Fraunhofer Institut Werkstoff- und Strahltechnik

LAMBDA PHYSIK

Micro cutting and drilling with ultra-violet laser light

Task

To generate microstructures, the various branches of technology and medical technologies require the preparation of the tiniest cuts and bores in materials made of a variety of metals, ceramic disks, or silicon wafers. Application examples are the drilling of injection nozzles for combustion engines, the cutting of stents for the medical treatment of arteriosclerosis, the drilling of nozzle plates for printers, or the manufacturing of beam splitters for X-rays.

The state-of-the-art in micro cutting is the application of q-switched Nd:YAG lasers in basic wavelength or frequency-doubled modes. Reducing the thermal load on the substrates requires the use of very short laser pulses in the order of only 15 ns. However, melting and melt segregation cannot be completely avoided.

A reduction of these effects can be achieved by applying lasers in the UV wavelength range. The ablation plasma tends to less absorb shorter wavelengths. This reduces the plasma temperature and subsequently the thermal load onto the cutting groove edges or the bore sidewalls resulting in a higher quality of the microstructures.
An implied advantage is the fact that laser beams of shorter UV wavelength can be much better focused resulting in smaller cutting groove widths. This allows the manufacturing of much more filigree structures.

Fig. 1: Part of a silicon wafer with laser cut structures

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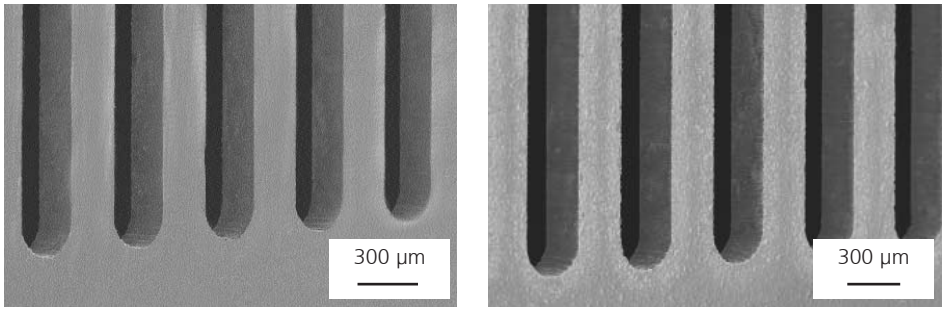

Fig. 2: a) Structures in silicon wafers, cut with the diode-pumped solid-state laser "GATOR UV". front side, b) back side

Solution

The Lambda Physics AG and the Fraunhofer IWS jointly developed the prototype of a UV wavelength micro-structuring machine for cutting and drilling of various parts and components.

The heart of the machine is a q-switched and diode-pumped solid-state laser with frequency tripling. The unit is a stable and low-maintenance industrial laser of the type "GATOR UV" with the following beam parameters:

- Wavelength	355 nm
- Repetition frequency	10 kHz
- Pulse length	15 ns
- Average power	3 W
- Beam quality	close to TEM_{00}

The machine is equipped with a UV scanner and plane field optics with a working area of 100 · 100 mm^2. The laser beam is switched by galvanic shutters instead of turning the laser power on and off. Subsequently, the laser is working continuously in thermal equilibrium conditions, ensuring highest beam quality. The small, compact design of diode-pumped solid-state lasers allows the design of a tabletop unit.

Results

With the above-described unit, laser-cutting tasks on silicon wafers have been performed.

The high beam quality makes it possible to generate cutting groove widths of 16 µm at a wafer thickness of 220 µm. The cutting process can be described as sublimation cutting because cutting of silicon does not generate much melt. Accretions of silicon oxide can be easily removed in an ultrasonic bath. The figures 1, 2a and 2b show structures that have been cut out of silicon.

Fig. 3: Diode-pumped, frequency-tripled Nd:YAG-laser "GATOR-UV"

We offer

- Micro cutting and micro drilling of customer specific parts and components
- Micro processing of the following basic material groups:
  - Silicon
  - Metals
  - Ceramics
- Technology development
- Feasibility studies