Laser Drilling MicroVias

Gil White, Rajesh Kumar, Simon Contreras, Ken Philips and Ron Weddell
Dynamic Details, Inc.
Anaheim, CA

Abstract
There is a growing need in today's electronic market for high performance Printed Circuit Boards (PCBs) with high-speed signals and enhanced performance. However, they must maintain signal integrity, PCB reliability, quality, and meet the overall thickness constraints of the application. In order to meet these demands, Microvia Technology is utilized to increase design real estate (routing density), improve signal integrity, reduce overall thickness, and enhance PCB reliability. Therefore, Laser Drilling Technology for microvias is fast becoming standard equipment for PCB fabricators in North America. This paper will discuss YAG and YAG/C02 combination laser drilling systems utilized in North America today, compare laser drilling efficiency of microvia materials, and the cost to drill microvias in high performance PCBs.

Introduction

An Engineering Test Vehicle (ETV) containing 230,000 blind microvias on different types of microvia materials was utilized to determine laser drilling efficiency and material strengths. Microvia materials included in the ETV are Resin Coated Copper, FR4 (1080 glass reinforced), Thermount®, a non-woven aramid. These are materials currently being utilized in Microvia Build-Up-Multilayer (BUM) PCB applications. We will present data extracted from the Engineering Test Vehicle and discuss the results for each Laser Drilling Technology.

Laser Drilling Technology

The laser drilling technologies utilized for the ETV are Nd:YAG and a combination of YAG/C02. The Nd:YAG system utilizes a focused Ultra-Violet (UV) laser beam to excavate material and cut cleanly through the copper and dielectric (non-reinforced or glass reinforced) material. The focused spot of the laser beam is between 25 to 50 microns in diameter. Microvias are created with a YAG laser system by Laser Spiraling or Laser Trepanning, and can utilize a combination of both methods. Laser Spiraling is a method in which a focused UV laser beam is set to a level capable of removing copper and glass dielectric. The UV beam spirals from the center of the microvia to the outside radius of the microvia. The precise path of the spiral will remove all material in the via z-direction down to the same depth. Laser Trepanning is a method by which a de-focused UV laser beam cuts in a circular pattern to remove dielectric without damaging the second layer of copper. This method does have a limit to the depth of material that can be cut in a single pass and the number of passes is programmable. Holes are clean and free of carbonization and do not require a pre-clean prior to plating.

YAG/C02

The combination YAG/C02 system utilizes the YAG (UV) technology to ablate through the copper and C02 (carbon dioxide gas) to blast through dielectric material. (See Figure 1.) C02 short pulse widths are utilized to provide via quality and a sidewall taper for ease of plating. The combined effort of the UV laser and the effect of high repetition rate C02 laser can create a quality microvia.

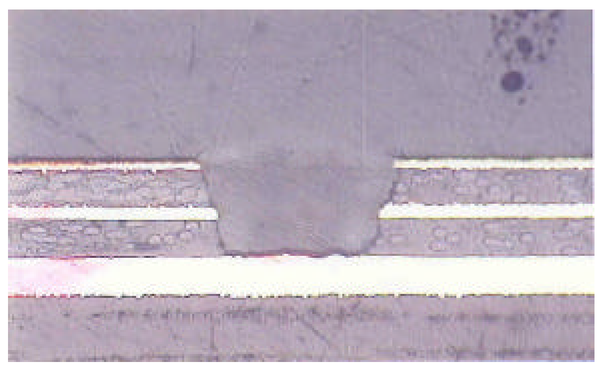

Figure 1 – Microvia Using YAG/CO_2

1080 Glass Reinforced

Prepreg with a glass style of 1080 contains woven fiberglass (resin filled) with 450 filaments in the machine direction and 450 filaments in the cross direction. It maintains a balanced construction with a thickness of .0028". This product is commonly used for one-plus BUM configurations with large form factors such as Telecommunications, and networking applications.

We begin our study by laser drilling glass-reinforced prepreg with a 1080 glass style and nine microns (¼ ounce) of copper. As shown in Table 1, the UV laser is 26% faster than the UV/C02 laser when laser drilling a 100 micron diameter microvia. However, when laser drilling a 150 micron diameter microvia the drill rates are similar, (47 vias/sec for UV and 40 vias/sec UV/C02), with the drill rate being the same for a 200 micron diameter (30 Vias/sec). The shape of each hole can be seen in Figure2 and Figure 3.

