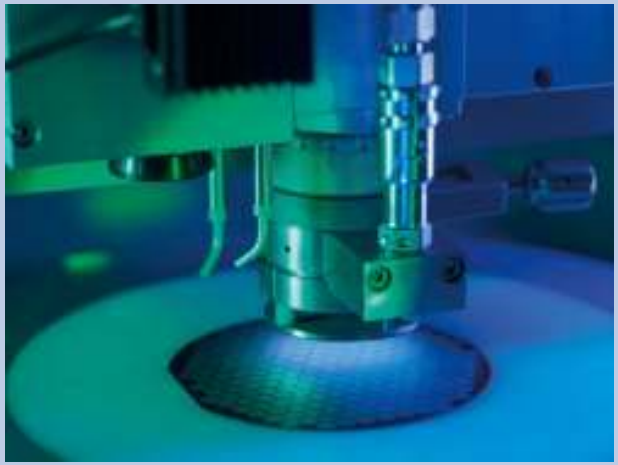


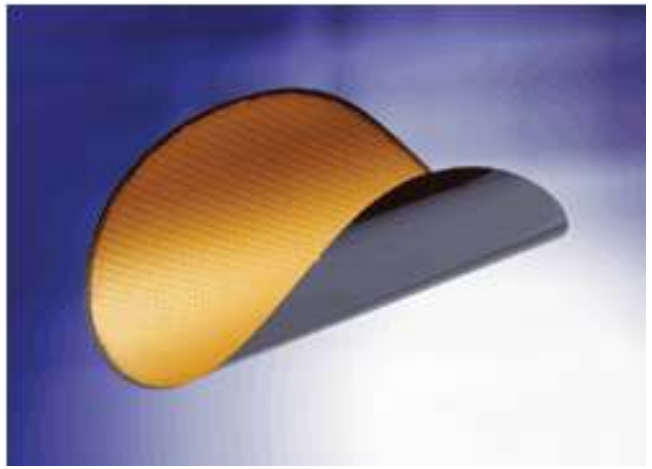
SYNOVA

Innovative Laser Systems

Semiconductors
Power Devices

Agenda

- Synova History
- Laser MicroJet Technology (LMJ®)
- Market and Technology Overview
- Applications done by Synova
- Thin Wafer Processes
  - Taiko Ring, Temporary Bonding
- Solutions and Benefits



Partnering for the future

- Holland Private Equity (HPE) has invested 20M CHF in October 2011 for a minority stake in Synova S.A.

- Solid multiyear foundation in place:
  - To strenghten our Supply Chain and partner with Strategic Suppliers
  - Increase our Global Infrastructure for Sales and Support
  - Add Micro Machining Centers in South Korea, the USA and China
  - Invest in Strategic Developments to exceed our Customer's actual requirements and future expectations
  - Strengthen our core competencies

History

- Synova S.A. has shipped over 100 Systems since 1997 across the World

- Our Innovative Laser Systems and unique technology has been recognized by several awards

"Water jet guided laser performs miracles"

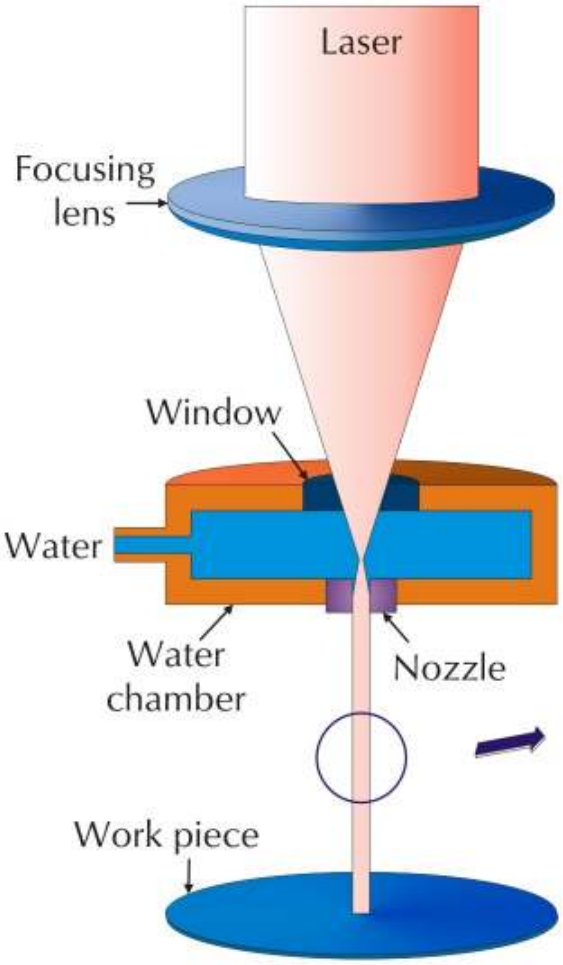
"Miles away from conventional laser"

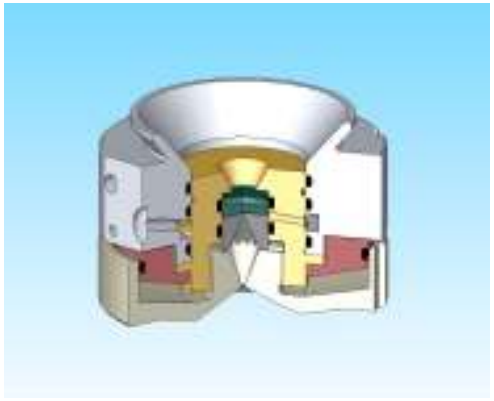
"Going where no other laser can go"

