Introducing Via-in-Pad Blind Via Technology to Any PCB Multilayer Fabricator

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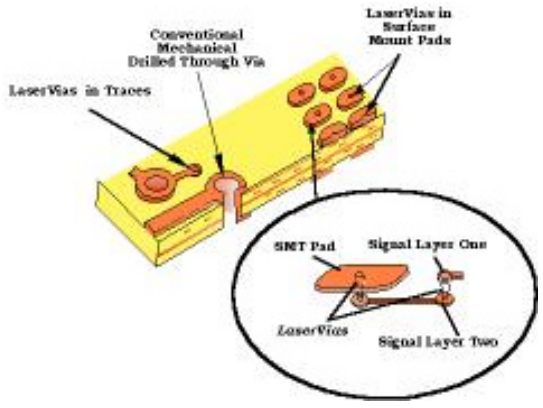
Abstract

"Via in Pad" Blind Via Technology can cost-effectively and readily be introduced as a sequential process step into any multilayer circuit board fabricator's existing process flow. This paper will discuss the fabrication 'manufacturing rules' and show how natural it is to introduce multi-depth laser drilling into any multilayer circuit board fabricator. No new fabrication procedures have to be developed or integrated into the conventional fabrication process for very high yield blind vias. A multidepth blind via process will be detailed that is not a build up or sequential layer technology. It is however, a direct replacement and is complimentary to conventional mechanical drilling.

Introduction

The emerging demand for blind vias in circuit boards is driven by the need for increased circuit density. The introduction of BGA and µBGA interconnect challenges plus other components with increased Input/Output (I/O) demands has revealed the shortcomings in circuit board interconnect density. No longer can fine pitch line widths and small mechanically drilled holes economically accommodate the increased requirements for circuit density.



One solution for the *"Interconnection Gap"* is blind via technology and the best blind via solution is Via-in-Pad interconnections.

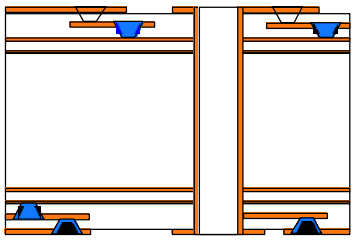
There are several methods for fabricating blind vias:

- Mechanically drilled- limited depth
- Mechanically drilled- sequential lamination
- Laser drilled- with or without copper mask
- Sequential build up - Photo Via defined
- Sequential buildup- Plasma Etched

All of the above blind via technologies can readily be designed and fabricated to accommodate Via-in-Pad interconnections.

The mechanically drilled blind vias have proven over time to be too expensive and have actually limited the growth and acceptance of blind via technology within the polymer multilayer circuit board industry.

The two sequential buildup technologies[1,2], Photo Via and Plasma Etched are finding early acceptance as blind via fabrication processes, but significant increases in fabrication costs occur when multi-depth (layers 1-2-3) interconnections are designed into the circuit board.



Sequential Build Up Blind Via Technology

Laser drilled blind vias can be economically produced for multi-depth interconnections. As with all technologies there are limitations and laser drilled blind via technology is no exception. There are several technology balances that have to be taken into consideration:

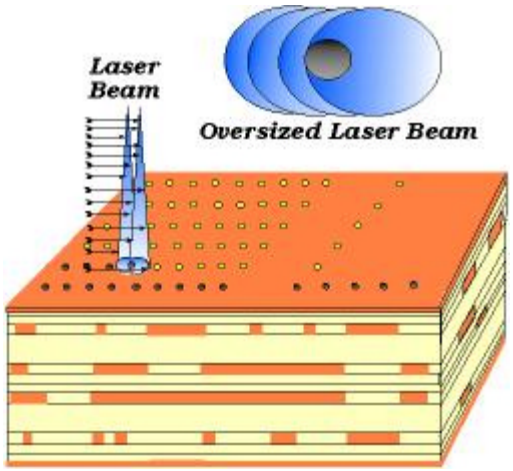
1. Ability to electroless (or direct plate) and electroplate small diameter blind vias
2. Ability to rapidly laser drill multi-depth blind vias:
   a. Define material lay up with laser drillable materials
   b. Define maximum laser energy so as not to damage either the copper mask or receiving pad
   c. Define "volume" of dielectric material the maximum laser energy will remove in a single pulse

One of the keys to cost-effective laser drilling is picking a dielectric material that will allow the laser beam to rapidly remove the dielectric material. While a tremendous effort has been given to develop laser drilling processes for FR4[3], the energy needed to remove the glass bundles while not damaging the epoxy polymer, has not succeeded as a production process from the stand point of drilling a satisfactory number of vias per second. The FR4 process is even slower for multiple depth blind via interconnections.

