

USING LASER TO MARK PRINTED CIRCUIT BOARDS (PCBs)

FIELD OF THE INVENTION

This invention is a method or process to mark data on PCBs with writing lasers without harming the PCBs.

BACKGROUND OF THE INVENTION

PCB manufacturers worldwide have been marking data on their PCBs by using ink or sticker labels. Both methods are, however, not reliable. For ink marking, the ink can be contaminated or its viscosity changes resulting in the markings being smeared or broken. There is the further risk of the ink marking being erased through the downstream production processes which the PCB undergoes. As for the sticker method, this is a labour-intensive process and the stickers may be tampered with or removed. It is also costly as the material used for the labels must be resistant to high temperatures. As the labels must be pre-printed, the PCB manufacturer faces the difficulty of including realtime data on the PCB batches manufactured and further runs the risk of delay in the printing time and the further risk of wastage of unused labels.

Laser marking eliminates tampering. It is a fast and precise method and due to its permanent nature, the markings will not deteriorate even when the PCB is subjected to heat or liquid processes. Presently, the PCB industry does not use laser to mark PCBs because of the occurrence of delamination. Present technology uses Q-switched pulse YAG laser. PCB fibreglass material is partially translucent to YAG laser light of wavelength around 1.06 microns. As most PCBs are multi-layered with copper sheets between layers, YAG laser light will partially pass through the surface but is absorbed totally when it hits the inner copper layer causing a reaction between the laser light and the adhesive holding the PCB layers together. This results in gases being emitted which are trapped at the copper layer.

Delamination occurs when the PCB goes through curing processes downstream which heats the PCB to very high temperatures. As the PCB undergoes the heating process, the gases expand and causes the layers of the PCB to detach from each other. Bubbles can be seen underneath the top surface of the PCB. Under high temperatures, the gases try to escape and moves through the board to the edge where they are finally released. This movement of the gas causes the detachment of the top and lower layers of the PCB. With the bubbles of gas which are trapped inside, the board is initially weakened. When the edges of the board opens to release the gases, the PCB becomes damaged. Some PCB manufacturers have made attempts to use laser to mark PCBs, but have todote been unsuccessful due to the delamination problem.

OBJECT OF THE INVENTION

The primary object of the invention is to provide a solution to the delamination problem encountered with YAG laser which is both viable and cost-effective in the PCB manufacturing environment. The process is automatic and there is no need for operator intervention. The marking data is generated by a computer at the time of marking so that any change to the data to be marked on the PCB can be made instantaneously, thereby eliminating the problems encountered with the traditional methods. Laser marking is also permanent. There is no damage or deterioration even when the PCB is passed through heat or liquid processes. Unlike the ink and sticker method, it is tamper-resistant. Another feature is that the laser beam which uses a small spot size allows marking of dense barcodes at any angle and area of the PCB. The laser system requires minimal maintenance as there is no replacement of consumables

SUMMARY OF THE INVENTION

To resolve the delamination problem caused by using traditional YAG laser, the invention utilises a 5 kHz pulse CO₂ 25 watt laser with a beam delivery adapted by scanning mirrors and a flat field lens which produces a beam of a very small spot size of between 50 to 300 microns. The process is operated by computer software specially written for this purpose. The 5 kHz pulse CO₂ laser emits a beam of wavelength of 10.6 microns. At this wavelength, when the beam impacts the marking surface, the beam's energy is absorbed totally by the surface of the marked layer. Negligible laser energy passes to the lower layers of the PCB, unlike the YAG laser beam, which because of the shorter wavelength of about 1.06 microns will cause a substantial amount of the laser to pass through and damage the lower layers of the PCB. The YAG laser also requires higher power since not all of the energy of the laser beam is absorbed in the marking.

DESCRIPTION OF THE INVENTION AND THE DRAWINGS

The accompanying drawings illustrate how the invention works, and serve to explain the principles of the invention.

Figure 1 shows how the YAG laser marking operates. Although the marking is done on the top layer of the PCB, the laser beam, because of the short wavelength, passes through to the copper layer.

Figure 2 shows the improvement on the YAG laser marking by the invention of the CO₂ laser marking process. The CO₂ laser beam of a longer wavelength does not penetrate to the lower layers of the PCB.

The embodiment of the invention is understood by referring to Figures 2 and 3. The laser generator emits a beam of laser light with a wavelength in the range of 9 to 11 microns. The laser beam is expanded by 3 times and is directed to a set of 2 mirrors. These mirrors are moved by motors. The motors are controlled by a computer which causes the laser beam to move and draw lines on the PCB. From the mirrors the laser beam goes through a flat field lens to focus the beam to a very small spot in the range of 50 to 300 microns in diameter. Markings on the PCB are drawn using vector graphics. The high intensity of the beam at the focussed point on the PCB causes the paint or PCB surface to burn and vaporise causing a colour change which is noticeable to the naked eye as well as any vision camera system.