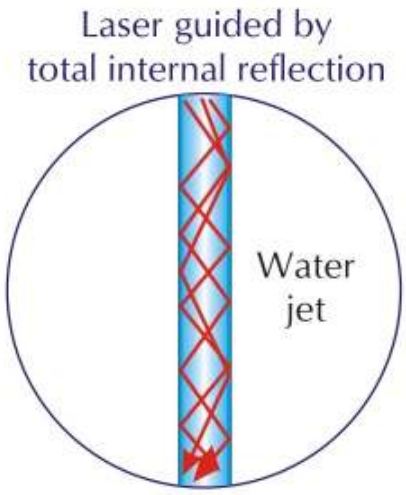
Global Infrastructure

Laser Microjet Technology - a simple principle

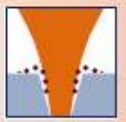
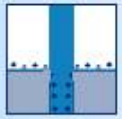
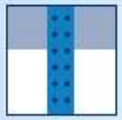
- **A Revolution in Micromachining**
- For the first time ever, it is possible to combine the advantages of both water and laser cutting in one operation. Utilizing the difference in the refractive indices of air and water, the technology behind Laser MicroJet® creates a laser beam that is completely reflected at the air-water interface.
- The laser is, therefore, entirely contained within the water jet as a parallel beam, similar in principle to an optical fiber.







Technology advantages

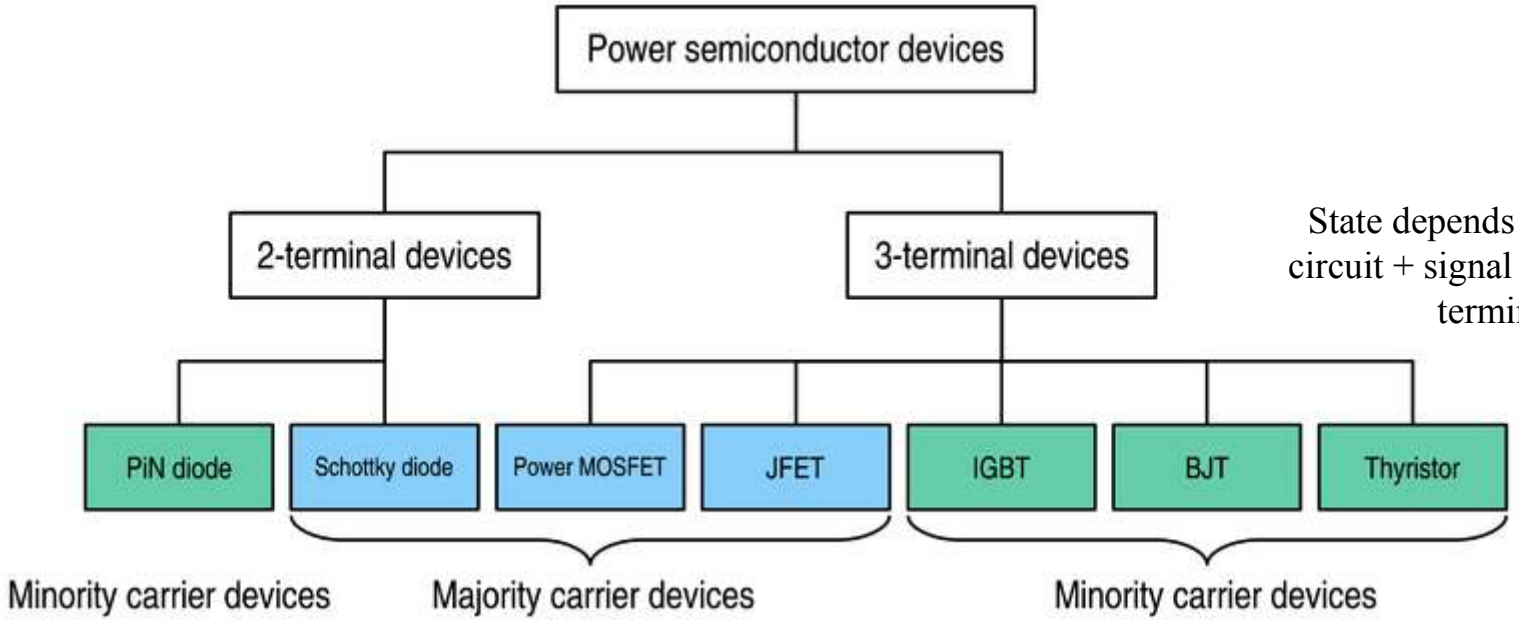
Conventional Laser		Laser MicroJet®
Requires precise focus adjustment		 No focus adjustment required, non-flat surfaces are not an issue, 3D cutting possible, variable cutting depth of up to several cm
Conical laser beam leaves non-parallel kerf walls		 Cylindrical beam results in parallel kerf walls, consistent high quality cutting
Limitations in cutting aspect ratio		 High aspect ratio, very small kerf widths (< 30 µm possible), minimising material loss, with simultaneous deep cuts possible
Heat affected zone		 Water-cooling process avoids thermal damage and material change, high fracture strength is maintained
Particle deposition		 A thin water film eliminates particle deposition and contamination, no surface protection layer required
Inefficient material removal leaves burrs		 The high kinetic energy of the water jet expels molten material, no burrs form

