Process development on water-jet guided laser cutting technology

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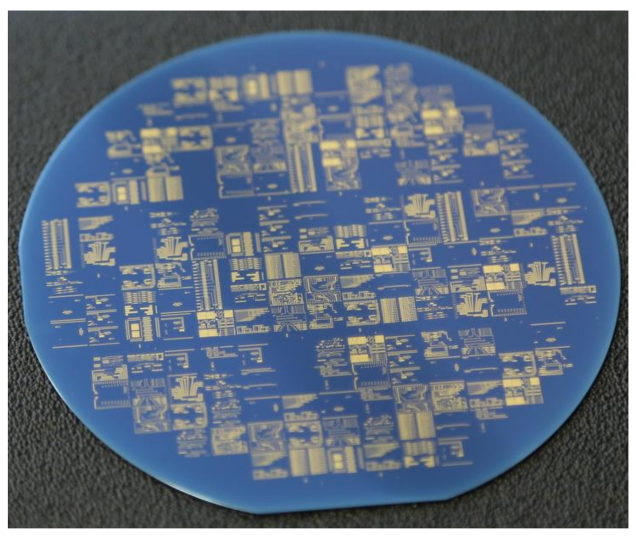
Motivation & Objectives

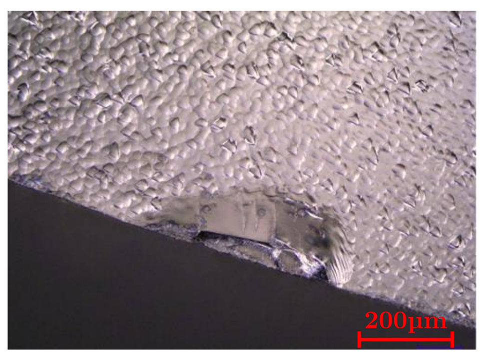


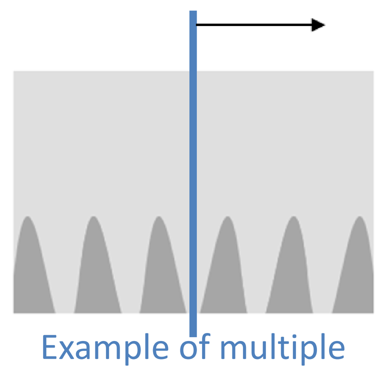
The dynamic semiconductor industry is craving for a fast and high quality processing method for complex multi project wafers. The Laser Microject® (LMJ) has already shown excellent results on industrial downsizing and dicing applications.

However the LMJ semiconductor market entry has been limited by two main cut irregularities: Splashes, a frontside defect causing kerf width variations and mater redeposition, and backside chipping which is a large defects caused by a stress induced fracture of the last layer of material.

The objectives of this project are to identify the phenomena causing these defects, to limit them by optimizing cutting parameters and cutting strategies, and to attest the efficiency of the developed strategies on customer applications.

Backside chipping



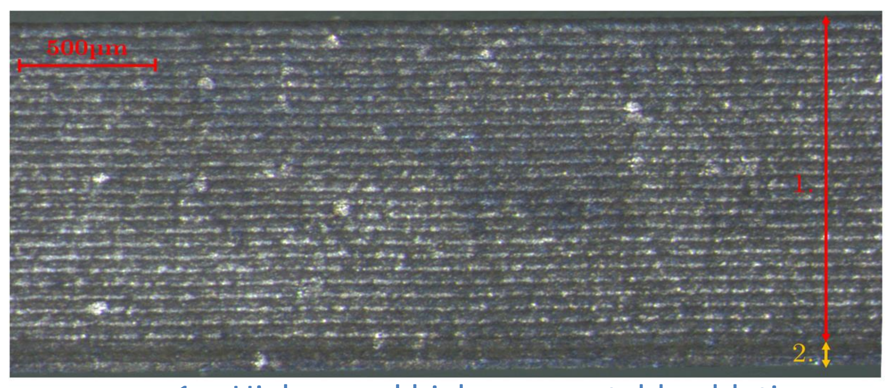


Example of multiple breakthroughs caused by kerf irregularities

As the last layer of material is being cut, the force applied by the jet and the shockwaves created by the pulsed laser cutting both induce stresses fracturing the material, creating a chip. After breakthrough, the jet is tangent to the cutting surface and stresses do not cause more chipping. However if the cut is irregular breakthrough will occur multiple times creating several chips. Thus stable ablation is critical in order to avoid creating backside chipping.