Table 1 – Standard. 1080 Vias/sec

Cu	Via Dia	UV	UV/C02
9 µm	100 µm	76	56
9 µm	150 µm	47	40
9 µm	200 µm	30	30

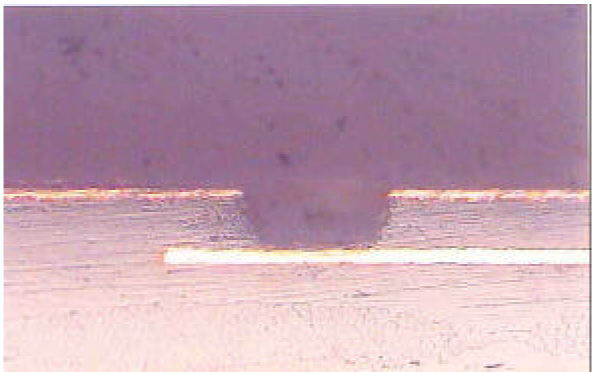

Figure 2 - UV/Co2

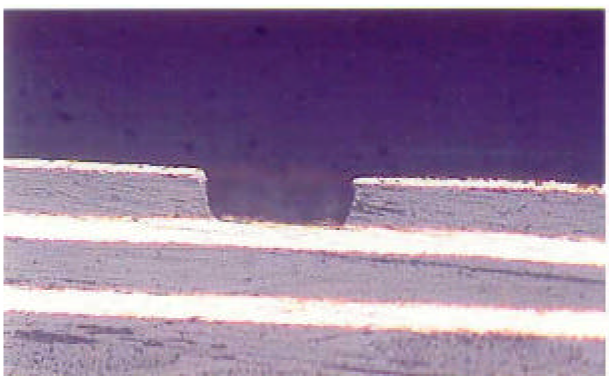

Figure 3 - UV

Resin Coated Copper

A single stage resin coated copper with 50 microns of resin and 9 microns of copper was utilized for this project. Resin coated copper maintains a non-reinforced epoxy system and is commonly used for BUM applications with small form factors or mobile products. Due to the non-reinforced epoxy system, resin coated copper can be laser drilled at a higher rate than glass reinforced systems. Therefore, the optimized drill rate for a 100-micron diameter in resin-coated copper is 97 vias/sec (UV) and 82 vias/sec for UV/C02 (see Figure. 2). However, the drill rate slowed to 54 (UV) and 50 vias/sec (UV/C02) for a 150 micron diameter and for a 200 micron diameter the rate slowed to 32 and 33 vias/sec. This is the same laser-drilling rate as glass woven reinforced 200-micron diameter microvias. See Table 2.

Table 2 – Resin Coated Foil Vias/sec

Cu	Via Dia	UV	UV/C02
9 µm	100 µm	97	82
9 µm	150 µm	54	50
9 µm	200 µm	32	33

Non-Woven Aramid

An epoxy Thermount® material with a thickness of 50 microns and copper thickness of 9 microns was utilized for this project. Non-woven aramid material contains a non-woven Aramid reinforcement is utilized with a multifunctional epoxy (Tg 180°) system. This material is utilized for high performance BUM applications small and large form factors and a standard for two plus or higher BUM configurations. Due to the non-woven nature of the material, non-woven aramid[1] material can be laser drilled at a higher rate than glass woven materials and the laser drill rate is similar to non-reinforced epoxy. The optimized laser drill rate for a 100-micron diameter microvia in non-woven aramid[1] material is 94 vias/sec (UV) and 69 vias/sec (C02/UV). For 150 micron diameter, 53 vias/sec (UV) and 46 vias/sec (C02/UV) and for 200 micron; 30 vias/sec (UV) and 35 vias/sec (UV/C02). See Table 3.

Table 3 – Non-Woven Aramid[1] Vias/sec

Cu	Via Dia	UV	UV/C02
9 µm	100 µm	94	69
9 µm	150 µm	53	46
9 µm	200 µm	30	35

Laser Drillable (LD) Prepreg

A laser drillable glass woven (1080) material with an epoxy resin (Tg 175 °C) was utilized for our evaluation. This material is designed for laser drilling and microvia one plus and two plus applications. The optimized laser drill rate for a 100-micron diameter microvia was 57 vias/sec (UV) and 62 vias/sec (UV/C02). For 150 micron diameter, 38 vias/sec and 43 vias/sec, and 200 micron; 28 vias/sec and 30 vias/sec. Compared to standard 1080 woven glass, 1080 LD glass laser drilled at a higher rate utilizing a UV/C02 laser, however, maintains a slower drill rate with the UV laser drilling system. See Table 4.

Table 4 – Laser Drillable Prepreg Vias/sec

Cu	Via Dia	UV	UV/C02
9 µm	100 µm	57	62
9 µm	150 µm	38	43
9 µm	200 µm	28	30

Cost

The cost to laser drill microvias has many variables. These variables include system cost, maintenance cost, system drill time or up time, system optimization, and type of material. Additionally, capital amortization of the equipment over x number of years plays a key role in determining cost of laser drilling microvias. By utilizing the above variables, we determined the cost of laser drilling with the YAG (UV) system is four to eight cents per 100 microvias with an average of six cents per 100 microvias, depending upon material. The cost of laser drilling using the YAG/C02 laser system is four to eight cents per 100 microvias with an average of six cents per 100 microvias.

Summary

YAG and YAG/C02 systems are capital intensive, however, both systems are efficient and cost effective methods for laser drilling microvias. By optimizing the UV laser system, we were able to increase velocity and power, which significantly increased laser-drilling speed. Also by increasing the laser speed, we decreased the cost to laser drill microvias with the UV system. For example, we laser drilled 3,180 microvias per minute at less than one tenth of one cent per microvia using a UV laser system with non-woven aramid[1] material. Also, with the exception of LD prepreg, the UV system was faster.

However, the cost to laser drill microvias is the same for both systems at less than one tenth of one cent. Also, all the microvia materials tested perform well in their specific applications. For example, Resin Coated Copper is widely used in mobile products with small form factors. 1080 glass reinforced prepreg is widely used in large form factors such as Telecommunications, Networks, and Server applications.

Non-woven aramid material is commonly used for high performance applications such as Avionics, Military, or applications with CSPs, and COB where planarity is required. Additionally, non-woven aramid[1] is the material of choice for two-plus applications due to the dimensional stability of the material. Our study shows that quality microvias can be laser drilled in standard glass reinforced prepregs or microvia materials using YAG or YAG/C02 systems efficiently and are cost effective.

Acknowledgements

1. Thermount® is registered trademark for the non-woven aramid.