The LMJ solves all drawbacks of conventional lasers

Power Semiconductors…Market Overview

- Technology Overview and Drivers
- Market Research

Power Semiconductor Classification

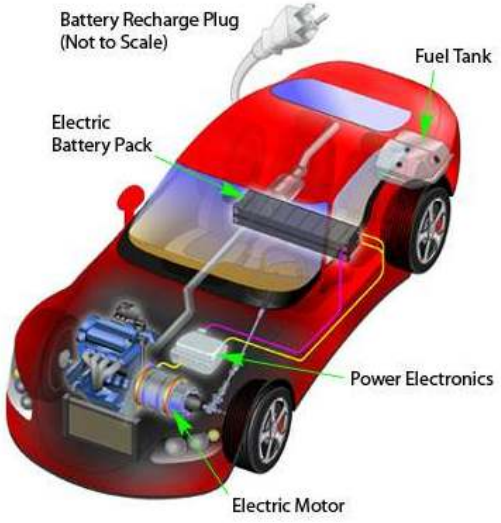


State depends on external circuit + signal from driving terminal

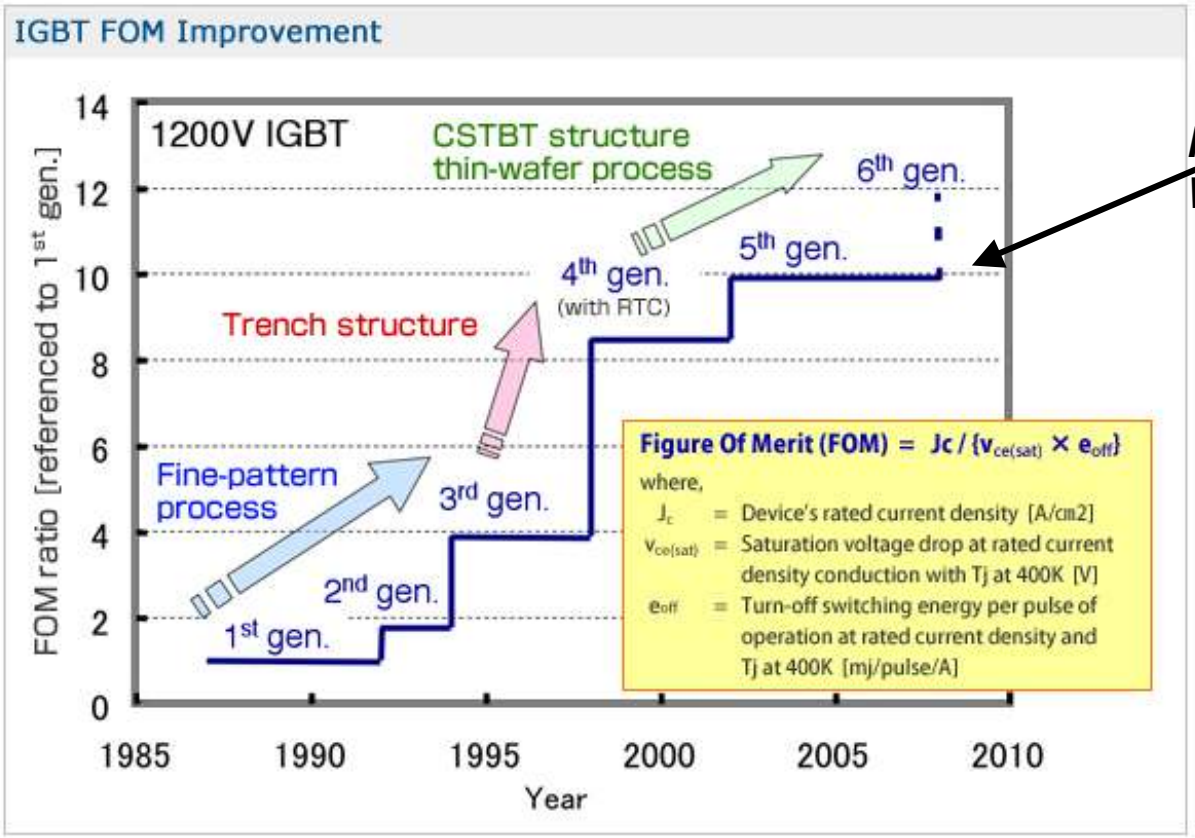
Both electrons and holes
Better on-state performance

Major Drivers

- Traction
- Renewable energy
- Hybrid & Electric Vehicles
- High-power industrial drives
- Induction Heating and welding
- Consumer applications – Chinese Market
  - Appliances
  - Air Conditioning



IGBT Evolution



Need n-Field Stop Technology With Thinner Wafers

FOM shows that performance improved approximately fourfold between the 1st and 3rd-generation chips. And if the performance of the 1st-generation chip is compared with that of the current 5th-generation chip, it has improved approximately tenfold. As we proceed with the development of the 6th-generation device, our aim is to achieve not only even lower power loss, but also an improvement in performance indicators of approximately 30% as compared to the 5th-generation chip.