Figure 3 illustrates the configuration of the controls necessary for the process to work which are:

- (1) A 2-dimensional control of the laser beam by way of 2 scanning mirrors which are moved by motors controlled by a computer.
- (2) Pulse-type laser to achieve good control of power stability, power level and on-off timing.
- (3) A flat field lens to focus the laser beam to a very small spot.

Figures 4, 5 and 6 illustrate the 3 methods by which the markings become visible. These will be further described below.

Figures 7 and 8 are illustrations on how the process can be incorporated in a line set-up. Figure 7 is a front view and Figure 8 is a side view of a typical laser machine configuration which incorporates the following components:-

- (a) 25-watt CO₂ laser with galvanometer type scanning head, flat field object lens of field size 110mm square
- (b) XY table with independent controller
- (c) 2 barcode scanners
- (d) Motorised cleaning rotary brush
- (e) Dust collector with centrifugal type suction pump
- (f) Master controller computer
- (g) Conveyor for handling and clamping PCBs during process

By reference to Figures 7 and 8, the PCB is first loaded onto a conveyor and clamped. The XY table transports the conveyor to marking, brushing and scanning positions. Brushing is required for PCBs with thick legend layer which creates more soot and interferes with scanning check. Dust and smoke is sucked away by a dust collector. The scanners are for scanning verticle, horizontal and other angle barcodes. The computer controller is able to cater for markings at any position on the PCB with serial number generation as required. The program is DOS based and uses arrow keys to select different options. Marking software can be customised to user specifications, e.g. alphanumeric fonts, code 39, code 93 and data matrix.

For the invention to work, the level of controls necessary are:

- (1) 2-dimensional control of the laser beam which is achieved by 2 scanning mirrors driven by galvanometers and controlled by a computer.
- (2) Laser power, adjustable from 1 watt to 20 watts, as different types of materials require different marking power for optimum results.
- (3) Pulse-type laser to allow good control over power stability, power level and on-off timing. Pulse rate can vary from 3 to 20 kHz.
- (4) On-off timing delay of the laser beam should be controlled within 10 pulses depending on the spot size diameter of a single pulse as measured on the surface to be marked and the allowable distortion in the marked character formation.

Using the CO₂ laser, 3 methods of marking are possible:

- (1) A white or other coloured layer is painted onto the PCB. This is done during the PCB manufacturing using a silk-screen painting process which then undergoes high temperature curing. This makes the layer resistant to attacks by chemical or mechanical wear. Thickness of this coloured layer is important, and should be in the range of 150 to 200 microns. If the layer is too thin the lines in the barcode marked may be worn away by subsequent processes. If the layer is too thick, too much soot will be generated and thin lines are difficult to mark because of large kerf. This white legend is necessary for barcode marking because of the high contrast that barcode readers or verifiers require. The laser beam power is set to a value that will burn a trench in the coloured layer to a depth just before it reaches the next layer. The bottom of the trench will take on the PCB colour which is usually dark green. Thus the dark line in a white background will provide enough contrast for the barcode reader to read the barcode marked. The process is shown in Figure 4.
- (2) A low power laser beam is used to mark directly on the green resist layer of the PCB. This will cause a contrast between the lighter marked area to the dark green of the background resist layer. The process is shown in Figure 5.
- (3) When the laser is used to mark directly on the PCB fibreglass material, lighter lines are marked across the surface of the PCB material. This process is shown in Figure 6.

Methods (2) and (3) produce markings which are visible to the naked eye and vision systems. However, as the contrast is not so great, the markings are not adequate/suitable for reading or scanning by barcode readers or verifiers.

CLAIMS

What is claimed is:

1. A laser marking apparatus for laser marking on printed circuit boards, the apparatus comprising:

a CO₂ laser generator for generating a laser beam suitable for laser marking on the printed circuit boards;

a beam delivery disposed in the optical path of the laser beam from the CO₂ laser generator, said beam delivery delivering the laser beam onto the printed circuit boards; and

a processor for controlling the beam delivery, thereby causing the laser beam to move and draw lines on the printed circuit boards.

2. The laser marking apparatus of claim 1, wherein the laser beam from said CO₂ laser generator has a wavelength in the range of 9 to 11 microns.

