 0.2mm through holes.

Fig 2: Clip for fluid delivery. The part features a 0.32mm dia hole at a compound angle, formed in the mould by an 11mm long retractable pin.

Combination of dissimilar materials for medical devices and drug delivery

The part shown in figure 3 was demonstrated recently running in an automated cell at a major international exhibition. Metal pins of 0.6mm diameter are picked up by a robot and placed into the mould which rotates on a turntable into the injection position. The molten polymer is injected around them, the turntable carries the moulded part out, the robot de-moulds the parts and places more pins for overmoulding. This is done using two moving halves of the mould so that moulding and de-moulding/insertion can be done simultaneously. The difference between this and a conventional overmoulding process is the level of precision involved. Mould design and accuracy for this type of process is critical for efficient operation. Medical components such as overmoulded needles have been produced and minute amounts of polymer can be reliably injected, down to fractions of a gram.

The process can be extended to cater for overmoulding of other materials, such as different polymers, filter membranes, and pharmaceutical compounds. This opens up a whole range of possibilities for the open-minded designer in terms of combining materials in medical device or drug-delivery manufacturing. Materials that can be processed by injection moulding include bio-resorbable polymers, x-ray opaque materials, and many FDA-approved grades of engineering plastics. It should be noted that various factors need to be considered when combining materials in the process, including temperature compatibility, thermal expansion and processing window.

Surface structures of sub-micron accuracy

Specialised processes such as electron beam lithography and focussed ion-beam machining can be used to produce surface structures less than one micron (0.001mm) in height. Applications for sub-micron surface structures include diffractive optics and tailored wettability (eg in micro-fluidics).

The image shown in figure 4 is of the surface of a micro fresnel lens that has accurately profiled surface features of 0.2-0.8µm height (the area shown in the image is 125µm across). The original surface structure was made by electron-beam machining, replicated in nickel, and incorporated into a mould for micro-injection moulding in a 4-cavity tool with automatic degating. Cycle time for the moulding process was less than 6 seconds.

Conclusion

Designers need to be made aware of the possibilities now available in terms of micro-moulding. There are many new applications waiting to be found for these innovative processes that are breaking through previous barriers in miniaturisation.

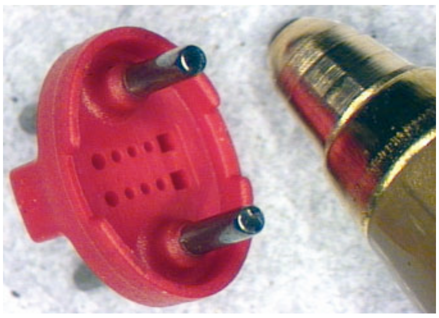

Fig 3: Micro-connector with 0.6mm dia insert-moulded pins (shown next to tip of ball-point pen).

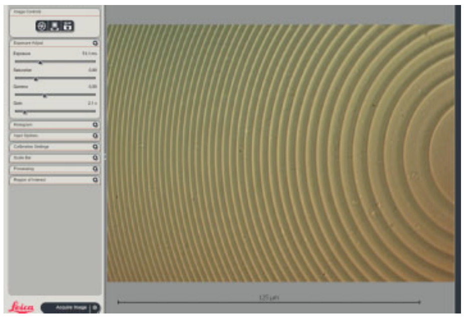

Fig 4: Moulded micro-fresnel lens surface structure. The view shown is 125µm wide.

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