From Mitsubishi

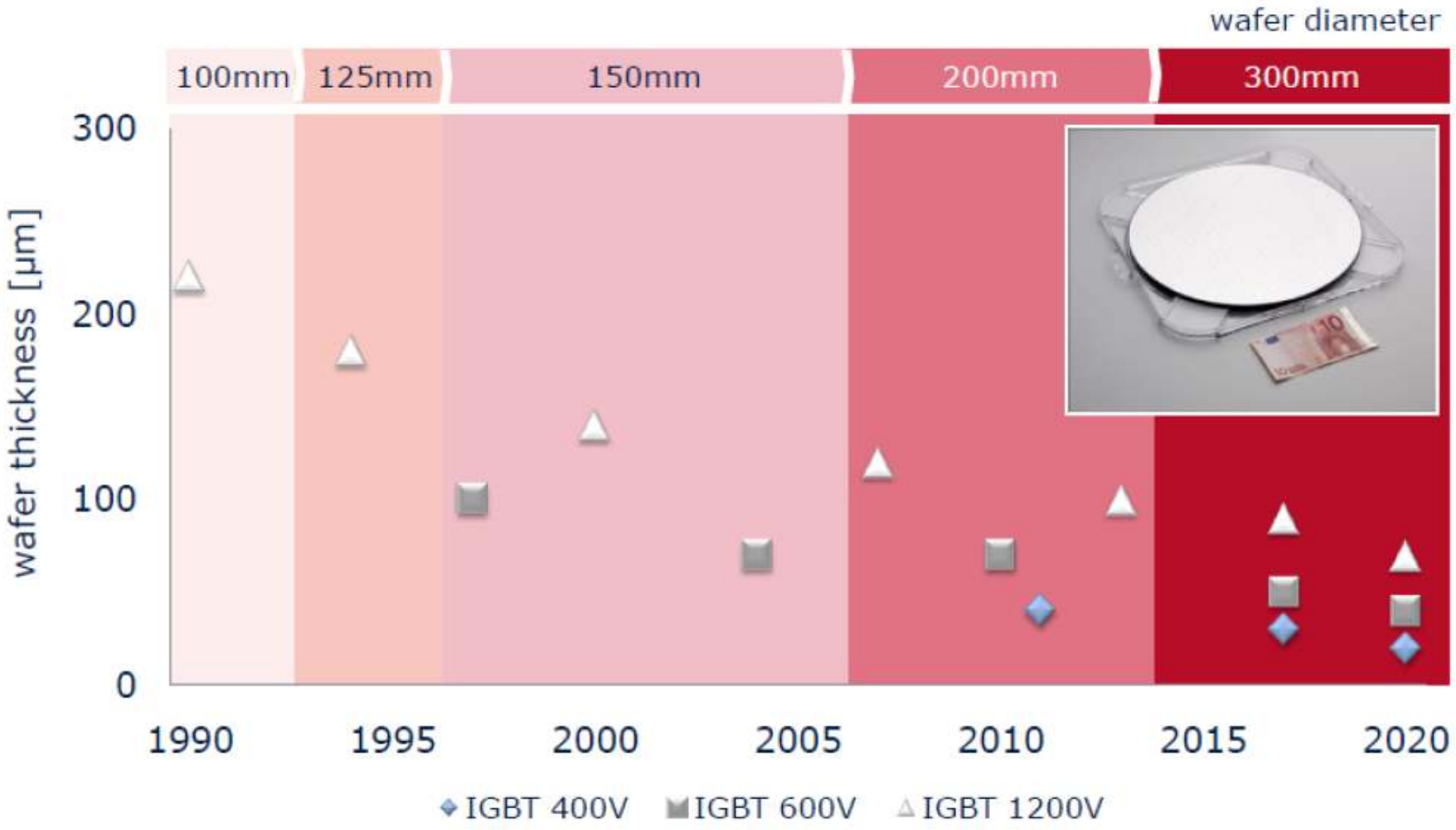
SiC and GaN for future applications

Main applications accessible to SiC and GaN
Specs / market data of today silicon devices

	Power supplies / PFC	UPS	HEV	Solar panel	Wind turbine	Industry Motor Drives	Energy Transport. Grid, Rail traction
Main devices	MOSFET Diodes	MOSFET IGBT Diodes	MOSFET IGBT Diodes	IGBT Diodes	IGBT Diodes	IGBT Diodes	GTO, Thyristor, IGBT PiN diode
Breakdown Voltage (V)	600 V	600 / 1200 V	650 V -> 900 V -> 1.2kV	600 V (90%) 1200 V (10%)	Today 690 V Trend: 3-4 kV	600 V to 1200 V	> 5 kV
Peek current (A) (for a single chip)	0.5 – 10 A	2 – 100 A	50 - 200 A	75 A	150 A	3 – 100 A	10 – 200 A
2008 volume (Munits)	MOS: 1,600 Diode: 1,600	IGBT: 800 Diode: 800	IGBT: 2.6 Diode: 2.6	IGBT: 12 Diode: 12	IGBT: 0.11 Diode: 0.11	IGBT: 25 Diode: 25	Wide range of specs / price
2008 ASP for a discrete device	Trans: $0.6 - $1 Diode: $0.3	Trans: $1.2 Diode: $0.6	Trans: $9 Diode: $5	IGBT: $8 Diode: $4	IGBT: $20 Diode: $8	IGBT: $8 Diode: $4	
2008 Si devices market ($M) (Discrete)	1,800	1,400	~ 40	150	< 3	~ 300	~ 110

