PEEK | Update

Laser Micromachining of PEEK and Polyimides: **Advanced Tube Geometries**

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Today, engineering plastics are widely used in the medical device industry. Polyether-ether-ketone (PEEK) and polyimides (also known as Kapton) are among the more commonly used plastics for these purposes. The medical device industry is focused now more than ever on creating less invasive surgical tools, and this trend has caused a shift towards the miniaturisation of devices. Traditionally many medical implants have been manufactured from biocompatible metals such as stainless steels, titanium, and nitinol, mainly due to their physical characteristics.

However engineering plastics are now leading a new frontier in implant design as the industry comes to grips with the advantages they can offer and gains experience in the complexities of machining these materials. As the transition to smaller devices takes place the advantages of polymers such as PEEK and polyimide from a manufacturing perspective become clearer. Not only do these devices offer excellent biocompatibility, it is also possible to extrude smaller tubes with plastic than with metal. This fact opens up a wide range of possibilities in terms of arterial implants, for example, as it becomes possible to offer products smaller in diameter than those which were previously possible using metals.

Blueacre Technology based in Dundalk, Ireland, designs laser micromachining systems and provides contract laser micromachining services, mainly for the medical device industry. Blueacre Technology has performed extensive development in-house to optimise the laser machining of polymer tubing. The findings of these developments have revealed the advantages and manufacturing challenges that must be overcome for the efficient and effective laser machining of polymer tubing.

For example, traditionally, laser machining is used in the manufacture of metallic arterial stents, and when optimised this process can offer both great flexibility and repeatability. However, current metal cutting processes almost always require post-processing to remove the laser machining dross.

When it comes to polymer machining the considerations are quite different. The developments that Blueacre Technology has performed mean that very little post-processing of laser machined polymer tubes is required. For instance, it can be the case that the only post-processing required for laser machined plastics is cleaning in an ultrasonic bath, as opposed to metals for which it is normally necessary to utilise a high cost post-process such as electrochemical etching. This means that production costs can be significantly lowered for devices that can perform a similar function.

In the medical device industry, metals have been used widely for many years, hence their material and machining characteristics are well known within the industry. For instance, the process of laser cutting of metallic stents has been very well developed, while on the other hand the laser micromachining of polymer stents requires the consideration of factors not normally encountered during metal machining. As polymers inherently have less

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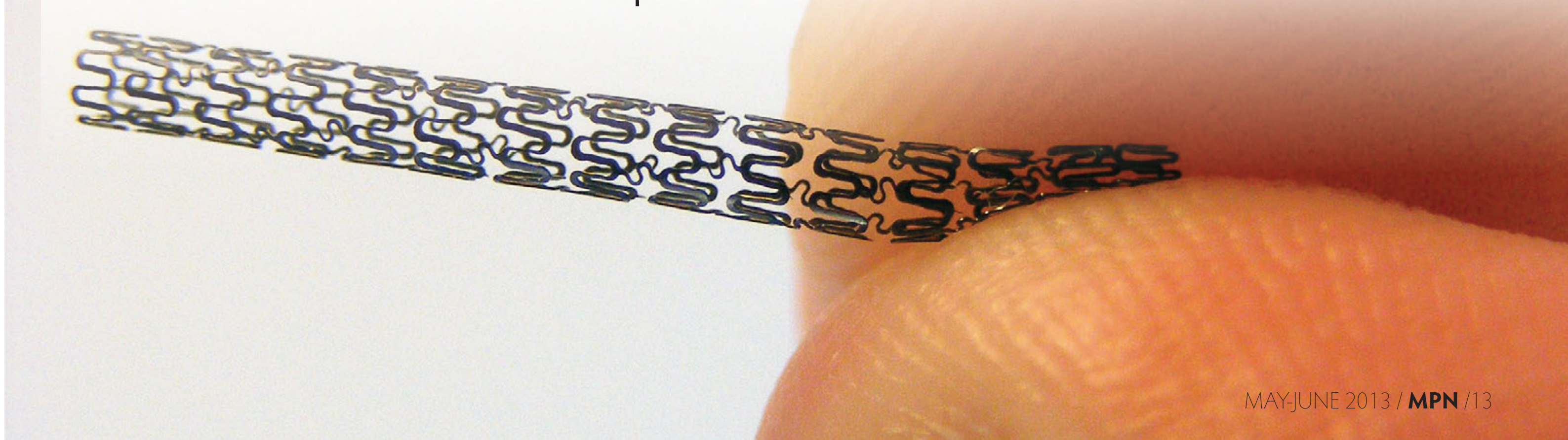
<< Figure 1: PEEK stent which has been laser cut using Blueacre Technology's proprietary dynamic alignment system. Strut widths are as small as 20 μm. >>



