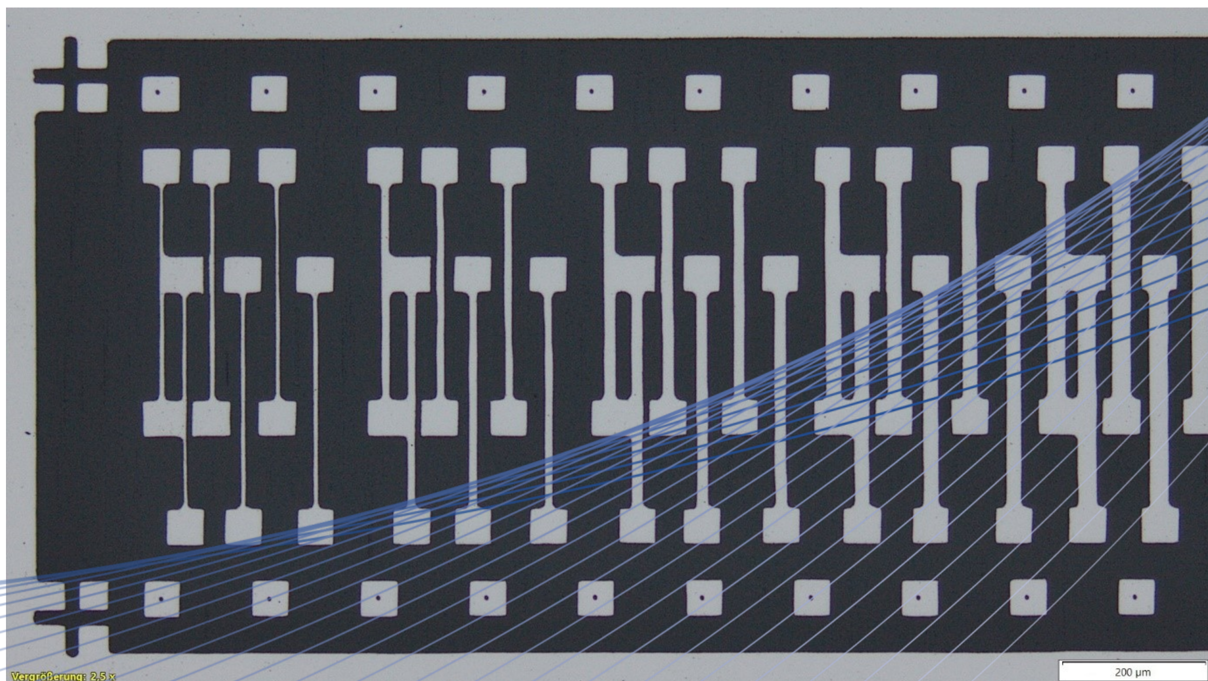
Tiny Structures on a Submicron Layer

LPKF ProtoLaser R4: down to 5µm/10 µm track/space capabilities demonstrated



LPKF
Laser & Electronics

Tiny Structures on a Submicron Layer

The power of laser light has many applications; from cutting thick steel plates for industrial applications to use by eye surgeons in medicine. These two examples have little in common besides a coherent light source. When we drastically narrow the field of application to laser etching of a conductive layer on an insulating substrate for electronics applications, some would like to process 70 µm thick copper, while others may need to work on sub-micron thickness.

The LPKF ProtoLaser R4, with a picosecond green laser source, is intended to process thin layers on delicate substrates. While it may not be as efficient as some more dedicated ProtoLaser models, it can also handle 35 µm (1 oz.) Cu on FR4. Its real strength, however, is a cold ablation regime – processing without (visible) heat effect, which could be crucial for processing thin layers.

Picosecond lasers bring two crucial advantages: thanks to the non-linear effect, laser light is absorbed in (otherwise) optically transparent materials for a particular wavelength, and due to the short pulse, the targeted material is removed before the heat can spread to the surrounding material. Combining the frequency of pulses with processing speed defines cold ablation or heat-affected processing of the target material.

Contemporary LPKF ProtoLasers are scanner-based, which means that in a limited area, the laser beam can be deflected very fast with the help of the mirrors. Depending on pulse repetition rate versus speed, pulses can be overleaped or barely touching. A certain amount of material will be removed based on laser pulse and material-specific damage threshold energy. Finding just enough power to generate just a thin isolation line without damaging the underlying substrate with high absorption could be a challenge.

