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APPLICATION REPORT

Report No: 145-3

Sample No: N.A.

CONFIDENTIAL

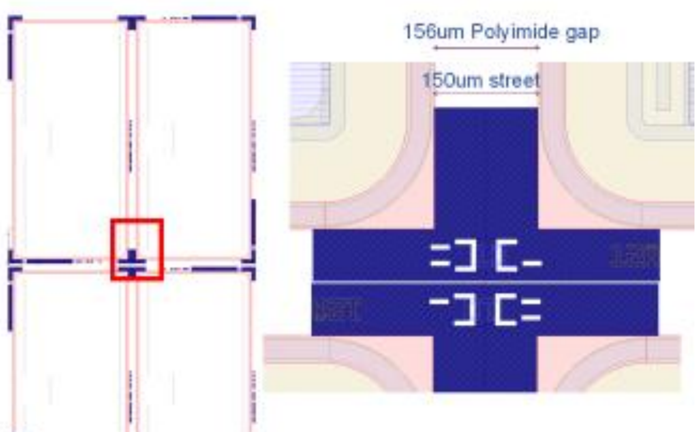
REPORT: SiC MOSFET dicing by Laser-MicroJet®

for Anonymous
by Jerry Chera; Synova USA

TASK/OBJECTIVES

The Laser-MicroJet® technology has been tested for the dicing of SiC MOSFET wafers. Additional process steps were also baselined: mounting wafers, post-dice cleaning, sorting into waffle packs and inspection. Anonymous inspection specifications were used. This report focuses on the laser dicing testing, as it is the critical step that drove the evaluation.

The objective is to dice through the complete wafer structure, following the cartesian street pattern depicted below.



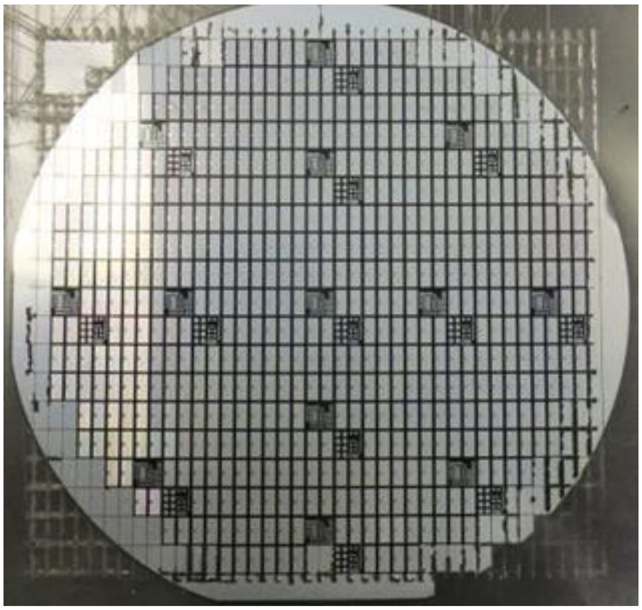
SAMPLE DESCRIPTION AND PREPARATION

Material	SiC
Dimensions	98mm diameter
Thickness	Approximately 600 microns
Quantity	Original Quantity of (3) wafers; (1) extra wafer processed as a final run.

Release of application report			
Project Leader		Responsible Application Group	
Name:	Jerry Chera	Name:	D[r] Benjamin Carron
Date:	30.04.2014	Date:	02.05.2014
Visum:	JC	Visum:	BC

INCOMING WAFERS

A quantity of (3) unmounted wafers were received, along with waffle packs to return diced parts. Below is a picture of an “as received wafer”.



APPROACH

1. Initial process trials were conducted on one wafer. In order to test efficiently, the wafer was cut into three pieces (2 quarters and one half). This wafer was used to test out a range of possible laser parameters, as well as to determine mounting, cleaning and unmounting parameters.
2. Two wafers were then processed, once parameters were defined.
3. An additional 4th wafer was sent to us for final trials, to address issues of water stains, scratches, uncut parts and liftoff seen on the previously mentioned (2) wafers.

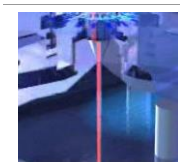
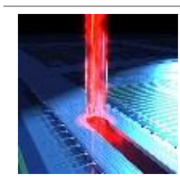
PROCESS: INSTRUMENT & TEST PARAMETERS

For these dicing experiments, a Synova LDS 200 laser dicing system, equipped with a frequency-doubled Q-switched Nd:YAG laser was used as the machine configuration. Tests were conducted in the Fremont CA micro-machining center. It is a manually loaded machine, allowing cutting and drilling any kind of metal piece.

