Laser-Microjet dicing of thin compound wafers and low-k wafers

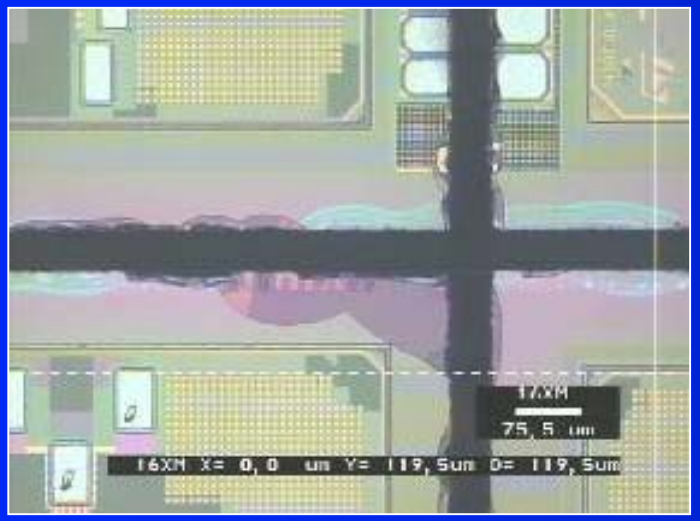
Tuan Anh Mai
Bernold Richerzhagen
Roy Housh
Delphine Perrottet

Synova SA, Ecublens, Switzerland

Thin compound wafers

New materials are increasingly used in the semiconductor industry:

- Compound semiconductors: GaAs, InP, SiC
- Low-k materials



Typical chipping and delamination of low-k layers due to abrasive sawing

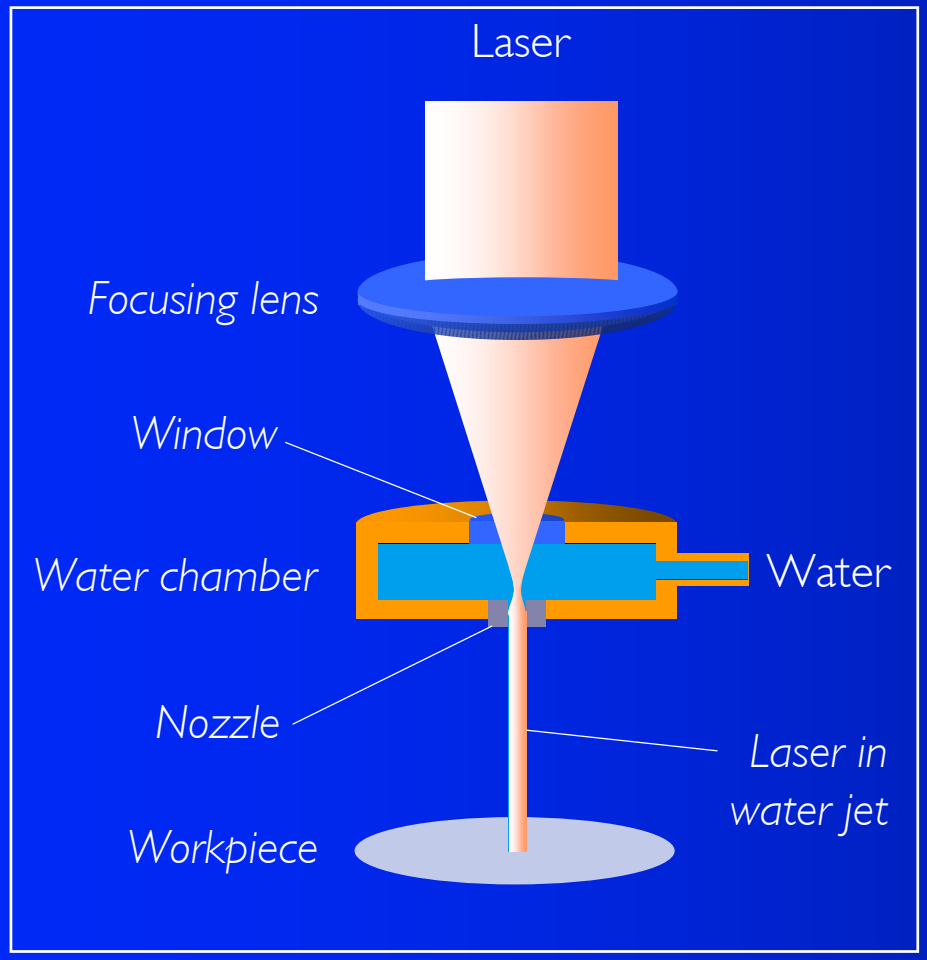
Additionally, the part of thin wafers (thickness below 100 microns) is increasing.