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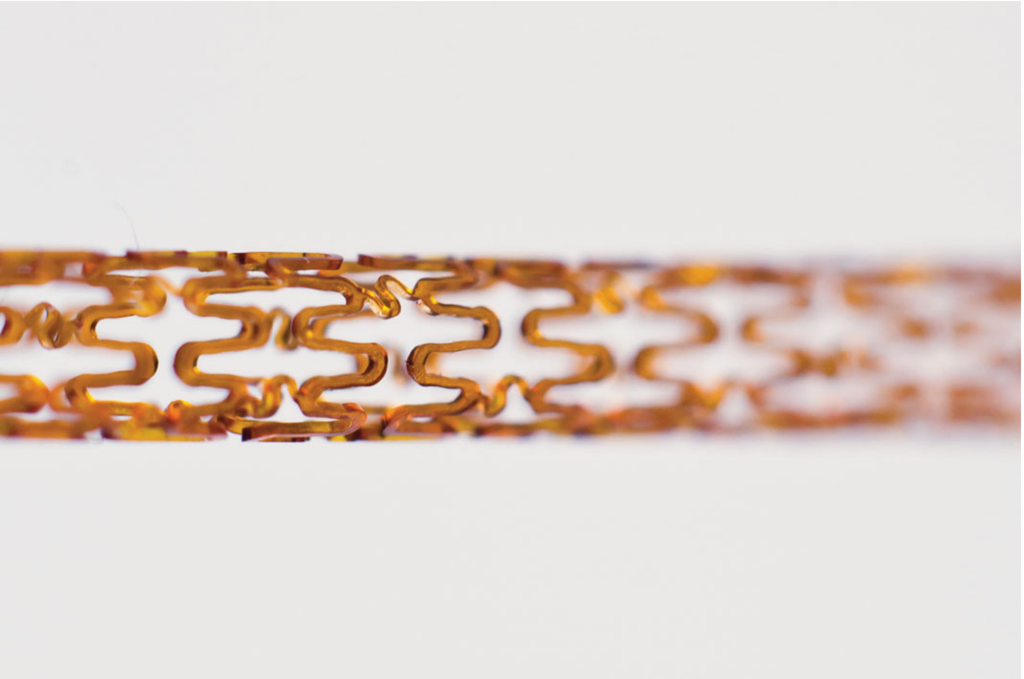

stiffness than metals, polymers tend to move around significantly more than metals during laser machining. This problem becomes more significant when machining small features (less than 50 μm) on thin-walled tubes. Blueacre Technology has become an expert in the field of the machining of polymer tubing having developed proprietary advanced auto-alignment systems. These systems offer the ability to track the tube position in real-time, allowing for high cutting speeds while holding tight tolerances over long parts and offering accuracies better than 5 μm.

While the mechanical alignment and stability of the laser cutting process is crucial, the quality and choice of the laser source is equally important. Considerations in choosing an appropriate laser source for any application include the colour of the emitted light, how the laser is operated (continuous wave or pulsed) and, if pulsed, the length of the pulse duration.

<< Figure 2: Polyimide stent laser cut using a pulsed UV laser source. The only post-processing required is cleaning in an ultra-sonic bath (Photo by Tomasz Staszak, 2013). >>

The colour or the emitted light strongly relates to how the light is absorbed and how the material is machined. UV lasers are very effective at machining polymers as the light is both well absorbed and has sufficient energy to break the inter-atomic bonds of the material, allowing for very clean cuts. Pulsed laser sources that operate with short pulse durations (less than 50 nanoseconds) also offer improved machining characteristics as it is possible to finely control the amount of heat generated in the work piece during machining, thus reducing any heat affected zones (HAZ) and reducing any effects on material integrity.

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Solid Concepts Adds High Temperature PEEK to Laser Sintering Materials Portfolio

According to a report published in April 2013 on *Industrial-Lasers.com*, USA-based selective laser sintering (SLS) service provider Solid Concepts is now successfully working with PEEK HP3, a grade of PEEK from German additive manufacturing machinery and materials manufacturer EOS. EOS offer the only available laser sintering machine in the world, the EOSINT P 800, for processing high temperature materials, including its own PEEK brand PEEK HP3.

According to the report, PEEK is the first true high performance polymer to be offered by Solid Concepts with additive manufacturing technologies. Parts created with PEEK are compliant with flammability requirements for aircraft cushions FAR 25.853 as well as the US Underwriters Laboratory (UL) plastics flammability standard UL 94 V0, and have very good chemical and hydrolysis resistance.

The addition of PEEK to Solid Concepts's SLS technology offerings adds the full benefits of complex geometries with high strength and heat deflection. Additive manufacturing of PEEK maintains the same high performance properties as moulding, extrusion and machining applications such as high stiffness and temperature resistance up to 240°C (464°F).

Prototypes and production parts built with PEEK are said to not only withstand chemical deterioration and damage, but also maintain good flexural and compressive strength at temperatures well beyond the operational range of standard nylon-based SLS parts.

Solid Concepts provides rapid prototyping and custom manufacturing services, with capabilities in PolyJet, stereolithography (SLA), Z-Corp, SLS, direct metal laser sintering (DMLS), fused deposition modelling (FDM), CNC models and patterns, QuantumCast advanced cast urethanes, and composites.