3. The laser marking apparatus of claim 1, wherein the laser power of said CO₂ laser generator is from 1 to 50 watts.

4. The laser marking apparatus of claim 1, wherein the laser power of said CO₂ laser generator is from 1 to 25 watts.

5. The laser marking apparatus of claim 1, wherein the pulse rate of the laser beam varies from 1 to 50 kHz.

6. The laser marking apparatus of claim 1, wherein the pulse rate of the laser beam varies from 3 to 20 kHz.

7. The laser marking apparatus of claim 1, wherein the beam delivery comprises an expander for expanding the laser beam from said CO₂ laser generator, two mirrors in the optical path of the laser beam for changing the delivery directions of the expanded laser beam, and a flat field lens in the optical path for focusing the laser beam onto the printed circuit boards.
8. The laser marking apparatus of claim 7, wherein the two mirrors are operated by motors, wherein the motors are controlled by said processor.
9. The laser marking apparatus of claim 8, wherein the motors are galvanometers.
10. The laser marking apparatus of claim 7, wherein the flat field lens focuses the laser beam to a spot in the range of 50 to 300 microns in diameter.
11. The laser marking apparatus of claim 1, wherein the processor is a computer containing marking software for operating the laser marking apparatus.
12. The laser marking apparatus of claim 1, further comprising a conveyor for handling the printed circuit boards during a laser marking process.
13. The laser marking apparatus of claim 1, further comprising an XY table for transporting said conveyor to predetermined positions, wherein the XY table is operated by an independent controller.

14. The laser marking apparatus of claim 1, further comprising a dust collector for collecting the wastage from the laser marking on the printed circuit board, wherein the dust collector has a centrifugal type suction pump.

15. The laser marking apparatus of claim 1, further comprising a motorised cleaning rotary brush for brushing off the dust from the laser marking on the printed circuit boards.

16. The laser marking apparatus of claim 1, wherein the printed circuit boards comprises a metallic layer and a top layer that is translucent to a YAG laser, thereby the laser marking is done on the top layer.

17. The laser marking apparatus of claim 1, wherein the printed circuit boards comprises a copper layer and a fibreglass layer, thereby the laser marking is done on the fibreglass layer.

18. The laser marking apparatus of claim 1, wherein the printed circuit boards comprises a copper layer, a fibreglass layer and a green resist layer, thereby the laser marking is done on the green resist layer.

19. The laser marking apparatus of claim 1, wherein the printed circuit boards comprises a copper layer, a fibreglass layer, a green resist layer and a paint layer, thereby the laser marking is done on the paint layer.

20. A method of laser marking printed circuit boards by utilizing the laser beam from a CO₂ laser generator, comprising:

using a processor to select marking specifications for marking the printed circuit boards; and

marking the printed circuit boards by using a beam delivery, thereby the laser beams are delivered and focused onto the printed circuit boards.

21. The laser marking method of claim 20, further comprising:

loading the printed circuit boards onto a conveyor for handling the printed circuit boards during the laser marking, thereby the printed circuit boards being transported to predetermined positions.

22. The laser marking method of claim 20, wherein the processor is a computer containing marking software for operating the laser marking apparatus.

23. The laser marking method of claim 20, wherein the beam delivery comprises an expander for expanding the laser beam from said CO₂ laser generator, two mirrors in the optical path of the laser beam for changing the delivery directions of the expanded laser beam, and a flat field lens in the optical path for focusing the laser beam onto the printed circuit boards.

24. The laser marking method of claim 23, wherein the mirrors are operated by motors, wherein the motors are controlled by said processor.

25. The laser marking method of claim 24, wherein the motors are galvanometers.

26. The laser marking method of claim 23, wherein the flat field lens focuses the laser beam to a spot in the range of 50 to 300 microns in diameter.

27. The laser marking method of claim 20, wherein the printed circuit boards comprises a metallic layer and a top layer that is translucent to a YAG laser, thereby the laser marking is done on the top layer.

28. The laser marking method of claim 20, wherein the printed circuit boards comprises a copper layer and a fibreglass layer, thereby the laser marking is done on the fibreglass layer.

29. The laser marking method of claim 20, wherein the printed circuit boards comprises a copper layer, a fibreglass layer and a green resist layer, thereby the laser marking is done on the green resist layer.

30. The laser marking method of claim 20, wherein the printed circuit boards comprises a copper layer, a fibreglass layer, a green resist layer and a paint layer, thereby the laser marking is done on the paint layer.

31. A method of laser marking printed circuit boards by utilizing the laser marking apparatus of claim 1, comprising:

using the processor to select the marking specifications for marking the printed circuit boards; and

marking the printed circuit boards by operating said beam delivery, thereby the laser beams are delivered and focused onto the printed circuit boards.

