Digital Micromirror Devices for rapid fabrication of large-area laser-ablated multicolour-grating patterns

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Digital Micromirror Devices (DMDs), which contain arrays of individually-controllable ~10μm square mirrors, have shown recent promise in applications for high-resolution additive [1] and subtractive [2] laser machining. Although generally used for commercial projectors, there is great interest in using DMDs for the projection of highly-demagnified spatially-patterned laser-light, where sub-wavelength-sized features can be machined using a single laser pulse.

Here we show recent results using 800nm wavelength, 1mJ, 150fs pulses from an ultrafast amplifier, at a repetition rate of 20Hz, in order to pattern arrays of ~10,000 individual gratings, each of size ~30 by 30μm, into a range of materials, to make contiguous structures on the order of 5 by 5mm final area, by stitching via the movement of a mechanical stage. Each individual laser-machined reflective grating corresponds to the minified version of the mirror pattern on the DMD at the time of the pulse, and hence the final sample produces a strong angle-dependent coloured appearance.

Initial results show conversion of a coloured bitmap image, into an ‘8 colour’ laser-machined sample with a resolution of 125 by 125 gratings and of total size 0.25cm^2, where each ‘colour’ corresponds to the use of one of eight different grating patterns on the DMD, each with a different line separation. When viewed at a specific angle, the visual appearance of the sample closely matches the colours on the original bitmap image file.

Currently, regions of order 0.25cm^2 can be patterned in ~15 minutes, but with faster stages the machining time could be reduced to the order of seconds when using a 1kHz repetition laser. This technique is likely to have applications in areas such as security or material-marking, where this process could easily be extended to produce hard-to-replicate, unique barcode-like identifiers on high-value or high-importance items.

[1] Mills et. al. Opt. Exp. 21, 12 (2013) 14853-14858
[2] Mills et. al. J. Micromech. Microeng. 23 (2013) 035005