REPORT: Sapphire wafer grooving by Laser-MicroJet®

for Anonymous

by Andrew Chung, Synova Korea

TASK

The Laser-MicroJet® technology has been tested for grooving ~150 µm thick sapphire wafers. The goal of this test is to do without no burning area around the intersection area of the street. And also without any contamination. I used a 40 µm nozzle this time.

SAMPLE DESCRIPTION AND PREPARATION

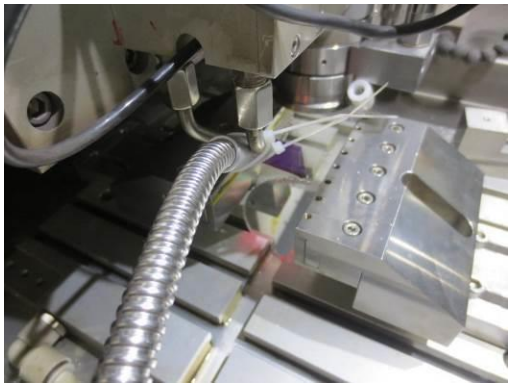
Release of application report			
Project Leader		Responsible Application Group	
Name:	Andrew Chung	Name:	Benjamin Carron
Date:	2014.07.25	Date:	2014.07.25
Visum:	SDE	Visum:	BC

SAMPLE	Material	*Sapphire*
	Dimension	*50*50 mm*
	Thickness	*~150 µm*
	Quantity	*4 pcs*

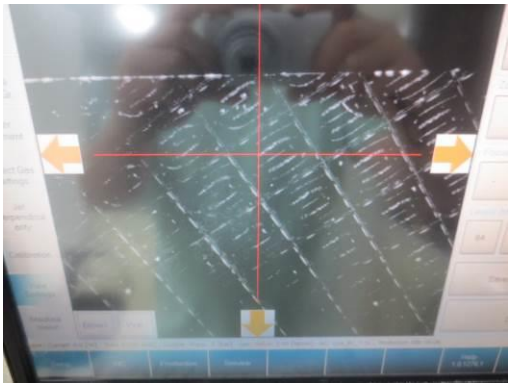
SAMPLE CLASSIFICATION	3T403050600	*Trial version*
	3T403051800	
	3T403051000	
	3T403051500	*Customer check version*

3 in 4 samples that I received from the customer were used for the establishment of the processing condition. I used wafer number, 3T403051500. Ready to be checked by customer.

BACK-LIGHT ILLUMINATION CONFIGURATION IN MACHINE



PICTURE 1: Digital camera image of the illumination system.



PICTURE 2: The lighting system could be helpful to see the line for the alignment.

The above two pictures shows the processing preparation and system that I need in order to do the back side of the pattern. When I put back light under the wafer, it could not cover all because the intensity and focusing of the light is not constant. As you see the above image, it would be easy to align even though I move the wafer position. The intensity of the light should be constant on the wafer loaded at an angle of 45 degree. I think UV light can be penetrated more deeper inside the wafer.

PROCESS: INSTRUMENT & TEST PARAMETERS

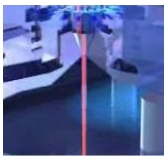
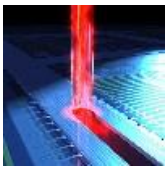
For these experiments, the LDS300M equipped with a frequency-singled Q-switched Nd: YAG laser has been used as the machine configuration in our lab.

It is a manually clean-room compatible machine, allowing to cut, drill, groove, scribe, trench, mark, or grind wafers of any kind of material.