In the Neuroelectronics group at the Technical University of Munich (TUM), one research focus is the development of µ-electrode-based biosensors with novel materials and fabrication methods. Therefore short-pulsed laser microfabrication is a promising method. For the laser producibility test, TUM provides two materials: 100 nm gold deposit on 70 µm polyimide foil and 100 nm platinum on 1 mm glass substrate and a recommended test sample pattern. Additionally, there are marks on isolated pads for demonstrating positioning accuracy.

The test sample layout

The test sample of an overall dimension of 1.9 x 0.85 mm, consists of four markers in the corners, each of them has four squares 40 x 40 µm with 20 µm gaps between them. All other square pads are 50 x 50 µm. Isolated pads are for drilling tests. The rest are connected in pairs with different thicknesses of lines and gaps between them. There are five groups, each consisting of 6 such pairs.

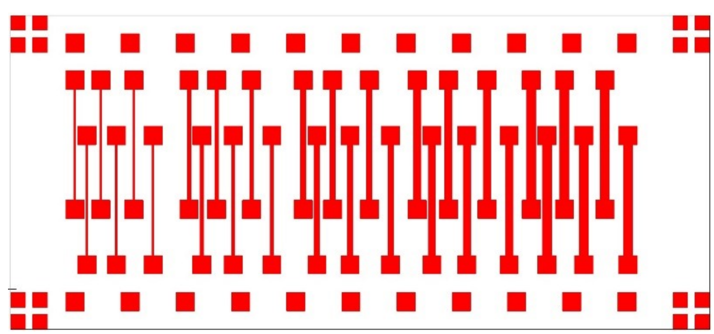


Figure 1: Test sample, design property of the Neuroelectronics group (TUM

Looking from left to right, track thickness if the first group is 5 µm, 10 µm in the second, and increasing for 5 µm until the last, which is 25 µm. Within these groups, the gap between tracks and neighbor pad grows from 5 to 10, …, 25 µm. Such an easy, thus carefully selected sample is supposed to display the minimum track width substrates can withstand during laser processing, with minimum gaps possible and repositioning capability.

The Sample Processing – 100 nm Au on 70 µm polyimide

A very thin layer of gold is sensitive to ablating energy from the laser. Using extremely low power and high frequency, a 13 µm wide channel was achieved. Laser tool path calculations were set to 15 µm spot size; therefore, insulation channels like 5 and 10 microns were not calculated (Figure 2). Beam offset to the tracks corresponds to the 15 µm tool. Consequently, minimum track widths were 8 µm, and minimum gaps on the sample were 13 µm wide (Figure 3). Penetration to the base substrate was 12 - 13 µm, as polyimide has excellent absorption for picosecond pulses of green laser light.

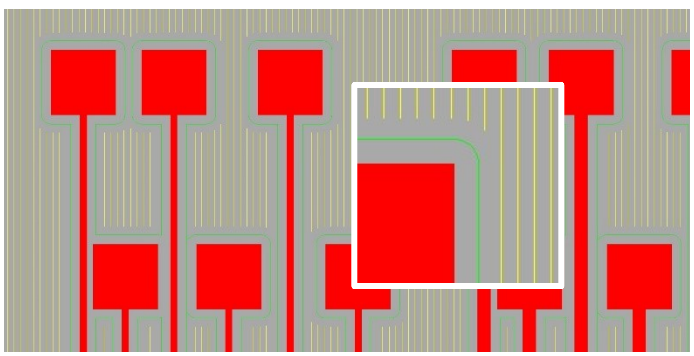


Figure 2: Laser tool paths, green - contour line around track and pads, yellow – removing larger areas between. Green is passing only when the gap is 15 µm or more.

Reducing beam diameter to 13 µm within tool settings in CircuitPro could narrow the minimum track width, but such a sample was not performed. Dots on the insulated pads are part of the positioning test.

The sample structuring time was 43 seconds.