Total Available Market was $3.8B in 08

Infineon – Wafer Thickness Roadmap

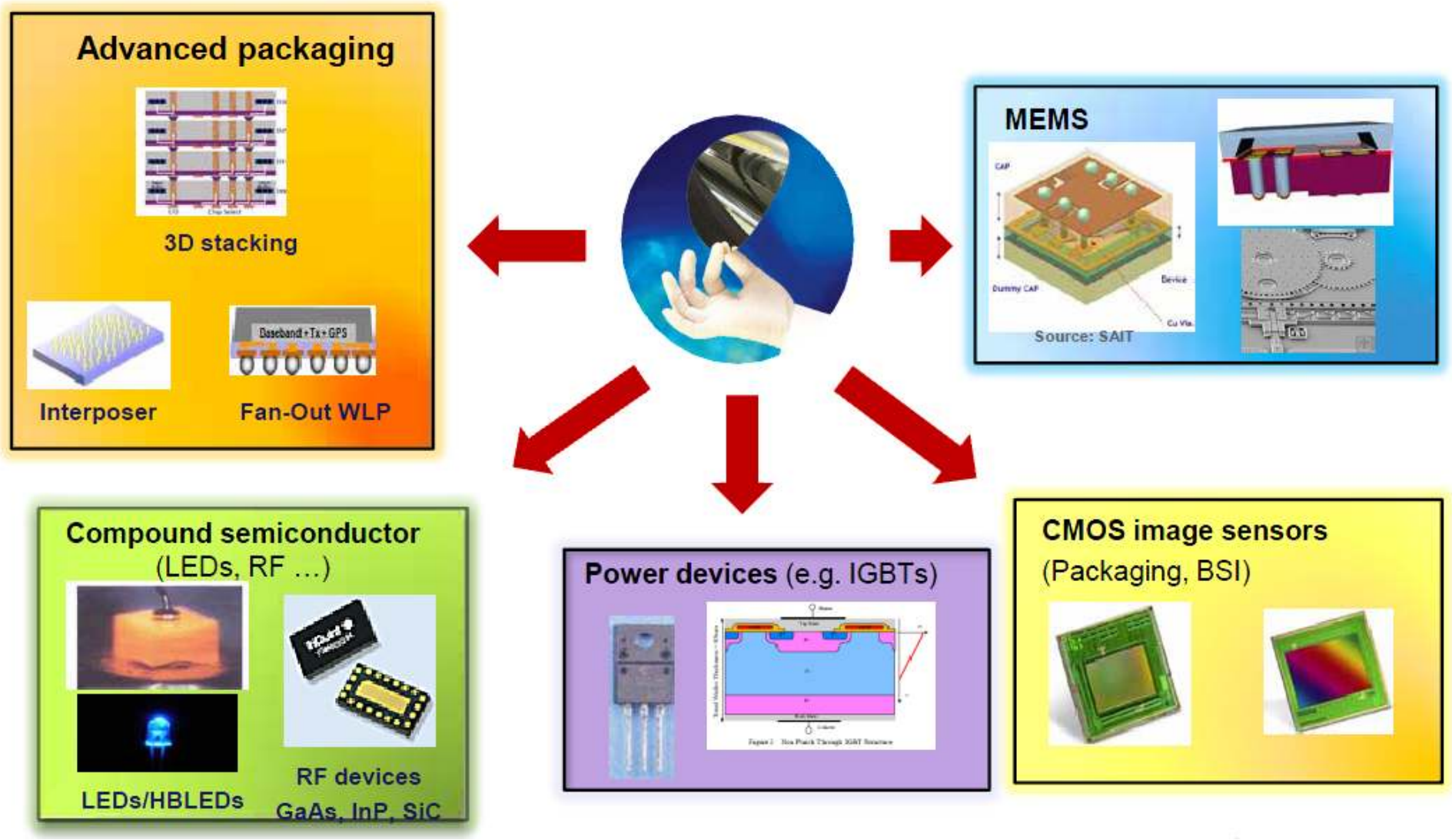


Wafer Thinning

- Established process
  - Thinning through Grinding. Well established for Flash Memory
- Drivers for Power Devices
  - Improved Performance…better battery life
  - Improved Heat Dissipation
- Challenges
  - Additional handling with new post-grinding processes
  - Thickness down to 120 microns
    - Die strength greatly reduced
  - Substantial mechanical problems
  - Breakage
  - Microcracks
  - Reduced Fractural Strength

