Going Where No Other Laser Can Go

Conventional dry cutting laser based machines are often the present day workhorse for many applications in the micromachining industry. These applications encompass the processing of different materials used in semiconductor manufacturing, watch making, medical devices, stencil masks, machine tools etc.

Using conventional lasers for precision cutting these materials is possible, when the material to be cut is relatively thin, say in the order of less than 200 µm. But what if you need to cut something thicker? The limitations posed by this form of laser cutting become evident due to divergence of the laser beam.

The laser beam can only be focused to a finite point, with a very limited depth of field. Before or after this focal point, the diffused beam will not deliver enough energy for satisfactory material ablation, resulting in angular kerf walls and thus a poor cut quality. This limitation by diffraction is unavoidable and inherent to any laser. Other problems associated with any form of conventional laser cutting are, the removal of ablated material from the kerf, edge chipping, heat affected zone (HAZ) damage and re-deposition of material or contaminants on the work piece.

A case in point is the cutting of thick silicon wafer which, if cut with a conventional laser, is impractical due to the limitations on cutting depth that can be achieved, not to mention the additional processing problems mentioned in the previous paragraph.

The water jet-guided laser technology Laser MicroJet® from Synova SA uses a pulsed laser beam focussed into a hair thin, low-pressure water jet, to guide the beam to the work piece and deep into the kerf. Since the laser beam remains contained within the water jet, until break-up of the latter occurs, the depth of field for cutting is greatly increased. The nominal length is approximately 1000 times the jet diameter, which can vary between 25 and 150 µm depending on the installed nozzle size. The resulting working length is therefore between 25 and 150 mm.

Now manufacturers working with this material have the means to cut pieces of up to several millimetres thickness, even in arbitrary 2D shapes. This remarkable capability means perfect processing, with absolutely parallel and clean cut kerfs, with the silicon retaining a high fracture strength, but with no HAZ, chipping or contamination, as the water jet provides instant cooling between laser pulses, flushes the ablated material from the kerf and removes it along with any contaminants from the work piece surface.

Table 1

Sample thickness (µm)	Cutting speed (mm/s)	Number of passes	Overall speed (mm/Min.)
320	100	5	1200
825	100	13	462
1560	120	21	343
1770	120	28	257

Table 2

Sample thickness (µm)	Cutting speed (mm/s)	Number of passes	Overall speed (mm/Min.)
1200	200	35	129

The amazing effect of guiding the laser beam in the water jet inside of the kerf is based on the fact that the kerf width is a few microns wider than the water jet so that there is still an air layer around the water jet allowing a loss-less guiding of the laser beam. The actual processing of the material is carried out in a multi-pass mode, using a 532 nm laser equipped Laser MicroJet®, with the laser power, pulse frequency and width, and the machine cutting speed parameters programmed for optimum results. The actual parameters used and the number of sequential passes required being determined by the type and thickness of the material. Typical results are shown in Table 1 for circular cuts made in 100 mm diameter wafer.

The remarkable results obtained are documented in Fig. 1 and Fig. 2, where the exceptionally high quality of the cut edges can be clearly seen.

Typical results for a further example are shown in Table 2 for straight cuts made in 150 mm diameter wafer.

The remarkable results obtained are documented in Fig. 3 and Fig. 4, where the exceptionally high quality of the cut edges can be clearly seen.

In a laboratory set-up, it has already been demonstrated that 100 mm silicon wafer can be cut with an 80 µm kerf width. The cutting depth is only limited by the stable length of the water jet, and not by a loss of power, since the jet always guides the laser beam to the bottom of the kerf.

The examples given above of the capabilities of the water jet-guided Laser MicroJet®, demonstrate its extraordinary possibilities for precision and damage free cutting thick materials, in this case silicon wafer – a place where no conventional laser can go!

Autor/Author:
Keith Stay
Technical Writer
Synova SA
Chemin de la Dent d'Oche
1024 Ecublens
Switzerland
Phone: +41 (0)21/694 3517
Fax: +41 (0)21/694 3501
E-Mail: stay@synova.ch
www.synova.ch