→ Dicing with mechanical methods becomes more and more difficult, due to:

- Chipping
- Cracking
- Low fracture strength
- Significant tool wear

→ **A new damage-free technology is needed**

Water jet guided laser



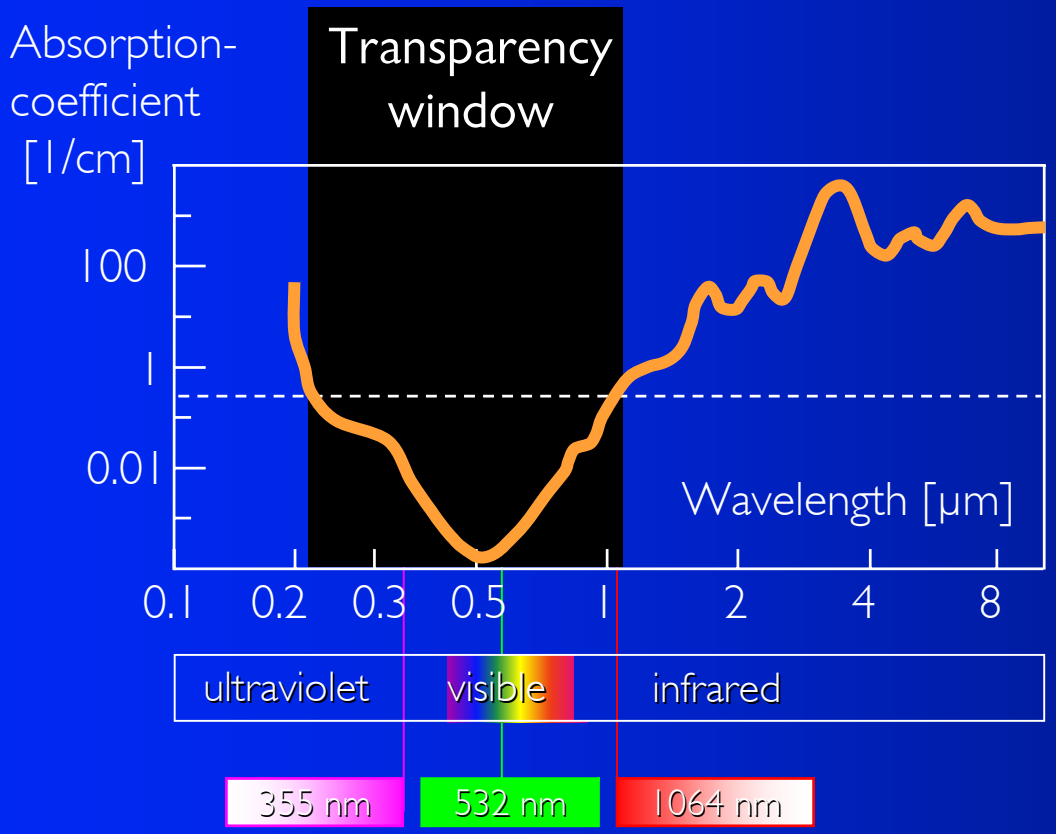
Principle

The water jet acts as a fiber of variable length for guiding the laser beam by total internal reflection.

The Laser-Microjet can process a wide range of semiconductor materials with high precision and quality - including the most brittle.

