Cleanroom Compatible Micro-structuring of Silicon using Ultrashort Pulsed Laser Systems

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The increasing demand of the watch industry to manufacture small high precision parts in Silicon leads to new manufacturing strategies. This report describes the development of such strategies using UV, green and IR ultrashort pulsed laser systems in combination with a cleanroom surface post treatment to improve cut and surface quality. All related work was done in the framework of the CTI project PICOFAB.

With ultrashort pulsed laser (USP) it is possible to machine hard and brittle materials with high Young's modulus, small specific weight and high wear resistance, like Silicon or ceramics, efficiently and with high precision.

In recent years major advancements have been made in the development of laser processes with high quality cutting edges and surfaces. Here we examined cutting of Silicon chips with three laser systems using different beam sources (UV, Green, IR). The UV (located at CSEM) and Green (project partner TRUMPF) laser systems use Galvo scanners for beam deflection, whereas the IR (project partner BFH) system is equipped with a trepanning optic. Laser cutting is followed by a cleanroom iterative etching and thermal oxidation procedure to remove residuals and to reduce the surface roughness. Table 1 lists laser system parameters and compares the sample quality parameters before and after post processing.

Table 1: Comparison of surface roughness before and after cleanroom post processing.

Ultrashort pulse laser [pulse length]	Surface roughness before treatment Ra [nm]	Surface roughness after treatment Ra [nm]
UV (343nm) [6ps]	177	158
Green (515nm) [6ps]	212	176
IR (1030nm) [900fs]	981	271

Figure 1 shows a Silicon sample cut with the UV USP laser system after the oxidation step and before the etching. The taper angle (which should ideally be 90°, here it is >86°) can be clearly seen on the right chip edge.

The taper angle can be further improved by using a trepanning optic. Challenging is the evaluation of the right cutting strategy to achieve a uniform and high quality cut.

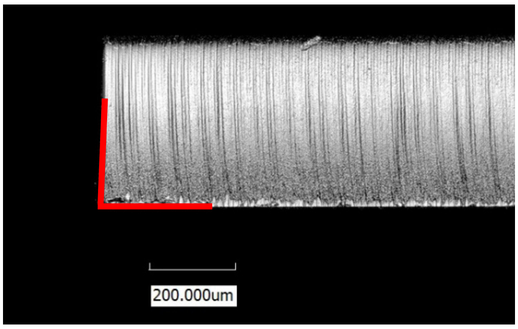

Figure 1: TruMicro UV manufactured Silicon cutting edge with thermal oxide layer. Taper angle >86° marked on the right side.

Using such an optimum laser cutting strategy, and applying the cleanroom treatment we achieve a result as can be seen in Figure 2, with a taper angle of 90° and a surface roughness Ra below 300 nm.

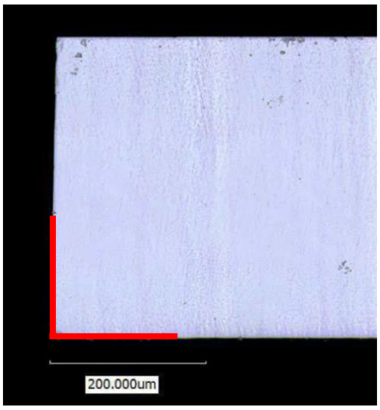

Figure 2: TruMicro IR manufactured Silicon cutting edge with a taper angle of 90°.

We could demonstrate that a combination of cleanroom technologies and USP laser cutting improves quality and precision of cutting edges for Si chips. The lasering process determines the initial surface structure. This structure will then influence the efficiency of the post process treatment. Therefore the coordination of both processes—laser and surface treatment—is essential to get the best out of both technologies.

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• TRUMPF Maschinen AG, Baar

•• BFH Bern University of Applied Science, Institute for Applied Laser, Photonics and Surface Technologies ALPS