Several LaserVia™ approved dielectric materials are available:

- Thermount® - DuPont Fibers
- RCC™ - AlliedSignal Laminate Systems
- FoldMax™ - Mitsubishi Gas Corporation
- Polyimide (flex materials)
- PTFE (various Teflon® materials)

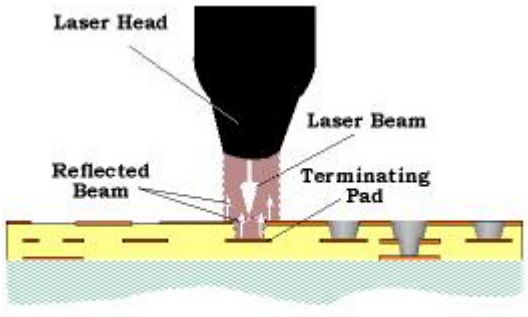
Another of the keys to successful laser drilling in rapid mode is to enlarge the beam in such a fashion so that the energy is broadly distributed across the enlarged laser beam. The beam is then effective as it travels at a rapid rate across the etched window. The laser is pulsed as one edge of the beam hits the window opening and shuts off after enough energy has entered the window to vaporize the dielectric material. With this process a Radio Frequency (RF) controlled Carbon Dioxide (CO_2) laser is required with sufficient wattage to allow the process to work. The beam is controlled in such a fashion[4] as to not damage the copper mask or terminating pad, but readily removes the dielectric material.



As laser drilling and fabrication processes mature (etching, plating etc.), narrow deep blind via interconnects will emerge to levels as deep as four layers down.

The Fabrication Process

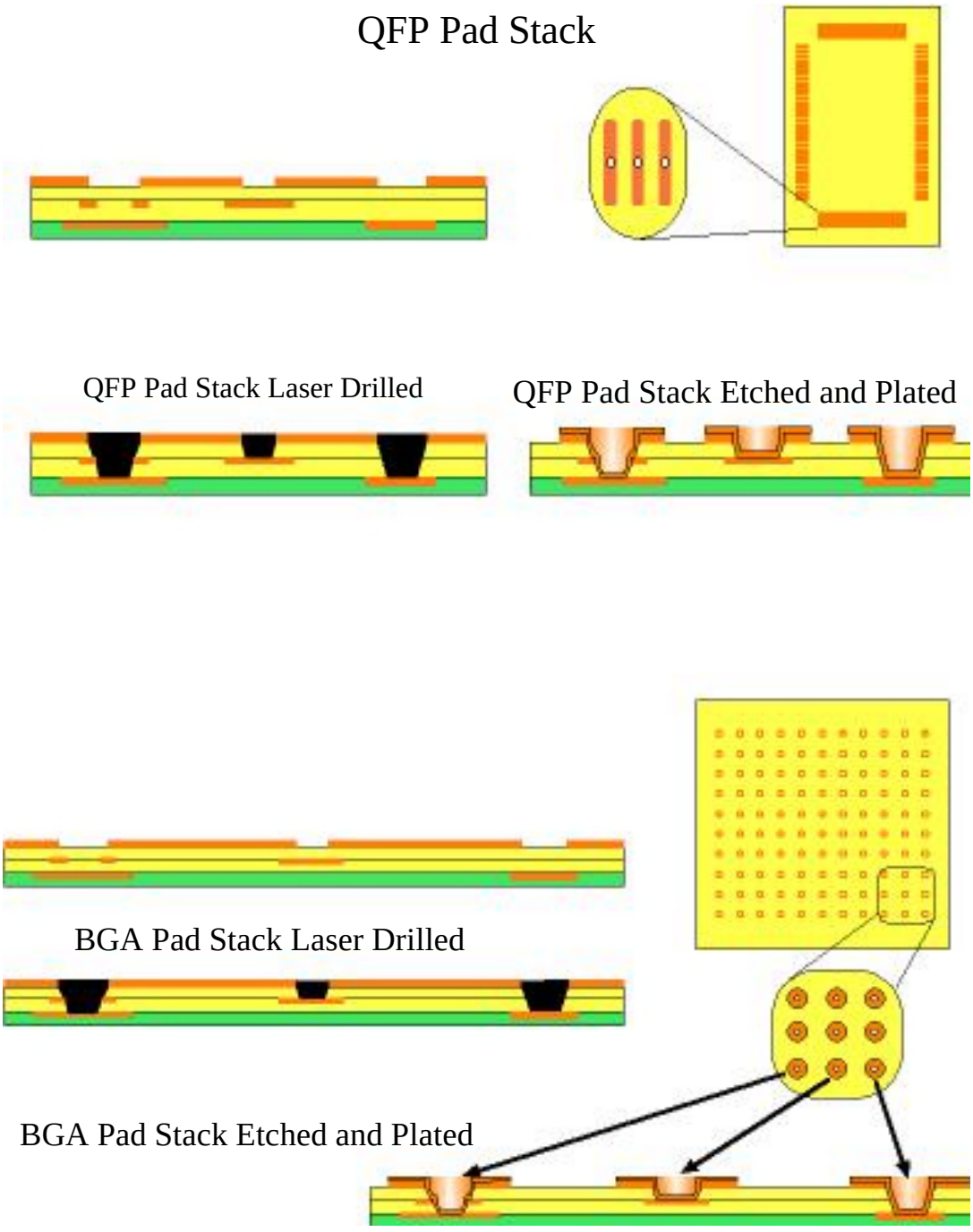
Very little is needed to introduce laser drilled blind vias into the typical multilayer fabrication process. It is necessary to have a thorough understanding of the entire multilayer process and the concept behind laser drilling before attempting to introduce laser drilled blind vias. The process technology we are discussing in this paper[5], called LaserVia™ Technology uses the outer layer of copper as a mask to reflect the laser energy plus the copper on the inner layers as terminating pads to also reflect the laser energy.



