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Submerged laser microcutting of Mg alloys with ns pulsed green laser for biodegradable stents

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INTRODUCTION: Laser microcutting is based on melt generation and expulsion (melt and blow) when continuous wave lasers are used. The use of pulsed lasers changes machining modality to ablation based cutting. Pulse duration becomes critically important and melt fraction can be reduced moving from long pulses (ms-µs) to short pulses (ns) and can be eliminated by the use of ultra-short pulses (ps-fs). Previous work determined that CW laser cutting allowed very high cutting speeds. On the other hand cutting with fs pulsed lasers allowed reduction of post processing and effective improvement of productivity in the whole production cycle of the biodegradable Mg alloy stents [1]. Another approach to laser microcutting is based on submerging the workpiece in a liquid and without the use of an assist gas [2]. Used with pulsed laser sources, the presence of liquid allows higher quality cutting by confining the ablation plasma, by increasing the mobility of molten material expelled from the cut kerf and by assisting machining through chemical action. In this work, submerged cutting with the use of 1 ns pulsed green fibre laser is studied. The effect of laser cutting parameters as well as liquid characteristics are investigated to achieve high quality cuts to reduce or eliminate any post processing stage in the manufacturing of biodegradable Mg stents.

METHODS: The laser source was a master oscillator power amplified (MOPA) fibre lasers operating with second harmonic wavelength 532 nm (YLPG-5 from IPG Photonics, Oxford, MA, USA), with the characteristics reported in Table 1. For workpiece positioning linear stages were used (ALS-130 from Aerotech, Pittsburgh, PA, USA) AZ31 sheets 0.25 mm thick were cut submerged in a liquid container (see Fig. 1). Deionized water, ethanol-water solution and machine lubricant oil were tested and compared to dry cutting conditions without the use of a process gas.

RESULTS: The preliminary results show that considerable differences in cut kerf morphology are present as a function of the submersion liquid (see Fig.2). The large kerf width obtained with the distilled water suggests that chemical reactions or mechanical interactions may take part in the process. High kerf quality was achievable with the ethanol-water solution.

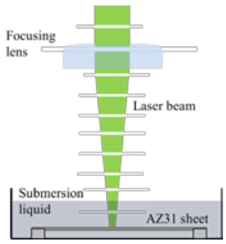

Fig. 1: Simplified scheme of submerged laser cutting of Mg alloy.

Table 1. General characteristics of the used laser source.

Wavelength	532 nm
Pulse duration	1 ns
Max. average power	6 W
Pulse repetition rate	20-300 kHz
Max. pulse energy	20 µJ
Beam diameter	22 µm

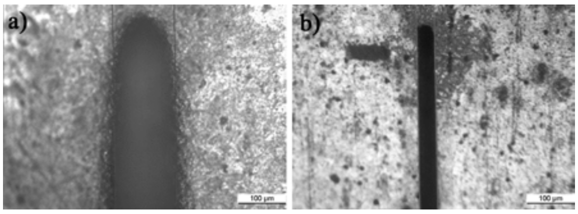

Fig. 2: Comparison between obtained kerf morphologies by submerged laser cutting in a) distilled water, b) ethanol-water solution.

DISCUSSION & CONCLUSIONS: The proposed method is promising for net shape stent manufacturing and has the potential to eliminate post chemical and electrochemical cleaning steps. The involved optical, mechanical and chemical phenomena are currently under investigation for a better comprehension of the process.

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