Major advantages of Laser-MicroJet® technology with regards to your application are:

- Cutting of arbitrary shapes
- No chipping on front side
- Negligible heat damage to the material

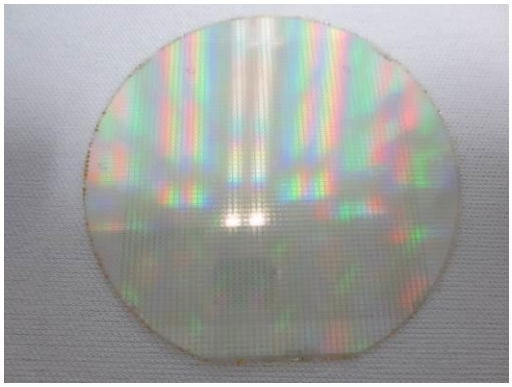
In the table below, the optimized processing parameters used in the experiments are summarized:

	**SYSTEM**	Machine type	LDS300<
	**MICROJET® PARAMETER**	Nozzle diameter	40 *µm*
		MicroJet® diameter	~32 *µm*
		Water pressure	300 *bar*
		Assist gas	He
	**LASER PARAMETER**	Laser type	L51G
		Wavelength	532 *nm*
		Pulse frequency	6 *kHz*
		Average power	17 *W*
		RF off-time	0.8 *µs*
		Pulse width	~105 *ns*
	**CUTTING PARAMETER**	Cutting speed	4.5 *mm/s*
		Number of passes	1
		Overall speed	4.5 *mm/s*
		Fixing system	clamps

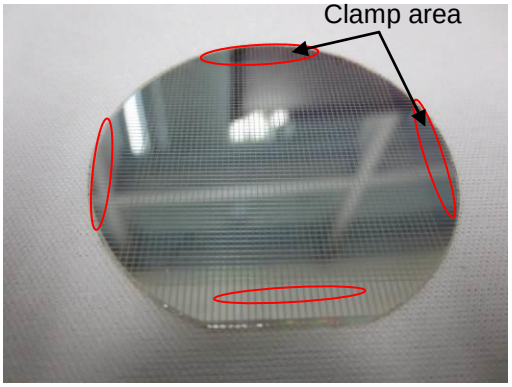
Results

For this fifth set of tests a 40 µm nozzle was used. I tried many times to establish the processing condition. So we could get rid of burning area but about 30 µm chipping around the processing line done by UV laser occurred. I guess that micro chipping made by UV laser got bigger by the second process of our machine.

The following microscope pictures give an overview on the quality obtained with the Laser-MicroJet® technology.

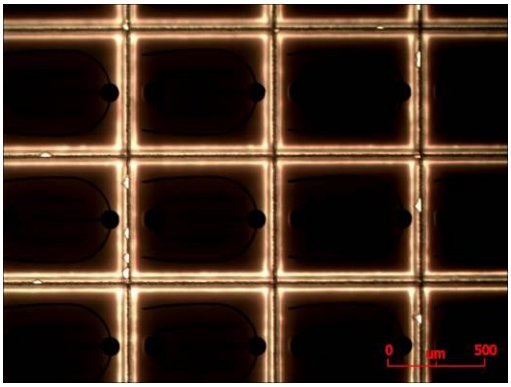


PICTURE 3: Digital camera pictures of the samples after processing.(Back-side view)

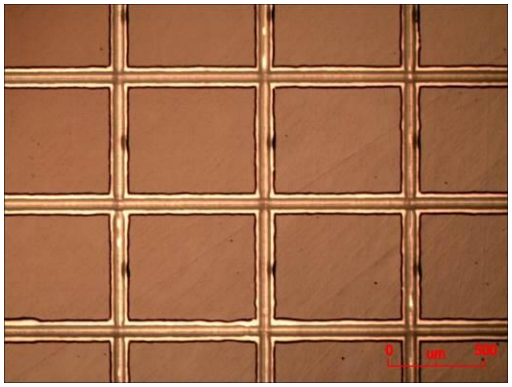


PICTURE 4: Digital camera pictures of the samples after processing.(Front-side view)