Drill-On-the-Fly LaserVia™ Technology

Design Rules:

The first step, like in all circuit board fabrication, is to bring the CAD design into CAM tooling. The CAD design will have to have a pad stackup that defines the "windows" or etched openings necessary to allow the laser to remove the dielectric material. The following drawings show the design rules for a QFP and BGA through final plating and etching:

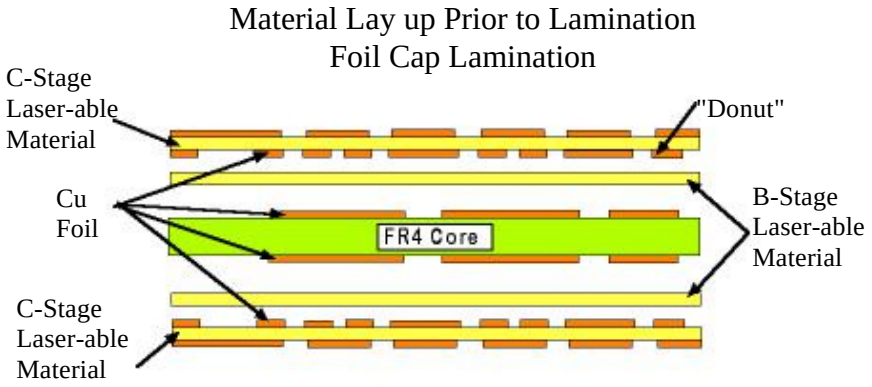


Most circuit board wet processing lines can plate a 1:1 ratio (diameter to depth) blind via. Since gas entrapment can inhibit blind via plating in the electroless line, a "bump or thump" of the agitation racking system can readily jar gas entrapped bubbles from the blind vias assuring continuous plating.

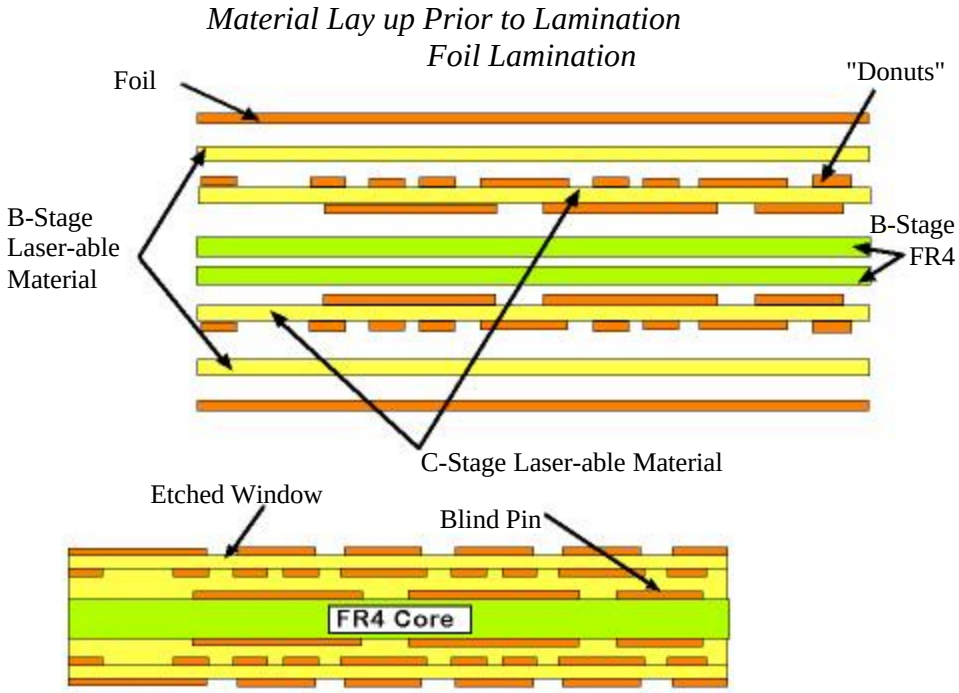
Material Layup:

Two lamination methods can be used to produce the multi-depth laser drilled blind vias:

1. Foil lamination: prepreg is used as the dielectric for the outer layer with copper foil. Donuts are etched in the layer two of the thin core material.



