Laser processing of mono- and multi-layer polymeric materials

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Abstract

Plastic materials are characterised by low absorption to laser radiation of wavelength < 2 μm; yet, above a certain threshold fluence non-linear absorption mechanisms can lead to efficient material ablation. Several studies on PMMA exist in the literature [1], whilst only a limited number of work presents pulsed laser processing of polypropylene (PP) and polyethylene (PE) [2,3].

In the present study, thin PP and PE films, 20 μm and 50 μm thick respectively, and their multi-layer combinations with aluminium (AL) as Triplex (PP 20 μm - AL 9 μm - PP 20 μm) and Duplex (PP 20 μm - AL <0.1 μm - PP 20 μm), have been exposed to nanosecond and picosecond infrared (IR) pulses and nanosecond green pulses. The BOREAS G15 (Eolite Systems) was utilised for IR and green nanosecond pulses and the Helios IR (Innolight GmbH) for IR picosecond pulses. Both lasers were mounted on machines equipped with X-Y translation stages on which the samples were mounted.

An extensive set of tests, at various translation speeds, was carried out. High quality incisions were obtained with IR picosecond laser exposures. In Fig. 1 (a) the microscope image of a 119 μm wide groove obtained with this laser on the PP film at 50 mm/s speed is presented. Nanosecond exposures, both IR and green, did not lead to remarkable results for monolayer polymeric materials, with intermittent interaction and heat damaged areas observed.

Depth measurements were been performed on the scribed samples by means of a mechanical profiler. In Fig. 1 (b) depth measurements of PE samples are reported at 50 mm/s speed. Above the threshold, ablation depth increases with fluence in a logarithmic fashion. Similar results have been obtained for PP and, furthermore, a complete cut of the film was possible for fluences above 12 J/cm^2.

Triplex was efficiently processed with green nanosecond pulses, whilst the same source lead to selective removal of the AL layer of Duplex. A complete cut of Duplex required the use of IR picosecond pulses.

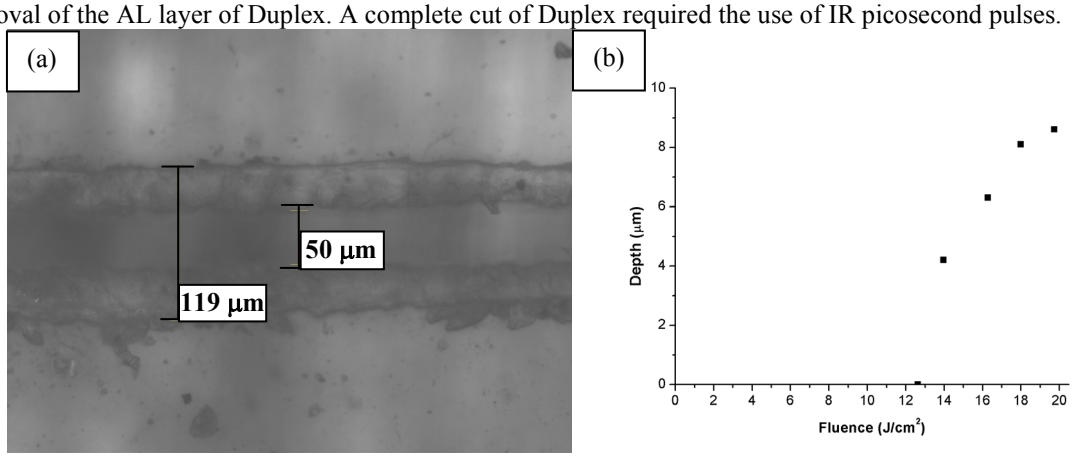

Fig. 1 (a) PP sample exposed to 500 ps, 1064 nm laser radiation at a repetition rate (RR) of 30 kHz. (b) depth measurements of PE samples exposed to 500 ps, 1064 nm laser radiation at a RR of 30 kHz..

In conclusion, high quality laser scribes have been obtained on materials used in the packaging industry. The results provide the necessary parameters for efficient processing of such materials, allowing the laser to be an effective alternative solution to more costly and energy intensive methods.

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