REPORT: Silicon texturing by Laser-MicroJet®

for Anonymous

by Bruckert Florent, Synova SA

TASK

The Laser-MicroJet® technology has been tested for texturing 3 silicon wafers.
The aim was to texture 9 cm^2 of 3 mono crystalline silicon wafers in order to improve the optical properties of the final solar cells.

SAMPLE DESCRIPTION AND PREPARATION

SAMPLE	Material	Mono crystalline Silicon
	Dimension	155X155 *mm^2*
	Thickness	180 *µm*
	Quantity	3 *pcs*

3 wafers were processed due to processing and testing time. The others were kept for the next iteration according your potential request.

Release of application report			
Project Leader		Responsible R&D Group	
Name:	Florent Bruckert	Name:	D^r Pedro Torres
Date:		Date:	
Visum:		Visum:	

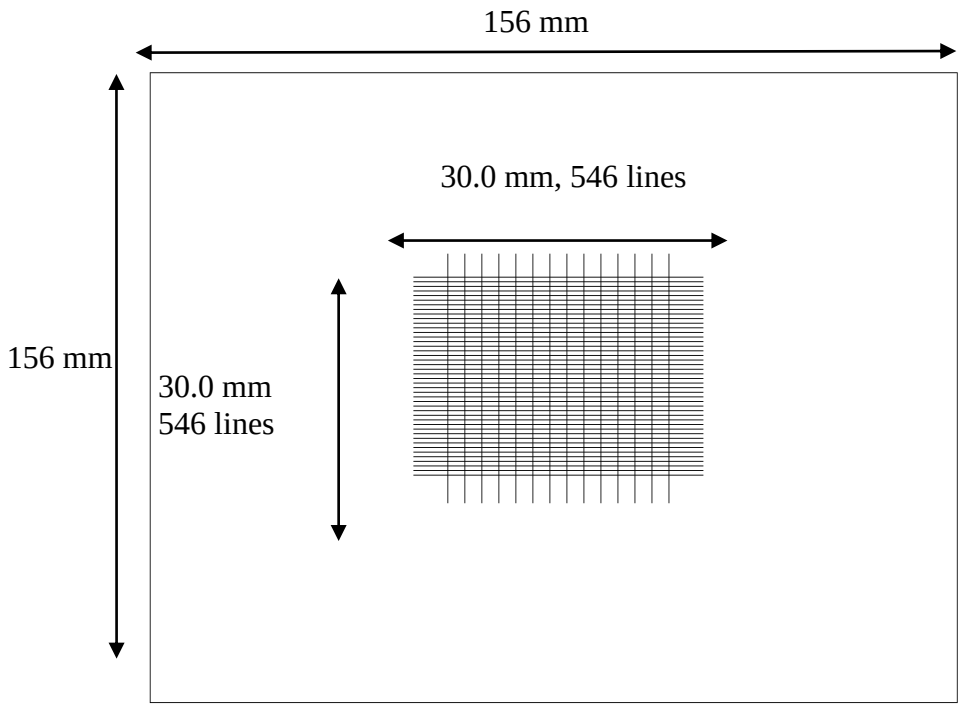


Figure 1: Drawing of the texturing pattern

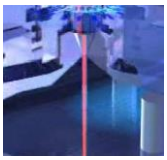
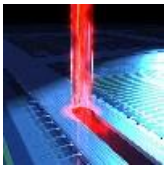
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, the LCS300, Nd:YAG laser, has been selected as the most suitable machine configuration.

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

- Cutting of arbitrary shapes
- Low heat damage to the material
- Smooth cut walls
- Low slag/burr formation
- Excellent wall surface quality

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

	**SYSTEM**	Machine type	LCS 300	
		Fixing type	Chuck vacuum and Laser Tape	
	**MICROJET® PARAMETER**	Nozzle diameter	30	µm
		MicroJet® diameter	25	µm
		Water pressure	300	bar
	**LASER PARAMETER**	Laser type	L51G	
		Wavelength	532	nm
		Pulse frequency	10	kHz
		Average power in jet	<1	W
	**CUTTING PARAMETER (ONE PASS STRATEGY)**	Cutting speed	50	mm/s

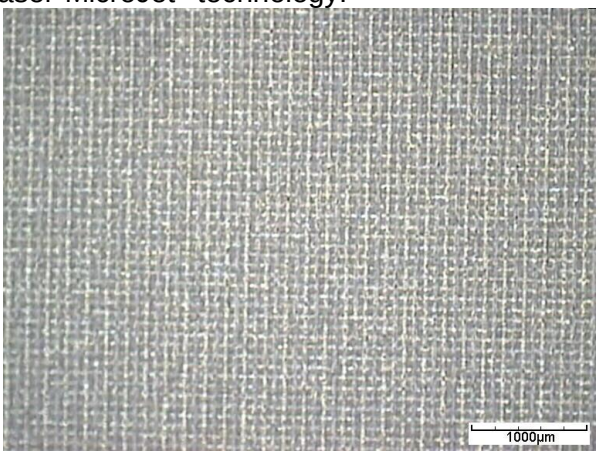
Note:
We have tried to develop specific pattern with a tilt; nevertheless, the parameters used for this test do not permit to keep a homogeneous depth control with a 30 µm nozzle diameter.