At the start of the cut a large 70µm deep defect was created as the plasma lifted-off the jet. This irregularity could be eliminated using a laser power ramp-up: The laser full power is reached in a few second allowing a low power cut start.

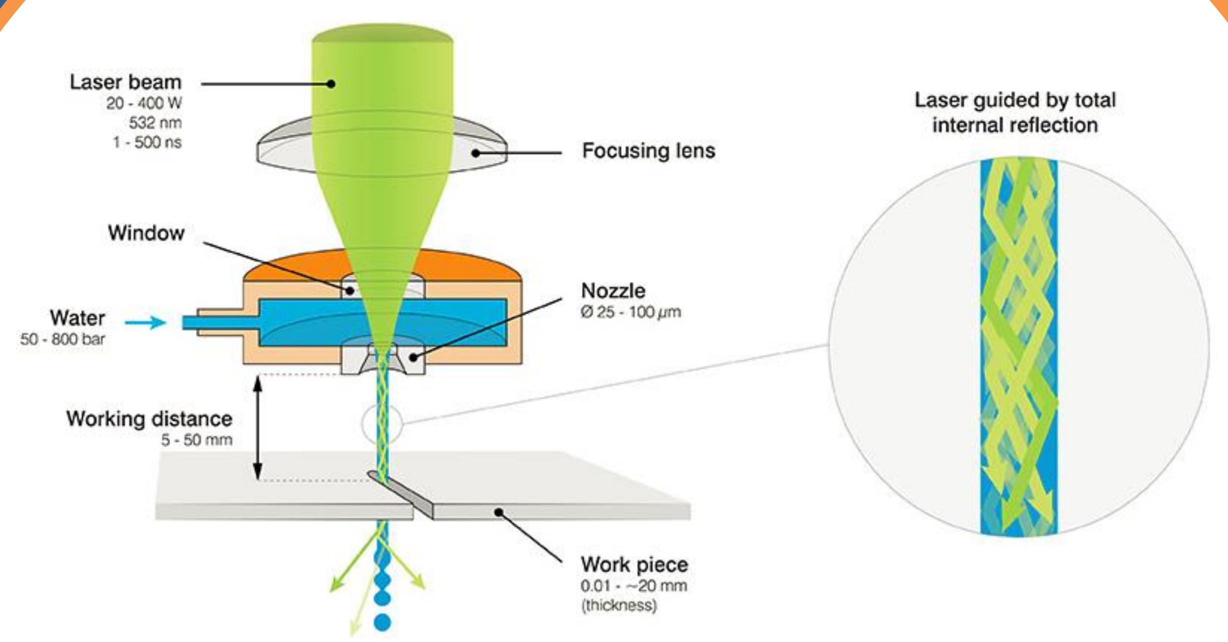
To stabilize the ablation of thick wafers a high power and a high speed were required. The last 100µm of material were cut in one pass using a low power and a low speed. This two speeds two powers strategy leaded to a regular ablation and a chipless continuous breakthrough.



1. High speed high power stable ablation
2. Last 100µm cut by a low power and low speed single pass

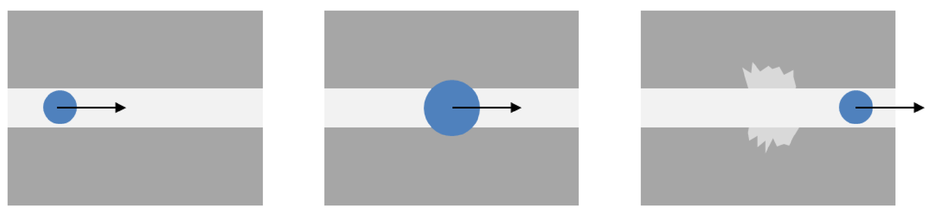
Backside chipping size smaller than 40µm was acheived.