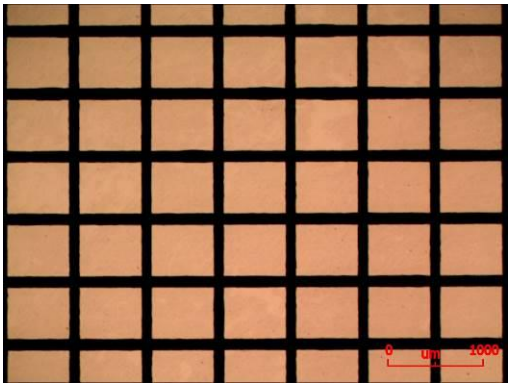
**O: Red circle is clamp area. (Does not processing)



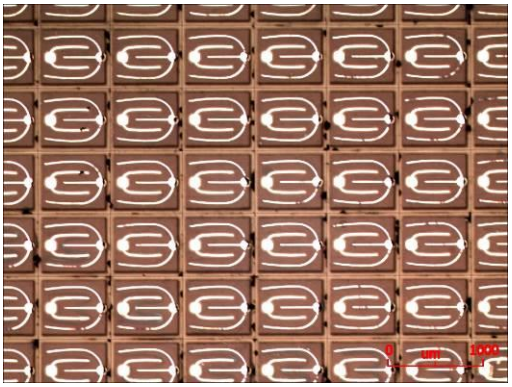
PICTURE5: Microscope image of street intersections. Sample 3T403051500.(frontside, dark field illumination).



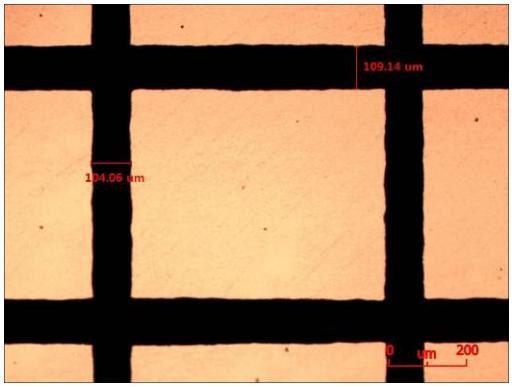
PICTURE 6: Microscope image of street intersections. Sample 3T403051500.(frontside, dark field illumination).



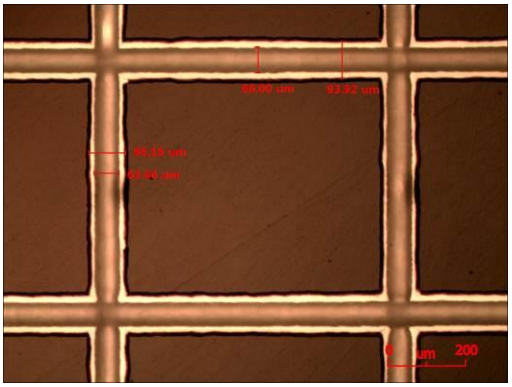
PICTURE 7: Microscope image of street intersections. Sample 3T403051500.(frontside, bright field illumination).



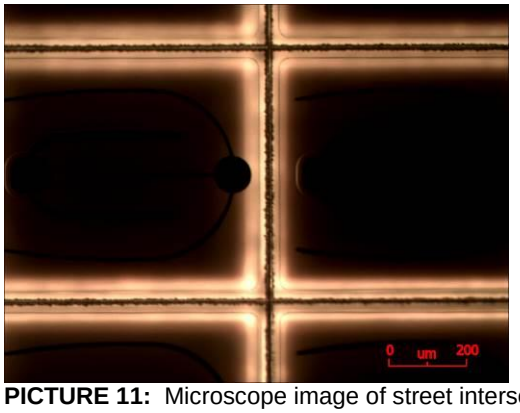
PICTURE 8: Microscope image of street intersections. Sample 3T403051500 (backside, bright field illumination).