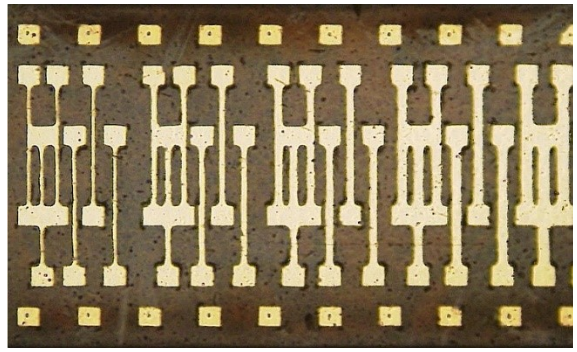


Figure 3: Au on polyimide sample with minimum tracks from 8µm and minimum gaps of 13 µm

100 µm Pt on 1 mm glass – results:

One of the advantages of a picosecond laser source is the processing of transparent glass. Short pulses with very high energy trigger a nonlinear effect - generating higher harmonics (higher frequencies, shorter wavelengths) necessary for processing glass. While using laser parameters below damage threshold energy, the laser light will pass through glass with its basic wavelength without any significant absorption.

Processing this sample, 100 µm platinum on 1 mm glass, works on these base physics principles and is supported by the flexibility of the LPKF picosecond laser source coupled with the virtually unlimited possibilities of LPKF CircuitPro PL software as a part of the LPKF ProtoLaser R4 system.

Running preliminary test lines with various parameters led to a 9 µm wide gap in the material. Consequently, setting this new beam diameter in CircuitPro PL software, additional isolation lines were generated, as seen in figure 4.

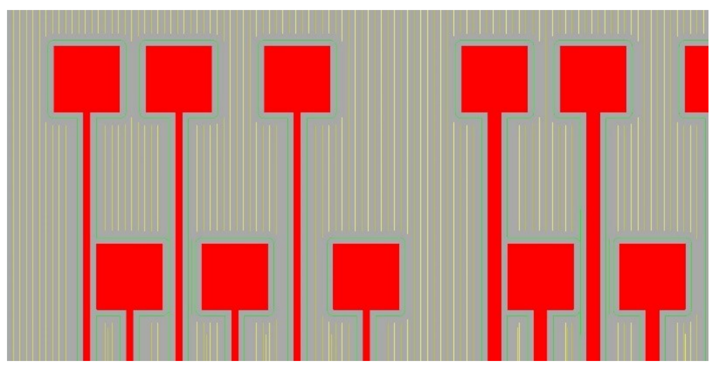


Figure 4: Laser tool paths, green lines are also calculated between pads and tracks 10 µm apart

The processed sample in Figure 5 demonstrates tiny structures of tracks with a minimum width of 5 µm and gaps of 10 µm. Dots on insulated pads are marks for the positioning repeatability test. The sample processing time was 43 seconds. A separate process of marking dots required 4 s.

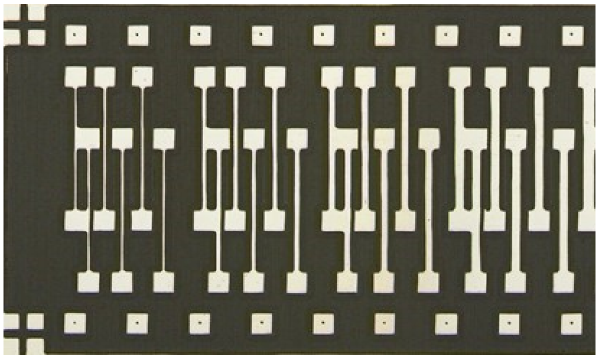


Figure 5: Pt on glass sample with minimum tracks from 5µm and minimum gaps of 9 µm

Conclusion

LPKF ProtoLaser R4 is suitable for processing sub-micron layers with great precision down to 5 µm/10 µm trace/space width with minimal to no damage to the substrate underneath. The process depends on the threshold energy of processed materials and can vary as described in the test. The flexibility of LPKF CircuitPro PL software enables operators to define a new laser tool based on preliminary test lines and recompute the complete process related to this new, user-defined tool.

LPKF ProtoLaser R4: Ultra-Short Laser Pulses for Research and Development

New materials are basic for many promising innovations, but sophisticated and flexible tools are required. LPKF ProtoLaser R4 stands for micro material processing with the lowest possible heat input for thermally sensitive materials.

Picosecond short laser pulses process the materials "cold". This allows the structuring of standard materials like FR4, of sensitive RF-substrates or flex, as well as the cutting of hardened or fired technical substrates, like AL_2O_3, GaN, or borosilicate glass. The precision laser system thus opens up new possibilities for micro-processing in laboratory experiments with entirely new materials.

The ProtoLaser R4 is a ready-to-use laboratory system in laser class 1. The laser system comes with an integrated camera and the easy-to-use LPKF CircuitPro software with a broad range of predefined parameters.

You concentrate on your solution, and the ProtoLaser R4 makes your ideas work.

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