Laser sources

Pulsed all solid state lasers (Nd:YAG)



Average Power
50–200 W

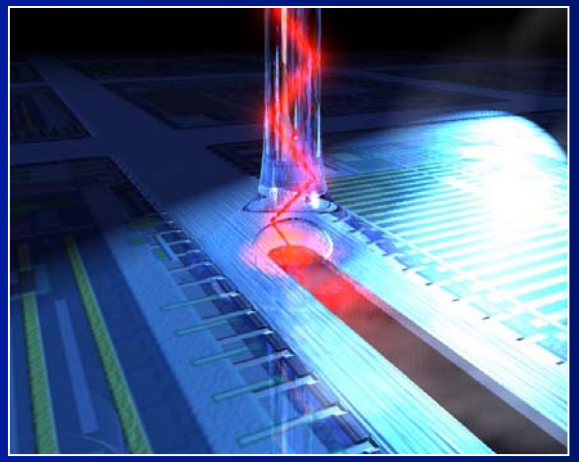
Pulse duration
0.1–100 µs

Pulse repetition rate
0.5–50 kHz

Water jet guided laser

Advantages

- Efficient particle removal of the molten material
- Cooling of the material between the laser pulses (no HAZ)
- Long working range → No need of focus control
- No contamination, thanks to a thin protective water film
- Very small tool size (diameter 23 to 60 μm)
- Negligible mechanical force (less than 0.1 N)
- Low water consumption (1 L/hour at 300 bars)



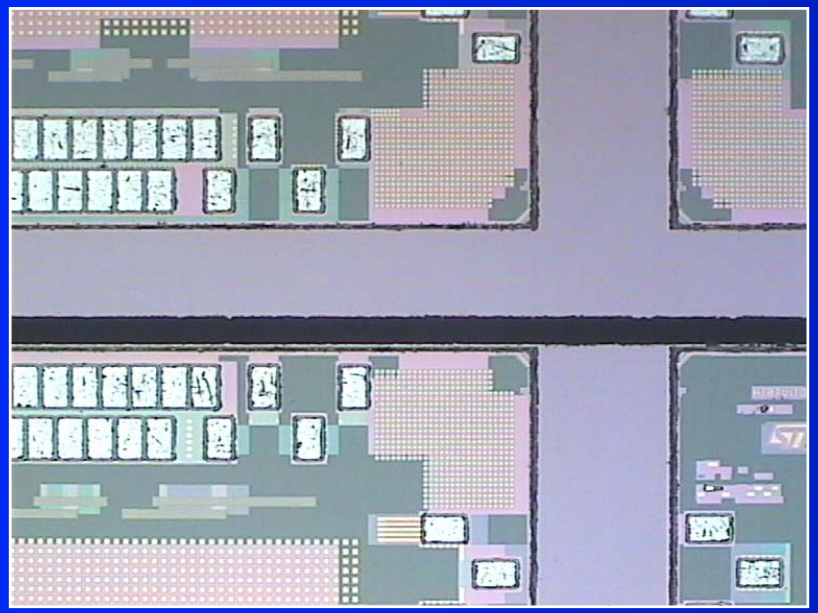
Technical parameters

- Multimode Q-switched lasers (infrared, green or UV) of up to 100 W
- Pure de-ionized and filtered water
- Water pressure: 50 to 500 bars
- Nozzles: sapphire or diamond

Dicing of low-k wafers

Using the water jet guided technology, gentle wafer dicing of thin low-k wafers is now possible:

- No chipping
- No thermal load
- No cracks
- Kerf can be very close to the die (3 to 5 microns on the picture)