2. Foil Cap Lamination: a thin core is used for the outer layer with a laser-able prepreg between circuit layers two and three.

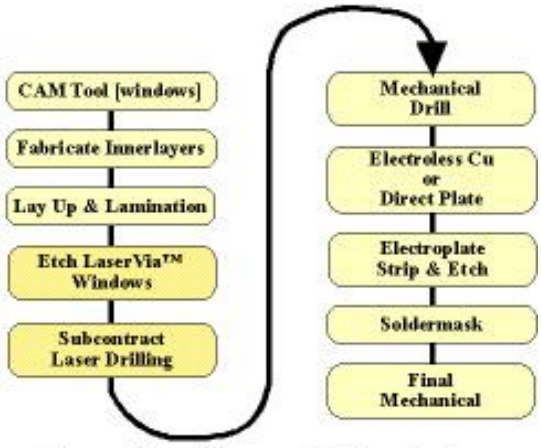


After Lamination ~ Prior to Lasing

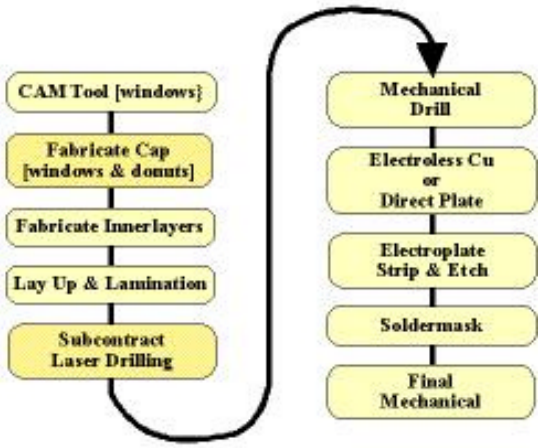
The preferred lamination process for multi-depth laser drilled blind vias fabrication is Foil Cap Lamination since the alignment of the outer windows and layer two donuts are imaged and etched at the same time. Using a typical inner layer registration technique for etching the outer windows and inner layer donuts relieves the problems that characteristically occur with material movement and “blind” registration to the layer two donuts.

Process Flow:

The two diagrams below depict typical laser blind via process flows, showing that laser drilling can be easily sequence subcontracted to a qualified laser drill source:



Process Flow Diagram - Foil Lamination



Process Flow Diagram - Foil Cap Lamination

Either foil lamination or foil cap lamination techniques can be used to produce multidepth blind vias. The choice is up to the fabrication process engineer and should be based on economics and the capability of the fabrication process. Inner layer registration of the blind pins or laser terminating pads is the most difficult and critical of the process steps.

Conclusion

Very little modification is necessary to introduce multi-depth laser drilled blind vias into Any multilayer fabricator. The process however must accommodate a circuit board designed to meet the process limitations of the fabricator. These process limitations are:

- Blind via electroless (direct plate) and electroplate diameter vs. depth capability
- Innerlayer registration capabilities or better stated: material movement compensation standards

These process limitations can readily be determined by designing a test coupon with multiple diameter blind via openings along with a reasonable dielectric depth.

Biography of Larry W. Burgess

Larry Burgess has over 30 years experience in the interconnect packaging disciplines. He received a Bachelor's Degree in Chemistry from Lewis and Clark College. He managed the circuit board development laboratories at Tektronix prior to founding a start up called Interconnect Technology Inc., which introduced design, fabrication and surface mount assembly as a complete turnkey PCB facility in 1986. Interconnect Technology also introduced a laser drilled blind via technology as one of the first to place blind vias within surface mount pads. In 1995 Sandia National Laboratories purchased a LaserVia™ Technology R&D License from MicroPak Laboratories where he is Chief Technology Officer. He has consulted to several fortune 500 electronic manufactures and circuit board fabricators. Currently Mr. Burgess is rasing funds to open the first of several, sequence subcontract, circuit board laser drilling centers in the United States. Mr. Burgess has given multiple papers at Nepcon, IEPS, IPC and ISHM and written and contributed to multiple published articles. He is a member of IPC, IEPS, ISHM, SAMPE, SMTA and IEEE.

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4. U.S. Patent Pending; Burgess
5. U.S. Patent 4,642,160; 2/1987, Burgess