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Multi-criteria optimization in CO_2 laser ablation of multimode polymer waveguides

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ABSTRACT

High interconnection density associated with current electronics products poses certain challenges in designing circuit boards. Methods, including laser-assisted microvia drilling and surface mount technologies for example, are being used to minimize the impacts of the problems. However, the bottleneck is significantly pronounced at bit data rates above 10 Gbit/s where losses, especially those due to crosstalk, become high. One solution is optical interconnections (OI) based on polymer waveguides. Laser ablation of the optical waveguides is viewed as a very compatible technique with ultraviolet laser sources, such as excimer and UV Nd:YAG lasers, being used due to their photochemical nature and minimal thermal effect when they interact with optical materials. In this paper, the authors demonstrate the application of grey relational analysis to determine the optimized processing parameters concerning fabrication of multimode optical polymer waveguides by using infra-red 10.6 μm CO_2 laser micromachining to etch acrylate-based photopolymer (Truemode™). CO_2 laser micromachining offers a low cost and high speed fabrication route needed for high volume productions as the wavelength of CO_2 lasers can couple well with a variety of polymer substrates. Based on the highest grey relational grade, the optimized processing parameters are determined at laser power of 3 W and scanning speed of 100 mm/s.

1. Introduction

Copper is traditionally the backbone of connection in electronics, particularly for very short distance communication such as intra- and inter-board applications. However, there is a serious challenge and limitation posed by this means of connection as the data rate continues to increase due to the reduction in size and a surge in the complexity of electronic devices. This has led to a steady rise in interest to deploy optical waveguides into printed circuit boards (PCBs), thereby a hybrid board is formed containing both electrical and optical channels. For this technology, a number of approaches have been (and is being) investigated, with each having specific merits. Amongst most methods reported in the literature, optical polymer waveguides seem to receive a significant attention in both research (academia) and application (industry) domains. This is not only due to the fact that polymer is cheap and easily available, but also the fabrication method is cost-effective and compatible with existing PCB manufacturing processes. Therefore, it offers a potential of rapid deployment of the technology and its integration with other devices.

In the aforementioned scheme, single mode or multimode polymer waveguides are patterned using materials with different refractive indices to form a core layer sandwiched between cladding layers. This is to insure that an optical signal launched into the core from one end is contained through the medium by total internal reflection. The cladding and core layers can essentially be formed using the same optical material or with two different types of materials having slightly different index of refraction. Photolithography, direct laser writing, laser ablation, inkjet printing, moulding, and hot-embossing are among the common methods of fabrication of optical polymer waveguides. Laser ablation, commonly used in drilling microvias on circuit boards, is the subject of this paper.

Laser ablation of polymer waveguides using UV laser sources have been reported for a number of materials including silicones, ORMOCER, Truemode™, epoxy resin and acrylate [1–5]. As shown in Fig. 1, the patterning process is initiated by spin coating a liquid

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