Drives the need for new laser-based edge removal and dicing

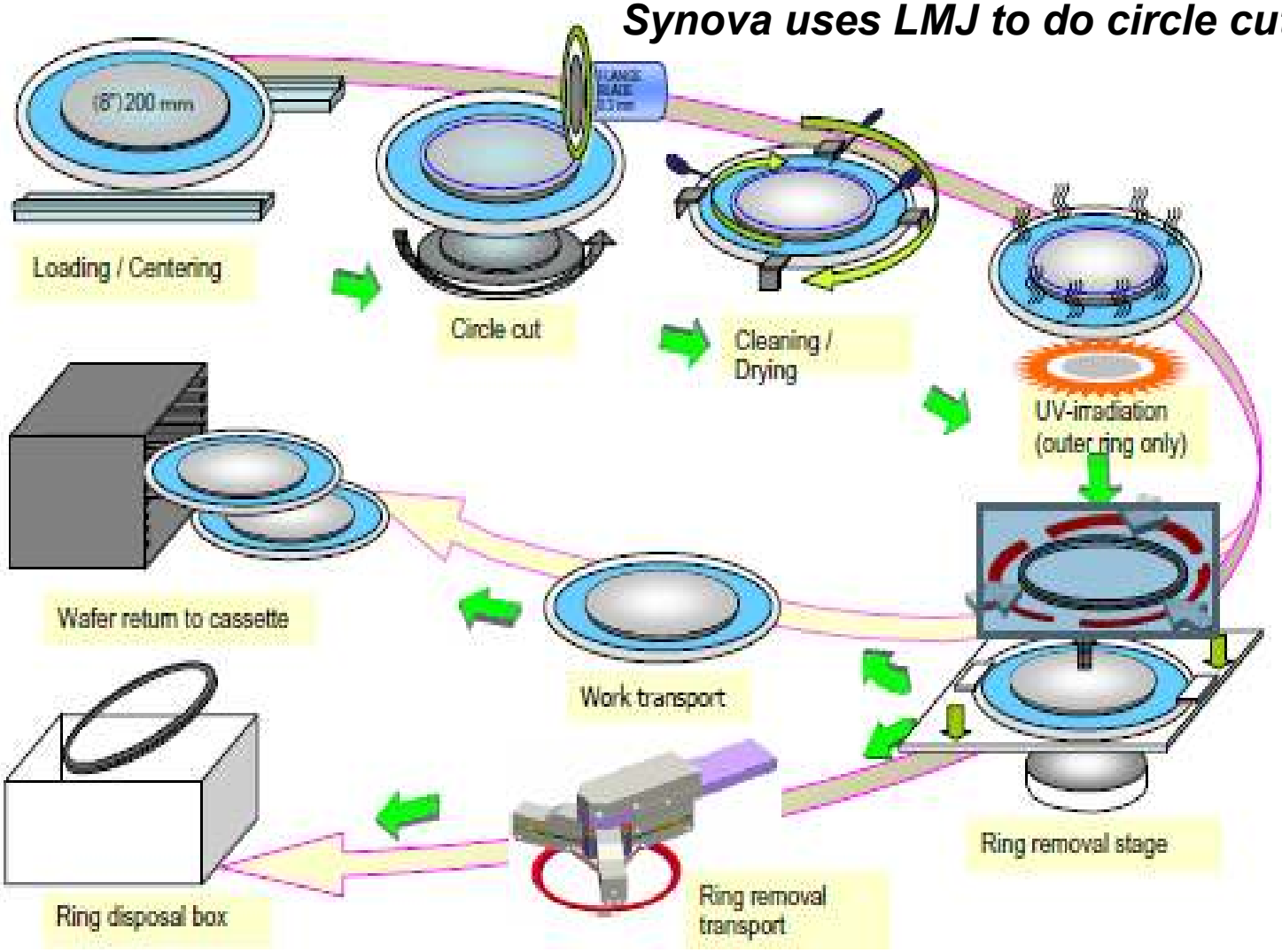
Thin Wafer Applications



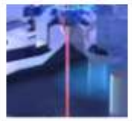
Taiko Wafer

Taiko Ring Process Edge Grinding and Dicing

Synova uses LMJ to do circle cut and dicing

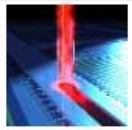


Thin Silicon Wafer Dicing



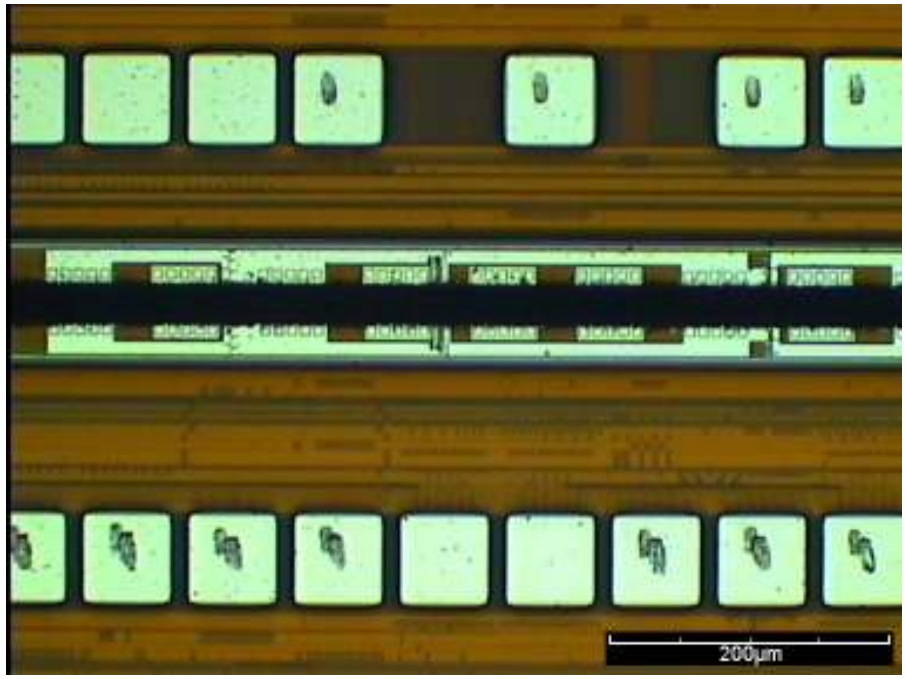
MICROJET® PARAMETER	Nozzle diameter	30	µm
	MicroJet® diameter	27	µm
	Water pressure	450	bar
	Assist gas	He	

