High-throughput multi-beam millisecond laser micro-hole drilling

Mitchell Leering[1], **Sundar Marimuthu**[1],

1- Manufacturing Technology Centre, Coventry, CV 79JU
Mitchell.leering@the-mtc.org

High-speed laser micro-hole drilling of titanium foils is a useful production technology that can be used to produce vital components for hydrogen, filtration, and microelectronics applications. This study presents a novel approach utilising multiple beamlets produced by a Diffractive Optic Element (DOE) to enhance drilling efficiency and throughput rate of 'on-the-fly' laser drilling. The research explores the use of a single-mode millisecond laser system combined with a specially designed DOE to generate an array of beamlets that simultaneously process multiple drilling sites on thin titanium foils.

The experimental setup involved 100 µm thick titanium foils, subjected to high-speed laser micro-drilling using a 2 kW 1070 nm single-mode millisecond fibre laser. The DOE, engineered to create a 5x1 pattern of beamlets, was employed to drill an array of micro-holes whilst maintaining continuous movement of the pulsed laser. This investigation looked at the effects of varying pulse energy, number of pulses, frequency, pulse duration, gas composition and processing strategies on the size, quality, and consistency of the drilled holes. Additionally, the effects of high drilling rates on hole circularity and positional accuracy are investigated. Optical microscopy and SEM were utilised to analyse the size and quality of the resulting holes. The melt-ejection dynamics and heat accumulation are investigated through high-speed and thermal imaging of the drilling process.

Results demonstrate that the DOE-assisted long-pulse multi-beamlet approach significantly increases the throughput rate compared to traditional single-beam drilling methods. Additionally, this study demonstrates the usefulness of longer pulsed millisecond lasers to increase the drilling throughput rate whilst achieving suitable hole quality.