32. The laser marking method of claim 31, wherein the laser beam from said CO₂ laser generator has a wavelength in the range of 9 to 11 microns.

33. The laser marking method of claim 31, wherein the laser power of said CO₂ laser generator is from 1 to 50 watts.

34. The laser marking method of claim 31, wherein the laser power of said CO₂ laser generator is from 1 to 25 watts.

35. The laser marking method of claim 31, wherein the pulse rate of the laser beam varies from 1 to 50 kHz.

36. The laser marking method of claim 31, wherein the pulse rate of the laser beam varies from 3 to 20 kHz.

37. The laser marking method of claim 31, further comprising:

loading the printed circuit boards onto a conveyor for handling the printed circuit boards during the laser marking, thereby the printed circuit boards being transported to predetermined positions.

38. The laser marking method of claim 31, wherein the processor is a computer containing marking software for operating the laser marking apparatus.

39. The laser marking method of claim 31, wherein the beam delivery comprises an expander for expanding the laser beam from said CO₂ laser generator, two mirrors in the optical path of the laser beam for changing the delivery directions of the expanded laser beam, and a flat field lens in the optical path for focusing the laser beam onto the printed circuit boards.

40. The laser marking method of claim 39, wherein the mirrors are operated by motors, wherein the motors are controlled by said processor.

41. The laser marking method of claim 40, wherein the motors are galvanometers.

42. The laser marking method of claim 39, wherein the flat field lens focuses the laser beam to a spot in the range of 50 to 300 microns in diameter.

43. The laser marking method of claim 31, wherein the printed circuit boards comprises a metallic layer and a top layer that is translucent to a YAG laser, thereby the laser marking is done on the top layer.

44. The laser marking method of claim 31, wherein the printed circuit boards comprises a copper layer and a fibreglass layer, thereby the laser marking is done on the fibreglass layer.

45. The laser marking method of claim 31, wherein the printed circuit boards comprises a copper layer, a fibreglass layer and a green resist layer, thereby the laser marking is done on the green resist layer.

46. The laser marking method of claim 31, wherein the printed circuit boards comprises a copper layer, a fibreglass layer, a green resist layer and a paint layer, thereby the laser marking is done on the paint layer.

47. A printed circuit board being marked by the laser marking method of claim 20.

48. The laser marking apparatus of claim 47, wherein the printed circuit boards comprises a metallic layer and a top layer that is translucent to a YAG laser, thereby the laser marking is done on the top layer.

49. The laser marked printed circuit boards of claim 47, wherein the printed circuit boards comprises a copper layer and a fibreglass layer, thereby the laser marking is done on the fibreglass layer.

50. The laser marked printed circuit boards of claim 47, wherein the printed circuit boards comprises a copper layer, a fibreglass layer and a green resist layer, thereby the laser marking is done on the green resist layer.

51. The laser marked printed circuit boards of claim 47, wherein the printed circuit boards comprises a copper layer, a fibreglass layer, a green resist layer and a paint layer, thereby the laser marking is done on the paint layer.

52. A printed circuit board being marked by the laser marking method of claim 31.

53. The laser marking apparatus of claim 52, wherein the printed circuit boards comprises a metallic layer and a top layer that is translucent to a YAG laser, thereby the laser marking is done on the top layer.

54. The laser marked printed circuit boards of claim 52, wherein the printed circuit boards comprises a copper layer and a fibreglass layer, thereby the laser marking is done on the fibreglass layer.

55. The laser marked printed circuit boards of claim 52, wherein the printed circuit boards comprises a copper layer, a fibreglass layer and a green resist layer, thereby the laser marking is done on the green resist layer.

56. The laser marked printed circuit boards of claim 52, wherein the printed circuit boards comprises a copper layer, a fibreglass layer, a green resist layer and a paint layer, thereby the laser marking is done on the paint layer.

A B S T R A C T

The process of using CO₂ laser to mark alphanumeric fonts, barcodes and data matrix on PCBs is a fast and precise method to attach information on PCBs without causing delamination to the boards. (Figure 1). By using a 5 kHz pulse CO₂ 25 watt laser with a beam delivery of a very small spot size created by scanning mirrors and a flat field lens and controlled by a computer (Figure 3), the laser markings on the PCB are confined to the surface to be marked without causing damage to the boards (Figures 4, 5 and 6). The small spot size allows marking of dense barcodes at any angle and area. The data for marking is generated by a computer at the instance of marking. The entire operation is automatic. The markings are permanent and tamper-proof.

FIG. 2