Opening of Via-holes in Flexible Electronics by a UV-Laser

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ABSTRACT: Progress in laser technology over the years and its flexibility of use promise a wide range of methods for the fabrication of organic and large area electronics (OLAE). Several examples of laser-machining in the reel-to-reel process are discussed, such as dicing of devices, drilling of via holes and opening of contacts. In this paper we will focus on laser drilling of via holes applied directly on flexible substrates for a two layer interconnect metallization. The substrates consist of a 50 µm thick and 200 mm wide web of Polyimide (PI) or Polyethylenterephtalate (PET). The challenge is to stop the laser on a metallization of a few micrometer thickness. The second metallization layer is deposited afterwards by screen printing or sputtering. An ultra-violet solid state laser with five axes in a reel-to-reel environment is used.

1. Introduction: For the goal of realizing a large volume production of organic and large area electronics, the feasibility of each production step in a reel-to-reel environment must be shown. The IZM-Munich has established a Roll-to-Roll application centre with a web width of 210 mm.

2. Laser process: We used a diode pumped solid state Nd:YVO Laser. The ultraviolet wavelength is 355 nm. Pulse length is about 20 ns with an average power of 5 W. The laser beam moves by a scanner according to vector graphic design. Superimposed the laser head is driven in X-Y direction, while the web is forwarded in steps of 200 mm.

Figure 1: R2R-laser. The substrate is fed in steps from the left.

3. Opening of contacts: In organic electronics on flexible substrates the laser must open via holes through thin layers of insulator and semiconductor by ablation. The laser has to stop on the thin copper (0,5 µm) without heating or damaging the PET-substrate.

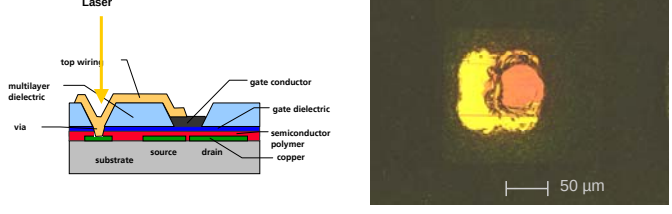


Figure 2 and 3: Schematic cross section and top view of a 50 µm diameter via with stop on 0,5 µm copper.

4. Interconnection holes through flexible substrate: For a two layer interconnect metallization the laser must open a blind via in 50 µm thick polyimide without affecting the free standing copper layer (5 µm) on the bottom side. With optimized power density of the laser beam the surface of copper remains smooth and the wall of the via has a slope of 60°, which is favorable for sputtering the next metallization layer. The removement of the redeposited vapor is done by a plasma cleaning with a combination of O_2 and CF_4.
The alignment accuracy of the laser via relative to the copper wiring is +/- 30 µm over the full area of 20 cm. It is limited by thermal shrink of the polymer substrate.

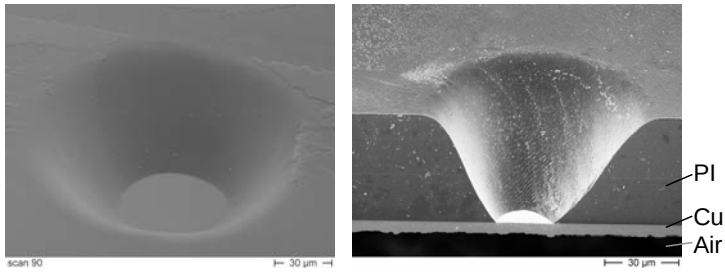
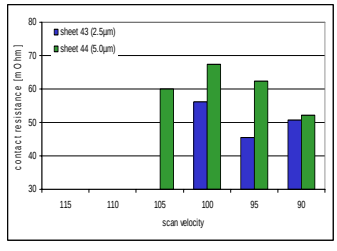


Figure 4 and 5: SEM pictures of blind vias in flexible substrate after plasma cleaning. Left: top view, right: cross section with ultra-microtome.

5. Electrical Measurements: The resistance between bottom and top metallization was measured with a 4 wire setup. It varies between 50 to 70 mOhm, depending on cleaning procedure and scanning velocity of the laser.



SUMMARY: The qualification of via opening by an ultraviolet laser process in Reel-to-Reel process environment is shown. Using proper laser parameters it is possible to ablate thick dielectrics and stop on thin copper metallization. After plasma cleaning the electrical resistance is below 0,07 Ohm.

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