REPORT: SiC and SiC Fiber cutting by Laser-MicroJet®

for Anonymous
by Jerry Chera; Synova USA

TASK/OBJECTIVES

To test The Laser-MicroJet® technology for cutting the SiC and SiC Fiber.
The following are the main objectives:-

a) Test minimum diameter hole which can be drilled in 10mm thick SiC
b) Test minimum diameter hole which can be drilled in 10mm thick SiC Fiber.
c) Create 2mm deep U shaped trench in SiC Fiber.

SAMPLE DESCRIPTION AND PREPARATION

PART #1	Material	SiC
	Dimensions	Irregular shape
	Thickness	10mm
	Quantity	1

PART #2	Material	SiC Fibers
	Dimensions	1.25 x 1.5 inch rectangular piece
	Thickness	10mm
	Quantity	7

Release of application report			
Project Leader		Responsible Application Group	
Name:	Jerry Chera	Name:	Dr Benjamin Carron
Date:	23.05.2014	Date:	23.05.2014
Visum:	JC	Visum:	BC

SAMPLE PICS

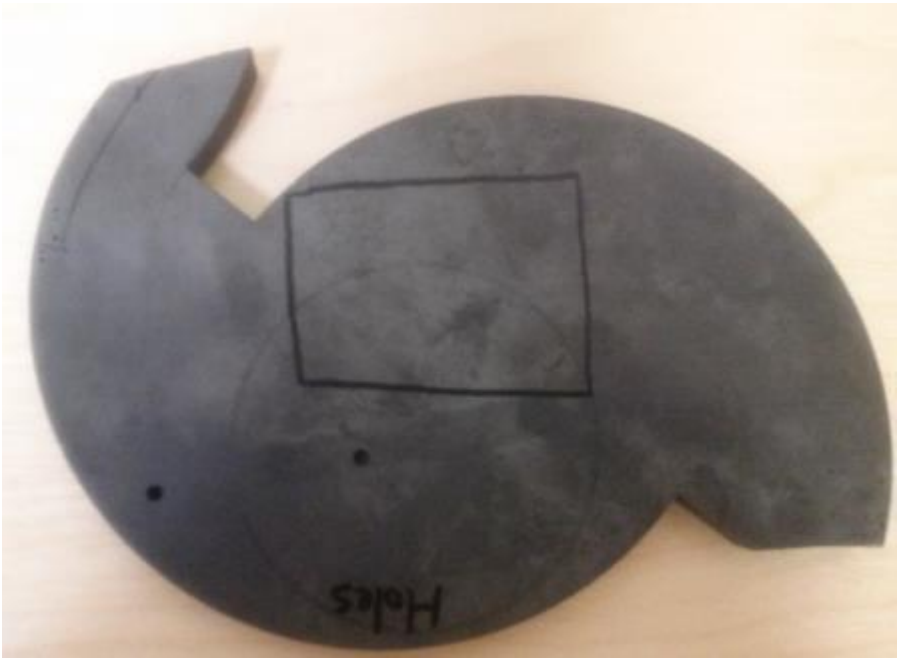


Fig. 1 – SiC

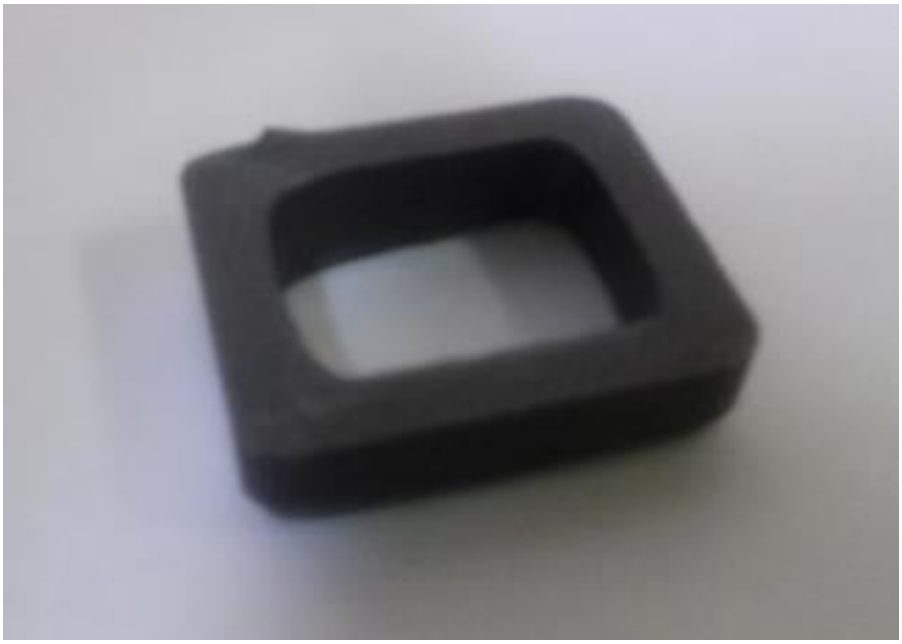


Fig. 2 – SiC Fiber

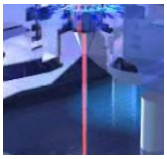
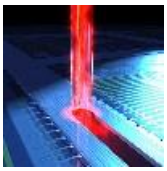
Process: Instrument & Test Parameters

