Laser Scribing of Sapphire Wafers and Display Glass with a Picosecond Fiber Laser

Laser scribing and dicing of extremely hard transparent materials such as display glass and sapphire wafers is a growing application space for laser microprocessing. These applications do not typically require lasers with immense pulse energy, but they do have incredible peak power requirements due to the need for nonlinear absorption in otherwise transparent materials without UV wavelengths and especially for bulk modification. These aspects make scribing of such hard transparent materials particularly well suited to Fianium’s picosecond fiber lasers.

Fianium’s high energy ultrafast fiber lasers produce picosecond pulses with energy up to 125µJ and ultra-high peak power on order of 1 megawatt, which is perfectly suited for nonlinear absorption in transparent materials. The lasers have tunable repetition rates from single shot on demand up to 40MHz, which makes them versatile tools for high-throughput scribing. The HE1060/532 provides the capability of inexpensive, maintenance-free, virtually defect-free scribing of hard sapphire wafers and tempered display glass.

- Up to 125 µJ pulse energy and 25W average power
- Picosecond and femtosecond pulse widths
- Single-shot to 40MHz variable repetition rate
- 1064 nm or 532 nm wavelength
- Designed for 24/7 operation and OEM integration
- Maintenance-free

Applications Lab
Fianium’s application lab in Portland, Oregon is available for clients to evaluate the effectiveness of Fianium lasers for their custom application. We offer a host of micromachining application capabilities and an array of laser sources with pulsewidths spanning the entire picosecond regime.

Scribing of Sapphire For Wafer Dicing
The recent growth in both the high brightness LED and display glass markets has driven investment into new cutting and dicing technologies for such difficult to machine materials. Conventional scribing of such materials has been conducted using UV nanosecond lasers for surface scribing in a scribe and break style process. However, Fianium’s ultrafast fiber lasers are capable of scribe and break processing of sapphire and tempered glass without the need for UV lasers. In fact, both green and IR wavelengths from Fianium’s picosecond lasers have been used to create surface scribes in such materials as demonstrated in Figure 1.
Fianium’s IR and green picosecond fiber lasers are suitable in a variety of laser microprocessing applications involving transparent materials, such as display glass and sapphire. The ultra-short pulsewidth provides the incredible peak power that allows for utilization of visible and IR lasers in a space conventionally filled by UV lasers, and opens up the new capability for improved surface and internal bulk material modification for scribing. Scribe and break procedures can be successfully conducted with lasers of both wavelengths in both surface and internal scribing modes. The high repetition rate of the lasers of up to 1MHz allows for incredibly high speed scribing in excess of 1m/s and for process parallelization. Fianium’s ultrafast fiber lasers are air cooled and designed for zero-maintenance 24/7 operation in an industrial environment, which makes them the ideal tool for a whole host of microprocessing applications, especially sapphire and tempered glass dicing.

More recently, internal scribing has also become of interest and patents in this realm have been granted to several companies. We do not compare techniques, but can generally observe that the main benefit of this processing mode is that it generates no debris and thus does not require a post-processing wash step.

To create internal scribes the laser beam is focused into the bulk of the transparent material and causes a disruptive modified scribe zone typically on order of a few microns wide and a few tens of microns deep. This modified zone creates a line of weakness along the material with which to guide the break. Figure 2 shows the single-pulse internal modification zone created in tempered alumina-silicate glass using a Fianium picosecond fiber laser with a wavelength of 1064nm. Since the scribe is made internally, there is no processing debris to wash away unlike the surface scribe shown in Figure 1.

Summary

Fianium’s IR and green picosecond fiber lasers are suitable in a variety of laser microprocessing applications involving transparent materials, such as display glass and sapphire. The ultra-short pulsewidth provides the incredible peak power that allows for utilization of visible and IR lasers in a space conventionally filled by UV lasers, and opens up the new capability for improved surface and internal bulk material modification for scribing. Scribe and break procedures can be successfully conducted with lasers of both wavelengths in both surface and internal scribing modes. The high repetition rate of the lasers of up to 1MHz allows for incredibly high speed scribing in excess of 1m/s and for process parallelization. Fianium’s ultrafast fiber lasers are air cooled and designed for zero-maintenance 24/7 operation in an industrial environment, which makes them the ideal tool for a whole host of microprocessing applications, especially sapphire and tempered glass dicing.

Materials such as sapphire and display glass are extremely hard and notoriously difficult to break effectively, but picosecond internal scribing and dicing can be a reliable process even in thick materials. For thick materials such as display glass, which are commonly up to 1mm thick, multiple scribe lines can be made along a single break plane to sufficiently weaken the material and reliably dice it as shown in the bottom of Figure 3.

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