

Microolution



CASE STUDY: MACHINING CATHETER ABLATION TIPS WITH ULTRAFAST LASERS:

How one manufacturer uses ultrafast precision to bring better tip designs to market

Machining parts small enough to be deployed through vascular catheters is challenging. One company has found a way to make a new type of ablation tip, using ultrafast laser technology to create micro holes to deliver more efficient, precise treatment.

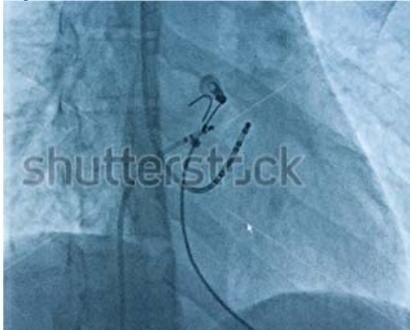
The medical device manufacturing industry is one of the most challenging, and exciting industries in the world. New devices are saving and extending lives, and implantable and minimally invasive devices are speeding therapies, reducing or eliminating hospital stays and accelerating recovery times. Machining these devices and the components that make them work, however, is becoming increasingly difficult. Parts must often be small enough to travel through human veins, perform complex procedures, and meet all government safety and quality requirements. New machining technologies are now making exciting new products possible.

One area in which machining technology is enabling safer, more effective devices is cardiac ablation for arrhythmia.

The human electrical system sends signals to the heart to pump blood throughout the body. This system doesn't always work correctly. Cells may send irregular signals, making the heart's chambers flutter randomly, causing what is known as arrhythmia. An increasingly common treatment for arrhythmia is catheter ablation, where a catheter with an electronic tip is guided to the heart to cauterize the source of the harmful signals.



There are several critical success factors to catheter ablation. One is directing the tip to the exact source of the faulty electrical signals, and the others is generating sufficient electricity to fully ablate the harmful tissue without damaging healthy tissue or, more seriously, over heating to cause scars or blood clots (thrombus). New tip designs feature imaging and sensing technology to identify the exact tissue to be ablated and to monitor the heat generated by the ablation to keep the temperature in a specified range. Reduced temperature, however, can make it difficult to create a lesion large enough to ablate the entire surface area at the arrhythmia source. Larger tip catheters can ablate more tissue more quickly, but with varying tissue thickness throughout the heart, smaller tips are also used to treat smaller areas.



Cardiac catheter ablation treatment

Newer ablation catheter tips use irrigation—flushing saline solution around or through the tip to keep the area cool enough to perform a successful ablation. The risk of introducing fluid into the ablation area is that the heat can cause it to boil, release steam or gas, and perforate the heart tissue.

New designs for irrigated catheter tips make irrigation more efficient—more cooling action from less fluid, reducing the risks of boiling—by designing holes to precise geometries to manipulate liquid dispersion. Machining these holes, smaller than the diameter of a human hair, has been economically unfeasible with traditional machining technology. Achieving the precise dimensions, with the edge quality and surface quality required to achieve more efficient dispersion, requires a level of precision and speed not found in legacy micro manufacturing technology.



Rendering of a laser-based ablation catheter tip machining center



Johnson Matthey, a leading manufacturer of components for the medical device industry, has found an answer using ultrafast lasers technology to make new ablation tip designs possible. Ultrafast lasers remove material without generating heat, enabling the machining of tiny holes with sufficient surface and edge quality to bring new catheter irrigation tip designs to life. Catheter tips [Using this manufacturing technology, the resulting catheter tips] manufactured using this technology require half the liquid flow of traditional irrigated catheter tips. This reduces the risks of both thrombus formation and perforation.

The most common challenge of any machining process is managing thermal damage to the part. Heat causes melting, burrs, recast and other damage that must be addressed in post processing. For parts as small as catheter tips, just about any thermal damage is unacceptable as it is extremely difficult to perform rework at micron-level dimensions. Ultrafast lasers work by sending pulses of light so quickly that each pulse removes a small amount of material before heat can be absorbed. The result is that the shapes, in this case, the holes in the catheter tips, are near perfect. The dimensions, surface and edge quality matches the designer's specifications to allow for more accurate liquid dispersion.



Laser machining station with detail

Although ultrafast lasers have been used in laboratories for decades, they are not hardened for industrial use, and are susceptible to environment conditions such as temperature change and vibration. Microlution is a pioneer in the commercialization of ultrafast laser technology, developing platforms with the stability, enclosures, part handling and motion control that have led to successful deployment in the most demanding factories in the world—automotive, medical and semiconductor. Together, Microlution and Johnson Matthey created a complete automated system to bring new catheter tips to market that are medically and economically successful.