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

- Dicing of hard materials such as SiC
- Advantageous process rates
- Cutting of non cartesian patterns
- Low heat damage to the material

In the table below, the optimized processing parameters used in the experiments for the **FINAL WAFER** are summarized:

	**SYSTEM**	Machine type	LDS200
	**MICROJET® PARAMETER**	Nozzle diameter	50 *µm*
		MicroJet® diameter	42 *µm*
		Water pressure	250 *bar*
		Assist gas	He (1.00 *L/min*)
		Working distance from diaphragm	10 *mm*
	**LASER PARAMETERS**	Laser type	LDP-200MQG
		Wavelength	532 *nm*
		Pulse frequency	20 *kHz*
		Internal power	36 *W*
		Pulse width	250 *ns*
		SHG temp.	30.9 *deg*
	**CUTTING PARAMETERS**	Speed	100 mm/sec
		Cutting time	60 mins

DICING RESULTS

Microscopic Pictures:
The following microscope pictures highlight the edge quality obtained with the Laser-Microjet® technology.

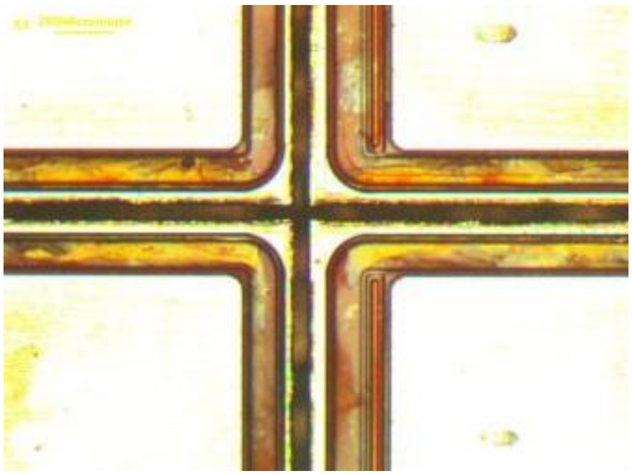


Fig 1: Cut showing intersection

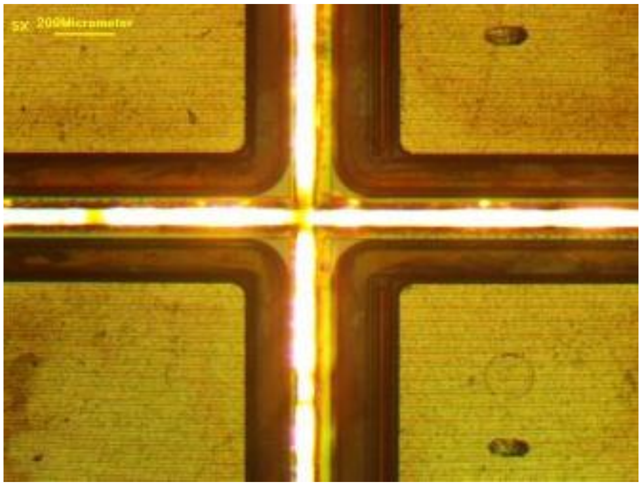


Fig 2: Cut top view with illumination

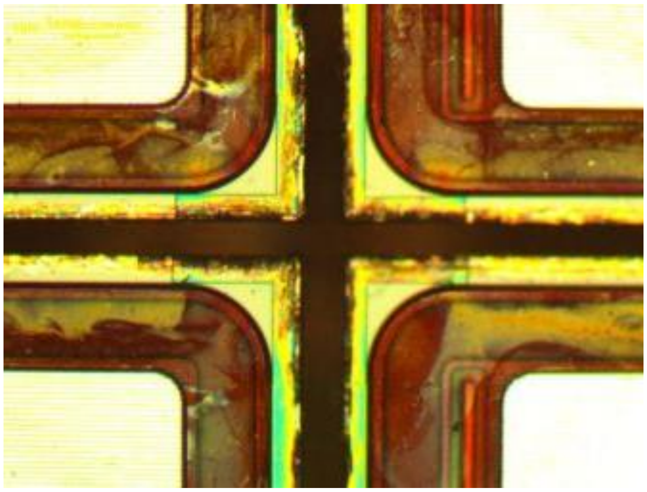


Fig 3: Cut top view at 10x magnification

Fig 4: Die edge quality top side

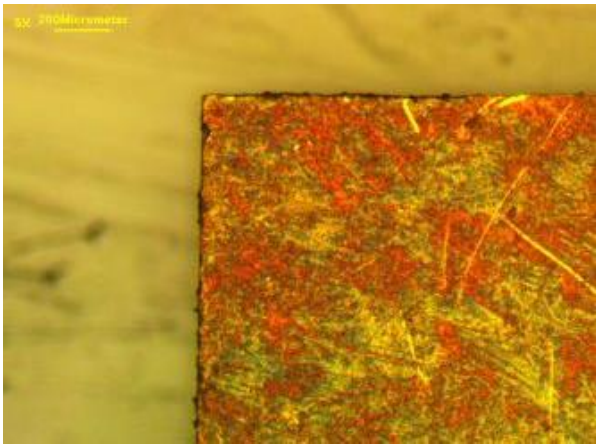


Fig 8: die edge quality bottom side

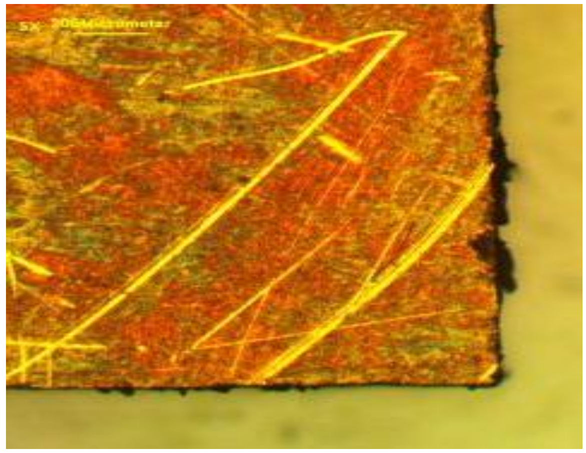


Fig 9: die edge quality bottom side

DISCUSSION:

There were many issues encountered during the first "2 wafer" run:

- Areas of the wafer remained uncut
- Some dies lifted from the tape during dicing
- Cleaning and handling defects were present.

Further optimization was done and an additional "Final Wafer" was processed.
The following document summarizes the areas of optimization:

Wafer Dicing Optimization.pdf

Although we were successful in addressing handling and cleaning issues on this final run, the problem of uncut regions remained. The process as defined seems marginal; some areas cut well and some do not. Typically, this is due to the disturbance of the laser jet. A potential solution would be to use a larger nozzle orifice, as well as experiment with power and frequency settings. This problem would require long term investigative work. Additional blank SiC, as well as metallized wafers would be needed.