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

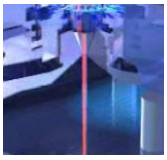
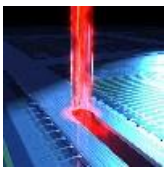
Major advantages of the Laser MicroJet technology with regards to your application are:

- High quality cutting
- Cutting of non cartesian patterns
- Low heat damage to the material

In the table below, the optimized processing parameters used in the experiments for part#1 (SiC) are summarized:

	**SYSTEM**	Machine type	LDS200
	**MICROJET® PARAMETER**	Nozzle diameter	50 *µm*
		MicroJet® diameter	42 *µm*
		Water pressure	250 *bar*
		Assist gas	He (0.98 *L/min*)
		Working distance from diaphragm	10 *mm*
	**LASER PARAMETERS**	Laser type	LDP-200MQG
		Wavelength	532 *nm*
		Pulse frequency	8 *kHz*
		Internal power	30 *W*
		SHG temp.	30.9 *deg*
	**CUTTING PARAMETERS**	Speed	5 mm/sec
		No. of passes for hole drilling (1mm dia)	153
		Cutting time for one hole (1mm dia)	38 mins

In the table below, the optimized processing parameters used in the experiments for part#2 (SiC Fiber) are summarized:

	**SYSTEM**	Machine type	LDS200
	**MICROJET® PARAMETER**	Nozzle diameter	50 *µm*
		MicroJet® diameter	42 *µm*
		Water pressure	250 *bar*
		Assist gas	He (0.98 *L/min*)
		Working distance from diaphragm	10 *mm*
	**LASER PARAMETERS**	Laser type	LDP-200MQG
		Wavelength	532 *nm*
		Pulse frequency	8 *kHz*
		Internal power	30 *W*
		SHG temp.	30.9 *deg*
	**CUTTING PARAMETERS**	Speed	5 mm/sec
		No. of passes for hole drilling (1mm dia)	32
		Cutting time for hole (1mm dia)	8 mins
		No of passes for trench (2mm deep)	2
		Time per trench	1 hour 24 mins

STRATEGY

We started by drilling 0.484 mm dia hole but found out that we could not cut thru even after 1 hr of drilling. A higher dia of 0.7 mm was tried without sucesss. Upon further experimentation we decided to try 1 mm dia which we were able to drill thru.

The holes were drilled using a double-spiral path, as illustrated in Figure 3, where the path first follows the blue arrows (inwards) and then red arrows (outwards), and is repeated as many times as necessary. The 25µm step value given in the table above corresponds to the distance indicated by the black double arrow. It corresponds to half of the nozzle diameter. A spiral path is necessary to drill deep holes with a high aspect ratio. In this case, the hole begins to be cut through in the center, and gets progressively wider on the backside, minimizing the taper

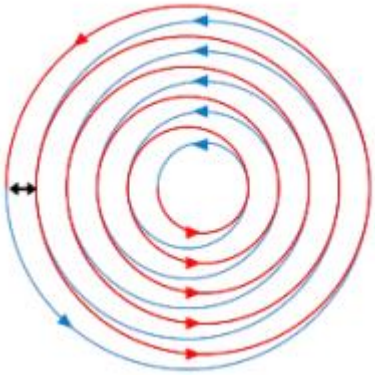


Fig. 3 – illustration of the path used for spiral drilling, following the blue arrows first, then the red ones.

RESULTS

The processed parts are shown in the following pictures.

Fig. 4a

Fig. 4b

Fig. 4a shows the two 1mm dia holes that was drilled on the SiC piece. Fig. 4b shows three 1mm dia holes on the lower left corner for this Fiber SiC material. Fig. 4b also shows the U shaped trench which was also cut on this material.