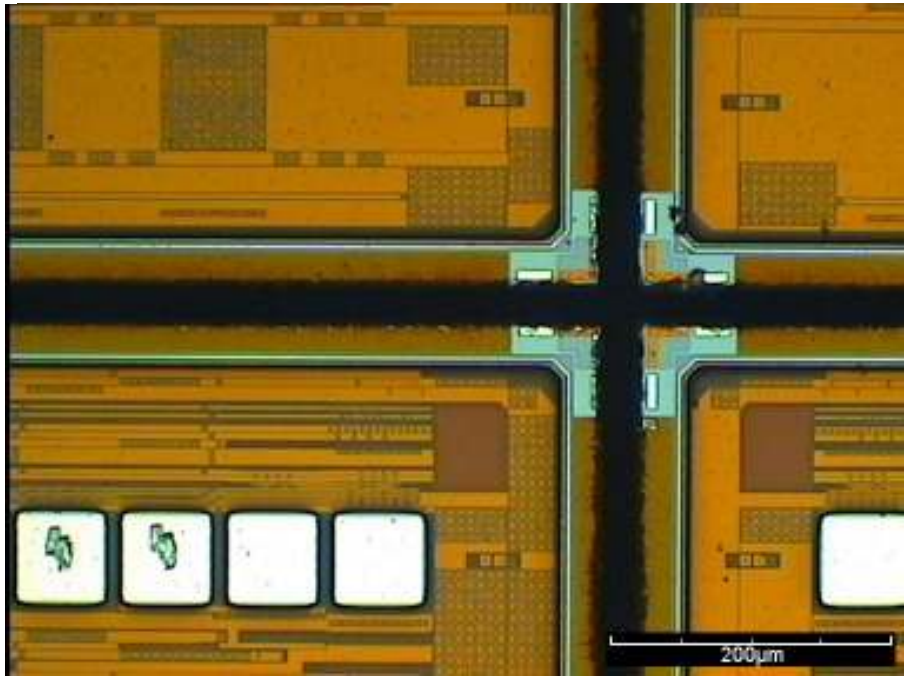
LASER PARAMETER	Laser type	L101G	
	Wavelength	532	nm
	Pulse frequency	40	kHz
	Average power	16	W



CUTTING PARAMETER	Cutting speed	200	mm/s
	Number of passes	8	
	Overall speed	25	mm/s
	Tape	Lintec ADWILL 611	

SAMPLE	Material	Silicon wafers	
	Dimension	Ø 200	mm
	Thickness	150	µm



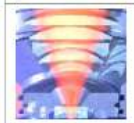


LMJ advantage vs saw: Less chipping, higher fracture strength, higher speed

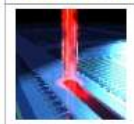
Wafer Egde Grinding

SAMPLE	Material	Silicon wafers	
	Dimension	Ø 150 / 200	*mm*
	Thickness	600	*µm*

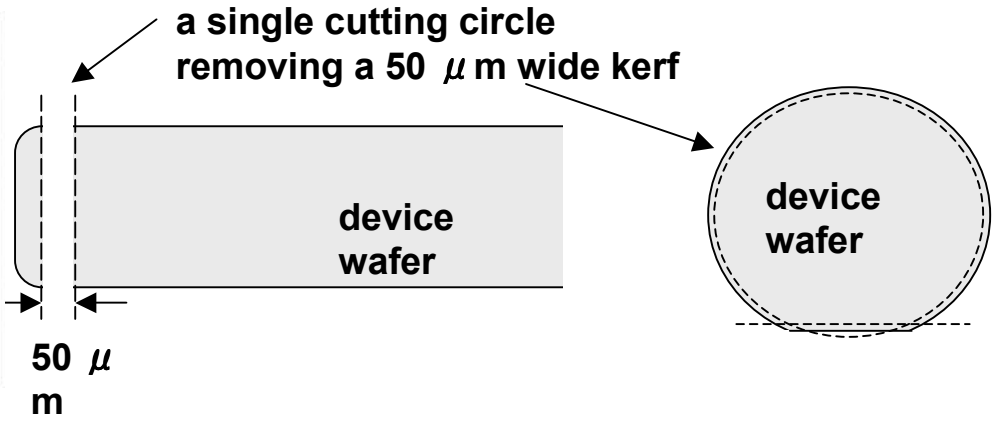
MICROJET® PARAMETER	Nozzle diameter	50	*µm*
	MicroJet® diameter	45	*µm*
	Water pressure	250	*bar*
	Assist gas	He	

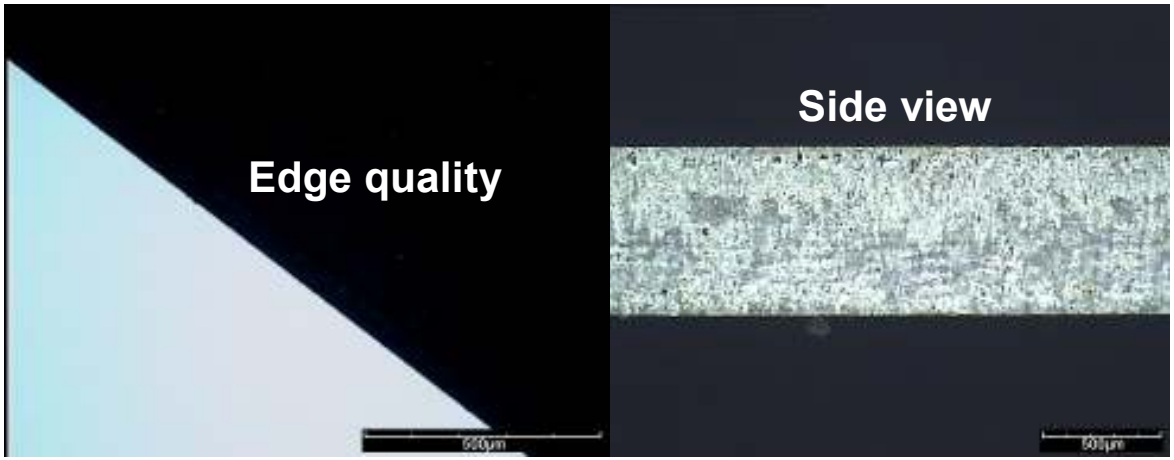


LASER PARAMETER	Laser type	L101G	
	Wavelength	532	*nm*
	Pulse frequency	23	*kHz*
	Average power	33	*W*