It was observed that even by doubling the number of passes, the incomplete cut issue remains present. A 100X inspection from the top side indicates that we cut down to about 350-400 microns in those uncut regions. Some of the uncut regions were adjacent to the lines which were completely cut thru. It is unclear if there remains some ESD contribution to this effect or if we are simply marginal with our laser parameter set.

We also continue to have issues with "die lift" on some areas. This is most probably related to our method of mounting the wafer to the tape. Being done manually today, one can notice air entrapment between the tape and the wafers. The delicate nature of the wafer, and the attention to reduce handlign defects, drives a need for an automated process. There are several “local assemblers” that we could partner with to address this issue.

CONCLUSION

SiC wafer dicing was investigated on SYNOVA LDS200. This machine is based on the MicroJet® technology and combines the advantages of the high energy pulsed 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 redeposition. These are advantages that are essential for cutting such materials as SiC with high quality.

In order to develop a robust and reliable process, additional work is required.

- More aggressive lasing parameters need to be tested (lower frequency, higher power), without creating chipouts and heat affected zone defects.
- A larger nozzle orifice also needs to be explored. Laser parameters would change accordingly.
- Further testing needs to be done on the contribution of an ESD buildup is also needed. This may drive a need to revisit the machine’s grounding scheme.
- There are conductive tapes available on the market. These should be tested. The level of adhesion (translating into die lift and tape residues) would need to be baselined for such a tape.
- An optimized solution for mounting wafers to the tape needs to be put in place
- An improved UV irradiaton system, with N2 purge capabilities, would be required (to optimize for tape residues)

At this juncture, a detailed study would need to be constructed and quoted

We thank you for your interest in our technology. We do believe that the Laser Microjet technology offers quality and throughput advantages for dicing of Silicon Carbide wafers in the long run.