RESULTS

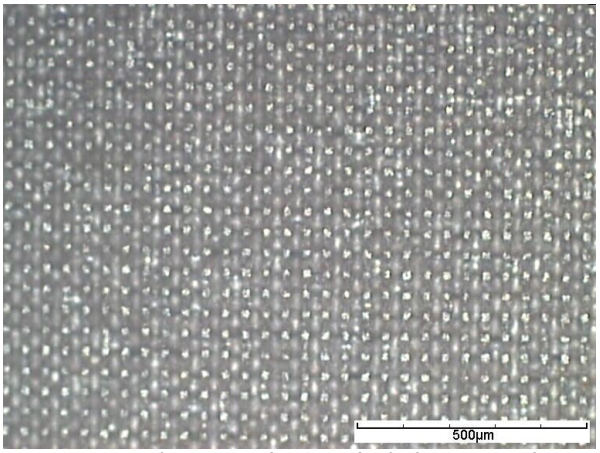
Sample reference	**Processing time per pattern (min)**
S1	7min30s (X lines) + 7min30s (Y lines)
S2	Idem: 15min
S3	Idem: 15min

Sample reference	Current of the diodes (%)	Deepness (µm)
S1	46	20-25
S2	46	20-25
S3	42	10-15

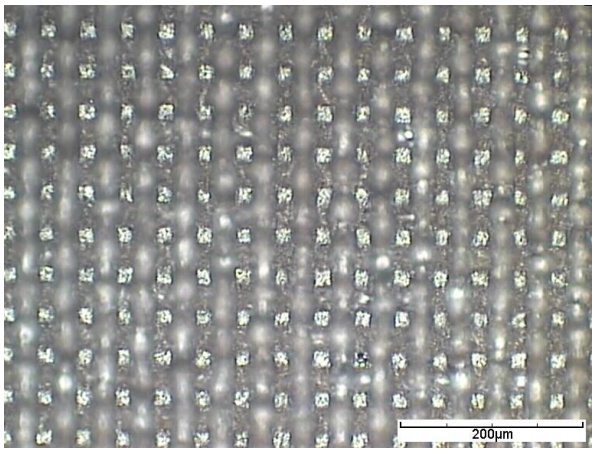
The following microscope pictures give an overview of the front side of the holes obtained with the Laser-MicroJet® technology.



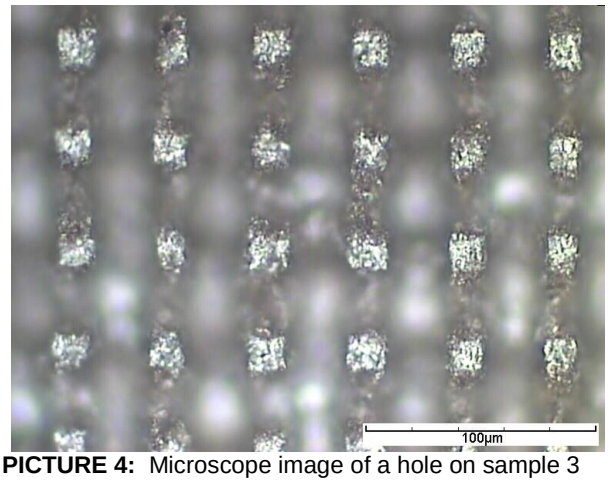
PICTURE 1: Microscope image of a hole on sample 1.



PICTURE 2: Microscope image of a hole on sample 1.



PICTURE 3: Microscope image of a hole on sample 2.



PICTURE 4: Microscope image of a hole on sample 3

	INES priorities	First results
• Speed / throughput:		
• Kerf-width:		22 µm
• Depth control:	X	Ok
• Contamination/Particles:		
• Heat-damage free:	X	No Heat affected zone
• Chipping/Cracks:		
• Edge Roughness:	X	To develop
• Tolerances:	X	To develop
• Fracture strength:		
• Other:	Uniformity	To develop

CONCLUSION

The texturing of silicon wafers was investigated on the SYNOVA R&D machine.
This machine is based on the MicroJet® technology and combines the advantages of a high energy pulsed fiber laser with a hair-thin water jet. While the laser is used for material ablation, the water jet is used for guiding the laser light, cooling the edges and preventing the sample from particle contamination, advantages that are essential for grooving of silicon wafers with high quality.

Summary:

- A green laser source (wavelength: 532 nm) has been used to texture 9 cm^2 on 3 silicon wafers; the absorption properties of the materials lead us to use the green source for the silicon ablation.
- We used different power parameters to limitation the grooving depth.
- On the front side, no Heat Affected Zone was found.
- The wafers have been cleaned and do not present any contamination.

Next steps:

- Irregularities are mainly due to an instable waterjet. Moreover the process time increases significantly. This waterjet breakdown can be solved by testing various ranges of working distance (Coupling unit-sample), water pressure, nozzle diameter etc.
- To minimize the pitch between 2 lines, a more developed study including more cutting strategies (use of a combination of air and helium assist gas, 2 different laser and speed configurations, finishing pass, etc) and laser parameters (wavelength, pulse frequency, cutting speed, pulse width) could be processed according to your requirements.
- To minimise the process time.
- If our technical solutions have satisfied your specifications, we would be glad to process more samples to prove the LMJ potential.

We thank you for your interest in our technology and would be glad to obtain a feedback about your results and the match with your requirements.