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Research Article

Experiment and Prediction of Ablation Depth in Excimer Laser Micromachining of Optical Polymer Waveguides

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Extending the data transfer rates through dense interconnections at inter- and intraboard levels is a well-established technique especially in consumer electronics at the expense of more cross talk, electromagnetic interference (EMI), and power dissipation. Optical transmission using optical fibre is practically immune to the aforementioned factors. Among the manufacturing methods, UV laser ablation using an excimer laser has been repeatedly demonstrated as a suitable technique to fabricate multimode polymer waveguides. However, the main challenge is to precisely control and predict the topology of the waveguides without the need for extensive characterisation which is both time consuming and costly. In this paper, the authors present experimental results of investigation to relate the fluence, scanning speed, number of shots, and passes at varying pulse repetition rate with the depth of ablation of an acrylate-based photopolymer. The depth of ablation essentially affects total internal reflection and insertion loss, and these must be kept at minimum for a successful optical interconnection on printed circuit boards. The results are then used to predict depth of ablation for this material by means of adaptive neurofuzzy inference system (ANFIS) modelling. The predicted results, with a correlation of 0.9993, show good agreement with the experimental values. This finding will be useful in better predictions along with resource optimisation and ultimately helps in reducing cost of polymer waveguide fabrication.

1. Introduction

Consumer electronics are experiencing uphill challenge to overcome high-frequency (>10 Gb/s) transmission problems such as cross talk, electromagnetic interference, and power dissipation especially with high interconnectivity [1]. Rush for miniaturization, addition of more features/applications, and communication at microscales (e.g., chip-to-chip) have exposed the limits of copper-based transmissions in electronic circuits. To overcome this bottleneck, an optically enabled printed circuit board is a viable solution as this technique has been successfully used for long haul communications, that is, optical fiber. The optical interconnections (OIs), used in conjunction with copper connection thus forming electric-optical bridge, are usually made up of polymer waveguides. Various fabrication techniques of these polymer waveguides have been proposed including laser direct writing, photolithography, inkjet printing, and laser ablation [2]. Amongst all, laser ablation is the preferred technique for fabrication primarily due to its proven use as well as availability with PCB manufacturers [1, 2].

Laser-matter interaction and its suitability for machining various engineering materials, including various polymers [3–5], have been well researched and documented in the literature. Micromachining using IR (infrared) laser sources particularly using CO_2 laser is common as it allows significantly higher rates of machining [6]. A few studies report the use of CO_2 laser process for polymer waveguide