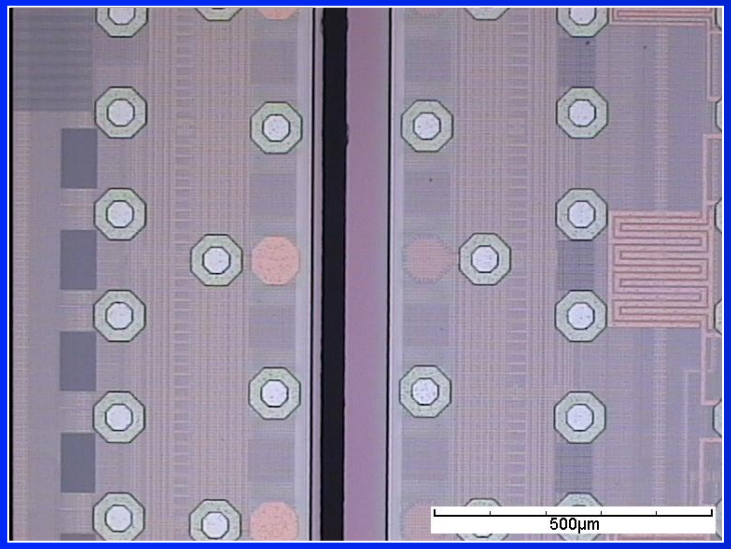
Parameters

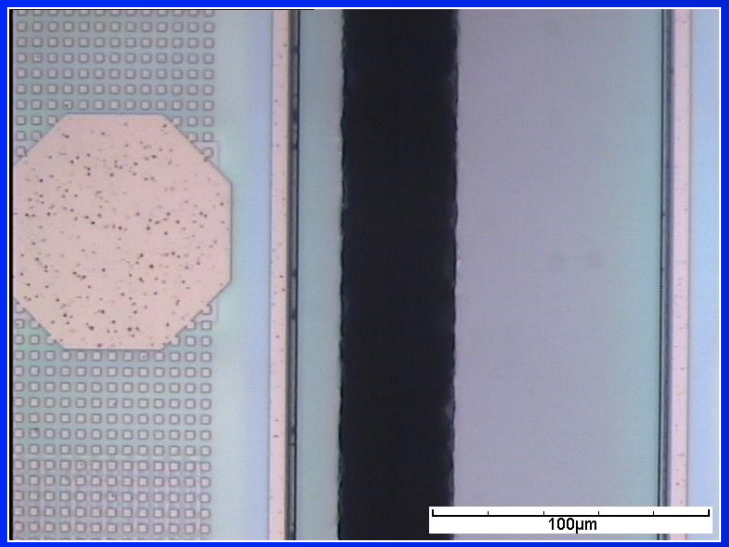
- Green Nd:YAG laser (wavelength: 532 nm)
- Nozzle diameter: 40 µm

Through cutting

- Wafer thickness: 100 µm
- Kerf width: 30 µm
- Cutting speed: 50 mm/s

Dicing of low-k wafers





Parameters

- Green Nd:YAG laser: wavelength 532 nm, average power 60 W
- Water jet diameter: 45 µm

Active area undamaged

Through cutting

- Wafer thickness: 75 µm
- Kerf width: 49 µm
- Cutting speed: 50 mm/s

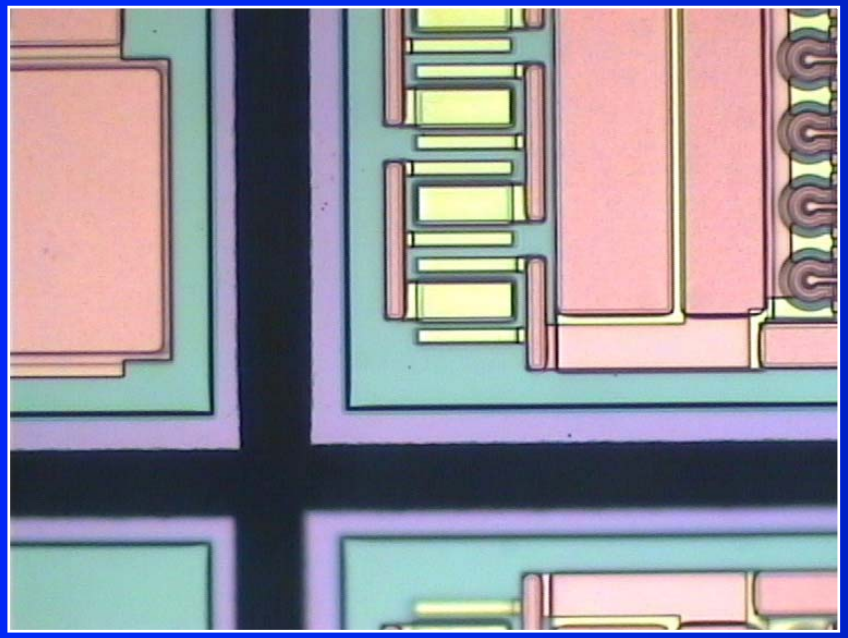
Dicing of GaAs wafers

GaAs is a brittle material:

- Mechanical methods generate chipping & cracking
- Conventional dry lasers generate heat damage & contamination; toxic gas is emitted

Advantages of Laser Microjet:

