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Laser Beam Positioning for Semiconductor Device Processing

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Direct laser structuring of materials in semiconductor device fabrication can supplement the conventional techniques of dry and wet etching of lithographically formed patterns. An advantage over the established etching techniques is that chemically inert and extremely hard materials such as silicon carbide and sapphire can be structurized by laser ablation. For such cases laser treatment is a very promising alternative to create structures within a reasonable time. An important precondiction for using laser microstructurization in device processing is the ability to precisely position the laser beam with respect to existing structures on a wafer. Moving the wafer under a rapidly pulsed, focused laser beam we obtain a beam positioning accuracy of less than one micrometer.

The commercially available laser workstation *ILS 500 Air* is placed in a clean-room environment of an industrial-like process line for electronic devices based on III/V-semiconductors. The complete beam path of the industrial laser processing tool is founded on an ultra-stable rigid granite structure. The Class 1 laser-safe micromachining tool is equipped with a frequency-tripled Nd:YAG laser (AVIA 355-4500, Coherent) providing pulse repetition rates from single shot to 100 kHz and a pulse duration of < 25 ns to 60 kHz. The open-frame wafer chuck is mounted on a high-precise XY motion stage that allowes handling of up to 6” wafers. The highly precise air bearing XY stage is CNC controlled and driven by linear motors. It allowes a maximum travel speed of 500 mm/sec. Four CCD camera systems in connection with a powerful image processing and vision system (Mike & Weingartner GmbH) provide high resolution automated workpiece alignment capability. Two of the CCD cameras are placed underneath the wafer chuck for automated front-to-back side alignment. A wafer can be aligned also in cases when the wafer’s front side having the alignment marks is flipped down for laser processing of the wafer’s back side, i.e. no alignment marks on the back side need to be processed.

The complete process flow is developed from wafer layout to the laser beam positioning and wafer processing. Typical layout data of devices or wafers can be used as starting point for laser structuring. Different CAD data formats (GSDII, DXF etc.) can be imported into the CAD program package GRAFFY© (Durst CAD/Consulting GmbH) and prepared for laser processing. The GRAFFY© software generates CNC output data that can directly be fed into the CNC control for execution.

To verify the positioning accuracy of the laser beam target wafers were lithographically structurized with gold patterns. The aiming points at the target are marked by gold spots of different geometries. These gold spots are surrounded by concentric rings or lines forming grids with known mesh widths. The distance between the lines having a width of 2 µm was 10 µm and 20 µm, respectively, allowing a quick estimate of the laser spot deviation from the aiming point with the help of a plain optical microscope without a measurement ocular. Alignment marks for wafer pre-alignment and fine alignment were placed on the test wafers. The aiming points were hit with a precision of less than one micrometer (see Fig. 1) which is sufficient for microstructuring with beam diameters of 10-20 µm.

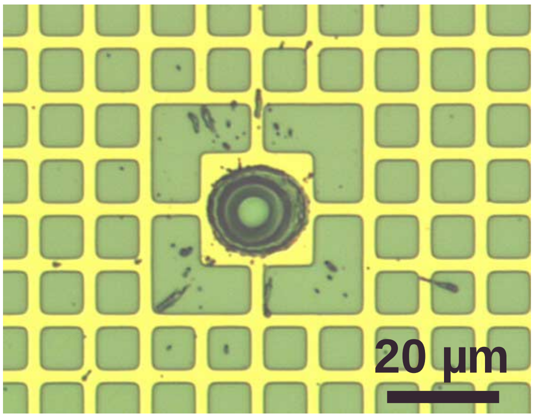

Fig. 1: Target structure (gold on silicon) hit by a single UV laser shot. The quadratic aiming point has a side length of 20 µm. The deviation center-to-center is X-0.6 µm and Y-0.2 µm.

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