The Laser MicroJet®

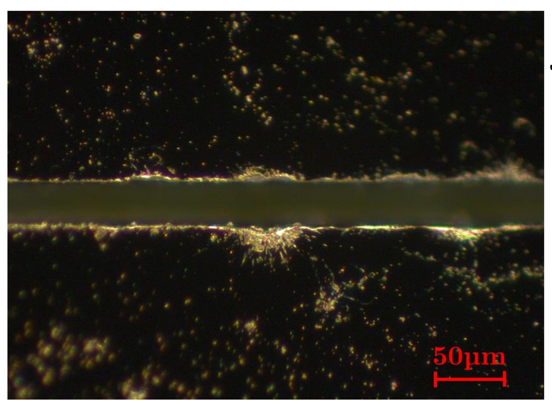


The Laser Microject® technology focuses a nanosecond pulsed green laser in a micro-metric diameter water jet. The water jet is guiding laser light through thick samples allowing fast cutting. The water jet is cooling the material, removing burrs and debris resulting in high-end cut quality and precision.

Splashes

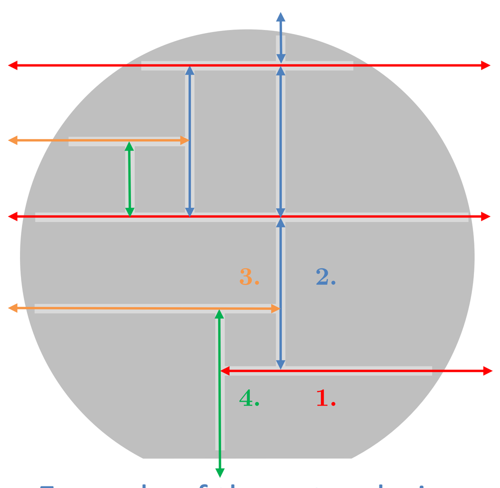


Water jet instabilities are generated by the water system vibrations, interactions of the laser and the water jet or by the water re-ejected by the cutting process. Instabilities grow and propagate along the jet axis. As an instability reaches the sample surface, material is ablated outside of the kerf creating splash:



Jet instabilities were reduced using a low water pressure, low power laser parameters and a high cutting speed. Thus limiting spashes.

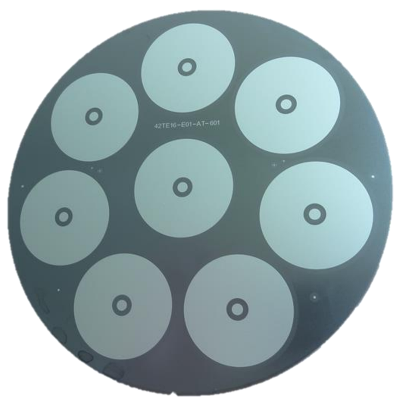
Avoiding splashes when dicing complex wafer required advanced cutting strategies. Cut must start outside of the material or in an already fully cut kerf. Small cut required a lower cutting speed



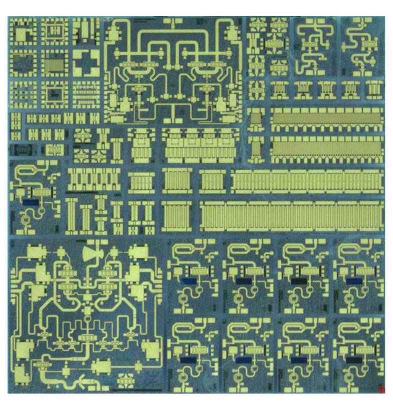
Example of the cut ordering of a complex wafer.

An optimization allowed to reduce splashes to 40µm

Customer applications



Downsizing of 8 circular pieces in silicon wafers with three thicknesses: 175µm, 420µm and 1450µm. The application required limitation of heat damages and backside chipping smaller than 50µm. 40µm chippping was acheived on all samples. The two speeds two powers strategy was required to cut the thickest sample.



Dicing of complex wafers with 50µm wide streets. Three different pieces had to be cut without damaging the electronic chips: 50µm thick GaAs, 125µm thick Si and 100µm thick SiC. Parameters were optimized for each material. GaAs being the most sensitive one, splashes could be limited to 65µm. However a splashe size smaller than 40µm was acheived for Si and SiC samples.

Conclusion & Outlooks

Phenomena leading to splashes and backside chipping were investigated. Backside chipping was limited to 40µm using a power ramp-up and a two speeds two powers strategy. Splashes was reduced to 40µm using low power laser parameters and ordering the cut of multi project wafers. The developed parameters and strategies efficiency was confirmed on customer application.

Concerning future works and investigations, the limit in thickness of the two speeds two powers strategy must be found and its effect on other brittle material must be investigated. A new R&D device limiting splashes called the «Splash Guard» must be tested on dicing applications

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