- No heat-affected zone
- High dicing speed
- No mechanical damage
- No emission of toxic gas or products



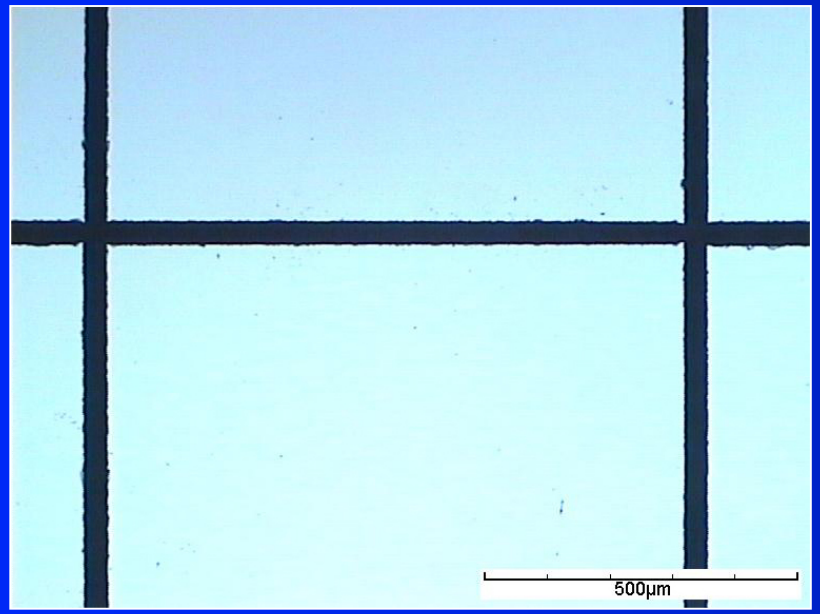
Parameters

- Infrared fiber laser: wavelength 1070 nm, average power 35 W
- Water jet diameter: 23 µm

Through cutting

- Wafer thickness: 100 µm
- Kerf width: 23 µm
- Cutting speed: 40 mm/s

Dicing of InP wafers



Parameters

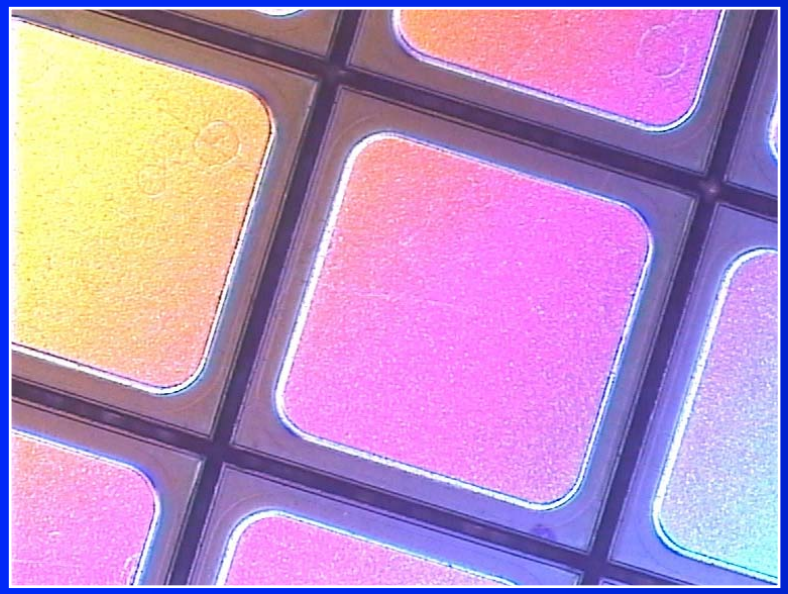
- Green Nd:YAG laser: wavelength 532 nm, average power 13 W
- Water jet diameter: 32 µm

Through cutting

- Wafer thickness: 100 µm
- Kerf width: 35 µm
- Cutting speed: 40 mm/s

- High process rates
- No chipping
- Parallel and smooth cut walls
- No need of protection layers

Dicing of SiC wafers



Through cutting

- Wafer thickness: 380 µm
- Kerf width: 45 µm
- Cutting speed improved of 40% compared to abrasive sawing (4.6 mm/s)