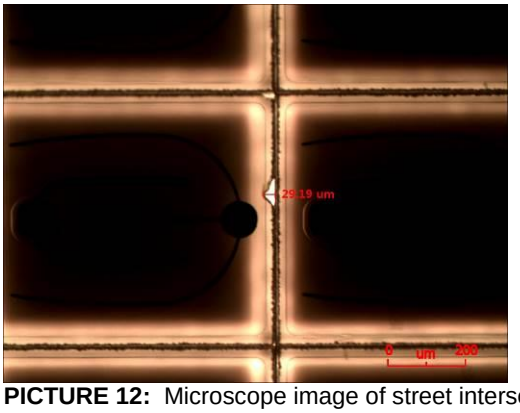
PICTURE 9: Microscope image of street intersections. Sample 3T403051500.(frontside, bright field illumination).



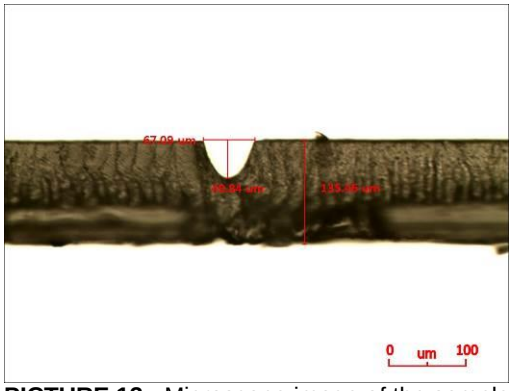
PICTURE 10: Microscope image of street intersections. Sample 3T403051500.(frontside, dark field illumination).



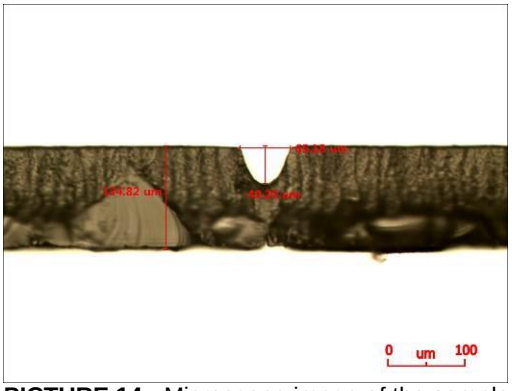
PICTURE 11: Microscope image of street intersections. Sample 3T403051500.(frontside, dark field illumination).



PICTURE 12: Microscope image of street intersections. Sample 3T403051500.(frontside, dark field illumination).



PICTURE 13: Microscope image of the sample. Sample 3T403051000 (cross section, dark field illumination).



PICTURE 14: Microscope image of the sample. Sample 3T403051800. (cross section, dark field illumination).

The table below summarizes Anonymous expectations and our results:

	What are your priorities? (please put a cross)	Quantified expectations or improvements
Speed / throughput:	X	4.5 *mm/s*
Kerf-width:	X	~70 µm
Heat-damage free:	X	No
Chipping/Cracks:	X	No chipping on the front-side but some chipping on the back-side(chipping around the UV scribing lines)
Tolerances	X	Grooving depth ~50 µm according to our optical measurements
Other:	v-groove capability	u-groove capability

CONCLUSION

The grooving of sapphire wafer was investigated on SYNOVA LDS 300M machine. This machine is based on the MicroJet® technology and combines the advantages the high energy pulsed laser with a hair-thin water jet.

These tests show that:

1. A very good front side quality is achievable but back side has some chippings.

2. No contamination is visible when clamps are used (except just near the clamps).

3. A 40 µm nozzle which allows a kerf width of about ~70 µm appears to be the best option for these samples. Indeed if a 50 µm nozzle is used some burning areas are visible on the metallic contacts due to the high transmission of the sapphire.

4. UV light illumination could be more helpful to align.

5. Obtained better shape like U-groove compared to V-groove shape requested from the customer.

6. I suggest that the process by our machine should be done before using UV laser in order to stop creating the chipping of the back side.

We thank you for your interest in our technology and we hope our results meet your requirements. Our sales will contact you soon to obtain a feedback about the analysis of these results and to discuss with you the further steps.