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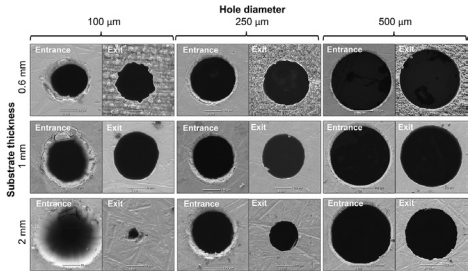
Parameters identified to reduce and eliminate micro-hole sidewall tapering in nickel alloy C263.



Ultrashort pulse lasers are used for high-precision drilling in microscale devices and aerospace and automotive components. Despite the high demand for this technology, it is limited by the sidewall tapering of the resulting hole. Introducing motion to the incident beam is a promising method for reducing sidewall tapering.

Le et al. optimized the parameters of laser precession to achieve high-precision micro-drilling. The authors drilled into a nickel-based superalloy, C263, commonly utilized in aerospace applications for its strength and resistance to oxidation.

Sidewall tapering causes the exit of a machined hole to be smaller than the entrance. The size of the laser-material interaction zone and the beam's self-limiting energy create the unwanted effect. Beam precession increases the accuracy and efficiency of the laser to achieve the desired, taper-free ablation.

The authors optimized the precession laser's performance and produced a taper-free hole.

A high incident angle generally improved accuracy; however, too high an angle reduced power and beam quality. A greater difference between the focus of the precession beam and the focus of the individual beam reduced tapering. The beam's scanning speed, which determined the overlap between laser pulses, also played a significant role.

"The incident angle of the rotating beam was expected to have the most importance, but it was less significant than relative focus position and scanning speed," said author Hoang Le.

The thicker the substrate, the more tapering appeared.

This insight into the underlying mechanisms behind laser micro-drilling is important for its variety of applications in aerospace and other devices that require precision drilling. The team believes the demonstrated capabilities and limitations of precession laser machining can be applied more broadly.

Source: "Investigation of precession laser machining of micro-holes on aerospace material," by Hoang Le, Vahid Nasrollahi, Themistoklis Karkantonis, Pavel Penchev, Sunder Marimuthu, Mickey Crozier, and Stefan Dimov, *Journal of Laser Applications* (2023). The article can be accessed at https://doi.org/10.2351/7.0000903.