Parameters

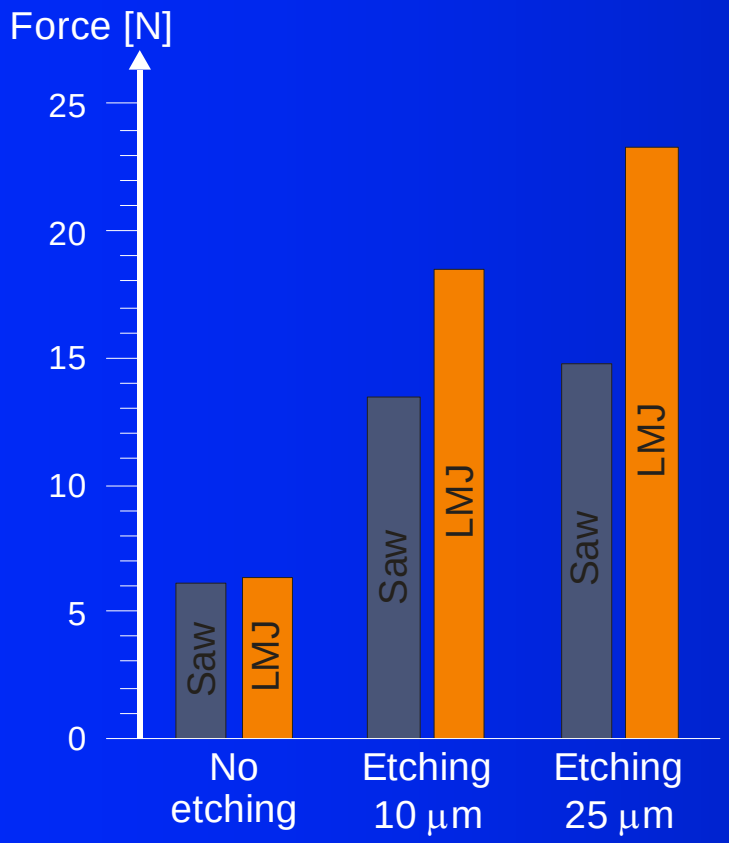
- Infrared laser: wavelength 1064 nm, average power 56 W
- Water jet diameter: 40 µm

The most significant issue with SiC is blade wear, which is approximately 100 to 500 times higher than for silicon.

→ Laser-Microjet has a lower cost of ownership, since there are no concerns with blade replacement and tool wear.

New fracture strength tests (silicon)

Following 2004 tests, which had proved an increase in fracture strength of **1.3** using the Laser Microjet compared to dicing after grinding, new tests have been conducted with a customer (Infineon Technologies) to highlight the influence of stress-release methods combined to LMJ dicing.



	Etching depth [µm]			
	0	*10*	*25*	
Fracture strength [N]	6.1	13.4	14.8	**Saw**
	6.3	18.5	23.3	**LMJ**

When a stress-release method is applied prior to Laser-Microjet dicing, die fracture strength is up to **1.5** times higher than with an abrasive saw.

The damages from grinding are more important than the ones from dicing. Only after stress release, the dicing damage has an influence.

Cost of Ownership (silicon)

		Cost of Ownership (Euros / hour)		
		Saw	LMJ	Comparison
	Investment	10	15.93	
Consumption	DI water	2.40	0.23	
Consumption	Blades	3.75	0	
Consumption	Lamps	0	1.20	
Consumption	Glasses, Nozzles	0	0.60	
Consumption	Electricity	0.40	0.90	
Consumption	Air/Nitrogen	1.56	0.52	
Other Costs	Cleanroom	0.85	0.91	
Other Costs	Operator	11.39	6.83	
Total Running Costs		**20.35**	**11.19**	

Study conducted by International Rectifier

Wafer thickness: 50 µm

Number of machines for identical throuput	
Saw	6
LMJ	1

Cost saving using the Laser-Microjet

Per year	-1.2 million Euros
After 5 years	-5.9 million Euros

Wafer thickness: 200 µm

Number of machines for identical throuput	
Saw	1.8
LMJ	1

Cost saving using the Laser-Microjet

Per year	-0.2 million Euros
After 5 years	-1.01 million Euros

The Water Jet Guided Laser