Microscopic Pictures:-

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

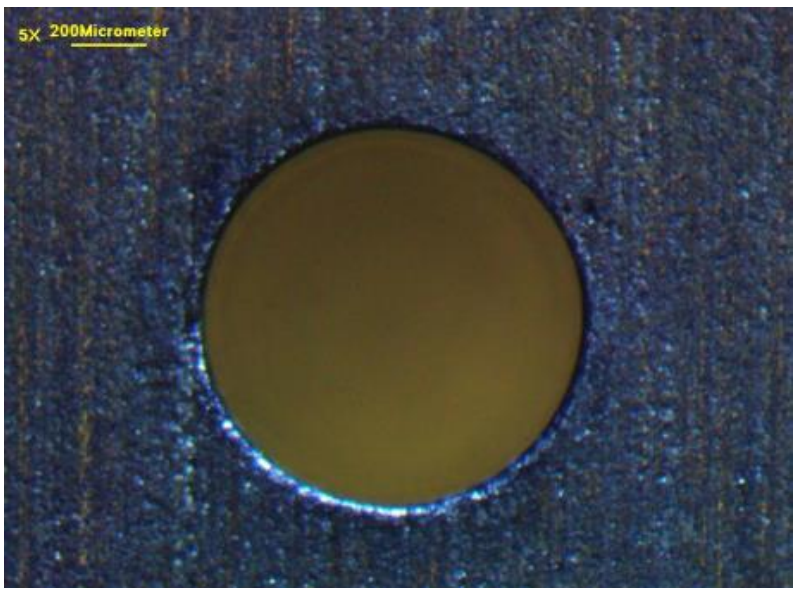


Fig 5: Hole thru SiC – top view

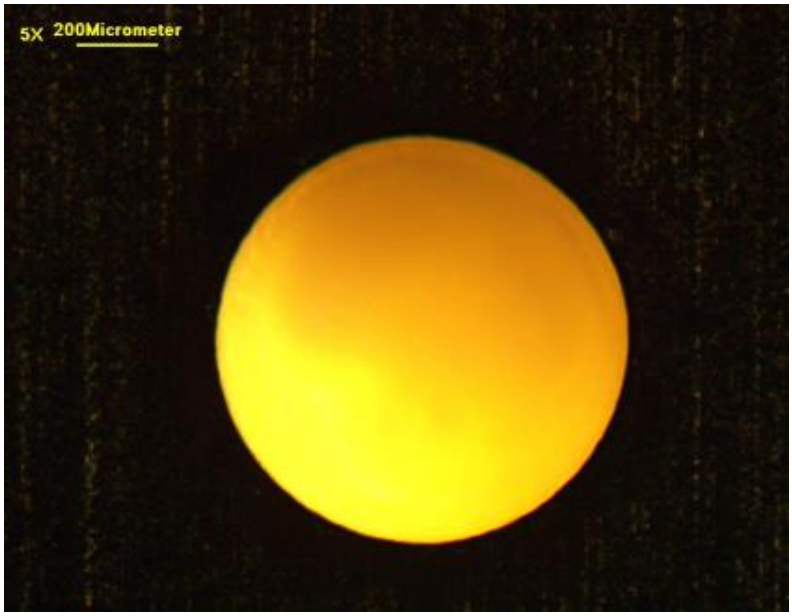


Fig 6: Hole thru SiC – top view – with backside illumination

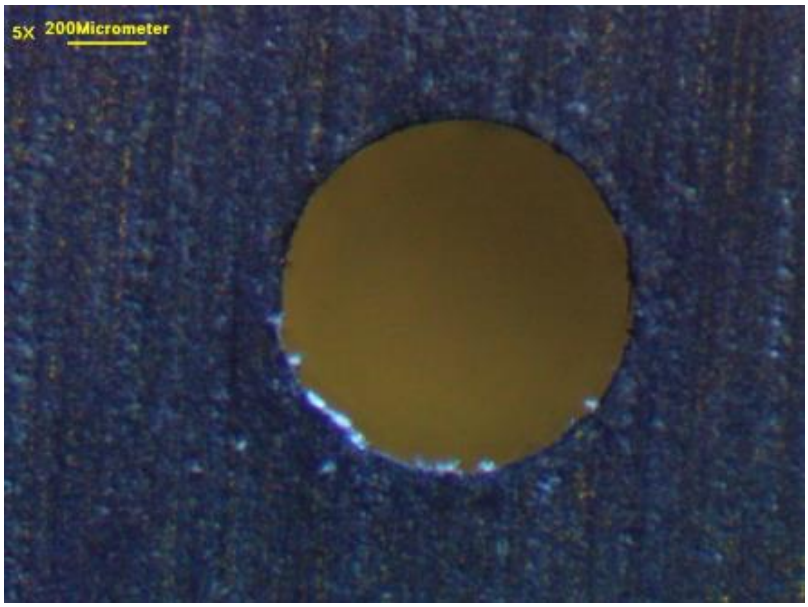


Fig 7: Hole thru SiC – Backside view

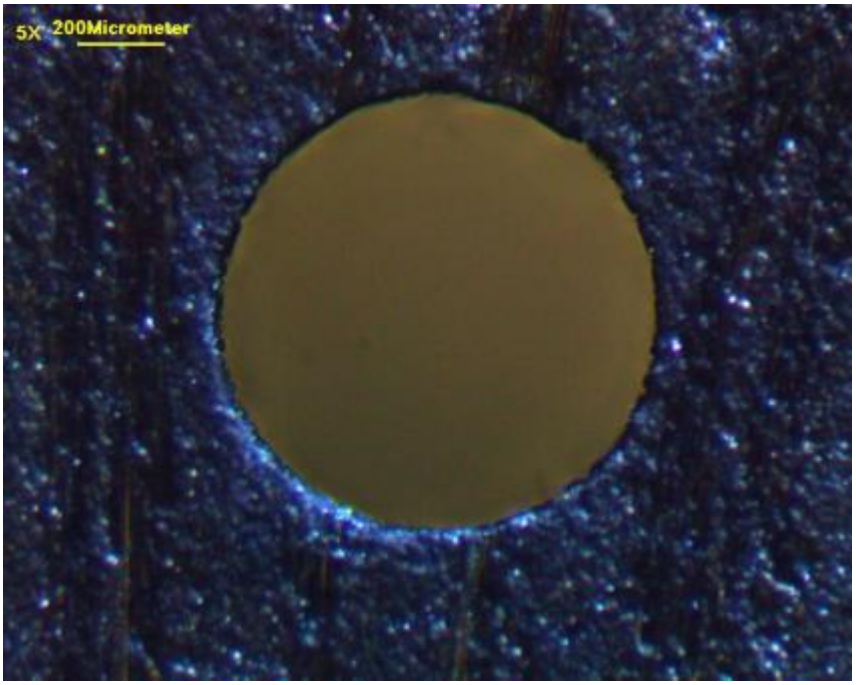


Fig 8: Hole thru Fiber SiC – Top view

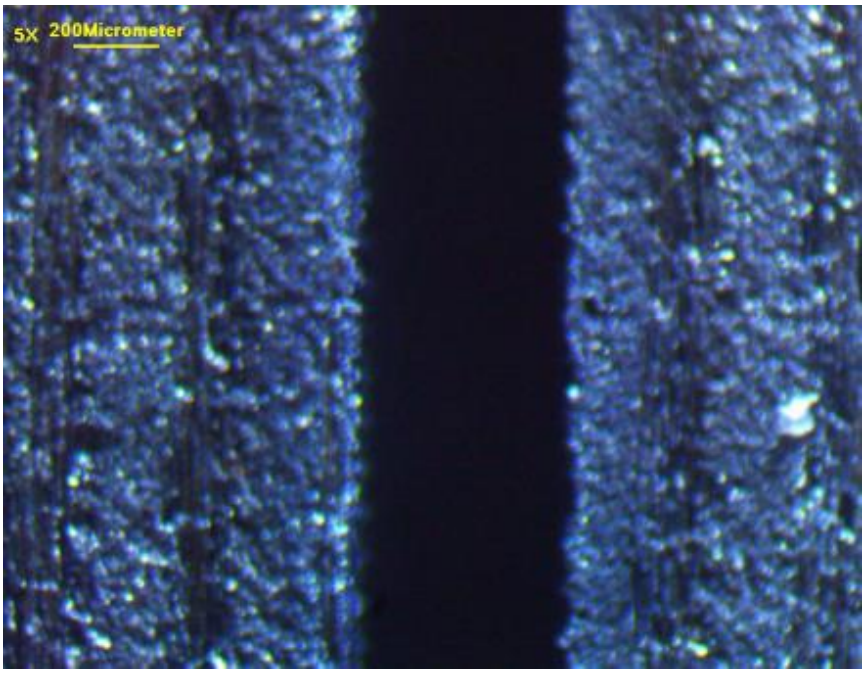


Fig 9: Trench view

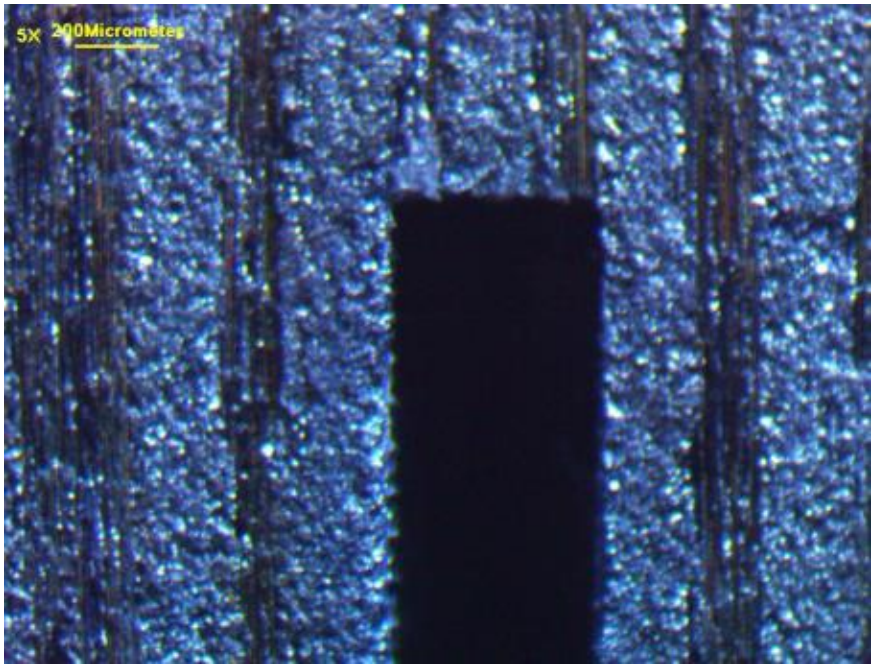


Fig 10: Trench view – showing end of the trench

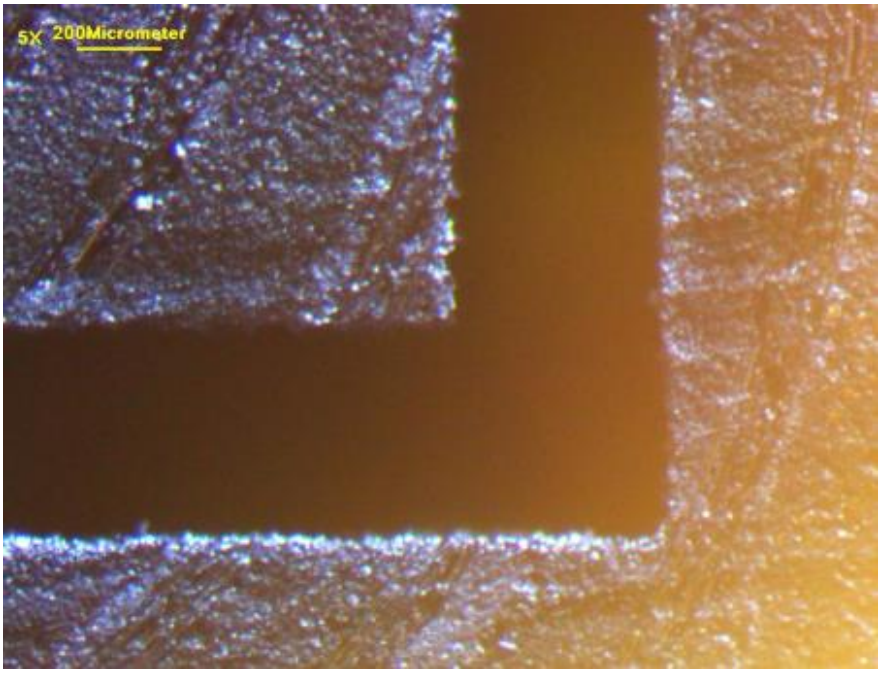


Fig 11: Trench view – showing the corner

DISCUSSION:

It was found that the hole drilling time was much longer in SiC as compared to Fiber SiC. There are various kinds of SiC materials and each of these can have various kinds of light absorption rates.The time for 1mm dia hole thru SiC was about 38 mins but the time to drill the same hole thru Fiber SiC was about 8 mins.

The trench was 0.4572 mm wide and 2mm deep. The depth varied from 1800 microns to 2050 microns and it is very hard to maintain even depth of 2mm. It took long time to drill the trench because we had to groove the materials to create this trench. The drilling time can be significantly improved with dual powered laser.

CONCLUSION

Cutting of thick SiC and Fiber SiC 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.

The cut quality was excellent as can be shown in the microscopic pictures above. The cut was totally free of burrs, heat-damage, and chipping/cracks on the top side. There was very few burr observed on the bottom side of the cut.

The cutting time can be significantly improved using the dual laser.

We thank you for your interest in our technology. We do believe that the Laser Microjet technology offers quality and throughput advantages for cutting Cu sheet with LCP coating in the long run.