CUTTING PARAMETER	Cutting speed	100	*mm/s*
	Number of passes	10	
	Overall speed	10	*mm/s*

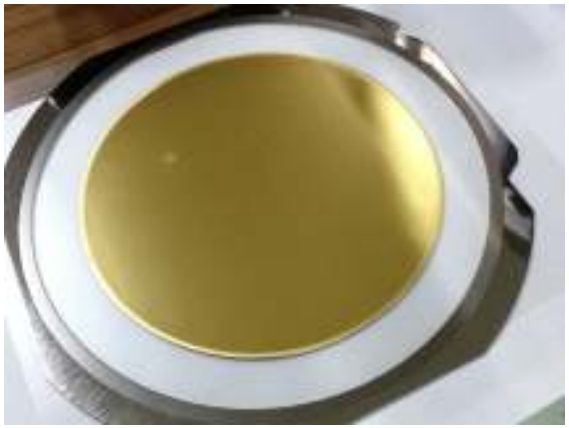




Wafer fracture strength improving before back grinding
→ yield improvement

Edge Grinding for Disco Taiko Wafer

The supporting edge ring can be cut off by the LMJ

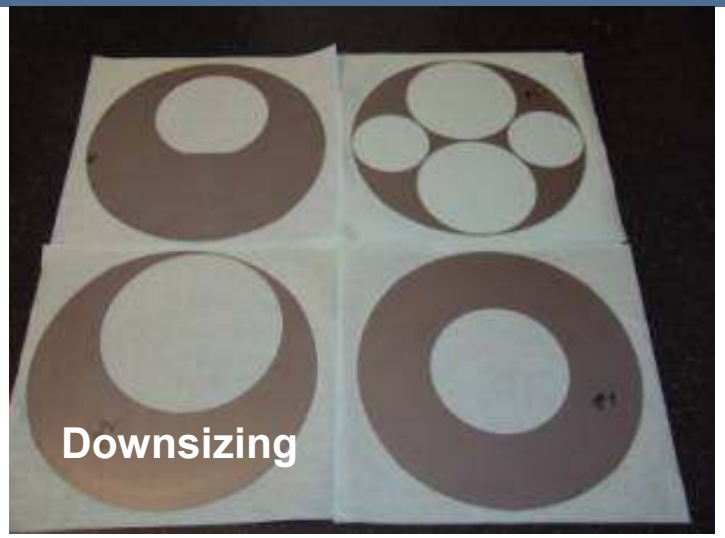


Before edge-grinding:

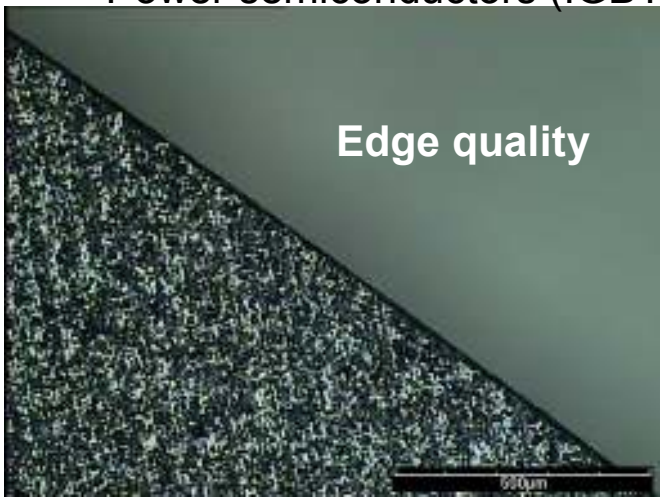
After edge-grinding:

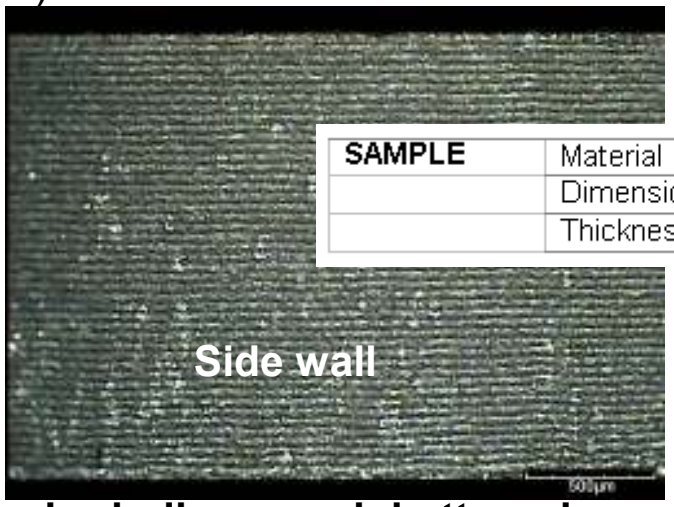
Downsizing

MICROJET® PARAMETER	Nozzle diameter	50	µm
	MicroJet® diameter	45	µm
	Water pressure	350	bar
	Assist gas	He	
LASER PARAMETER	Laser type	L101G	
	Wavelength	532	nm
	Pulse frequency	15	kHz
	Average power	33	W
CUTTING PARAMETER	Cutting speed	120	mm/s
	Ablation per passes	75	µm



- Very successful application for
  - Wafer downsizing
  - Power semiconductors (IGBT, GTO)

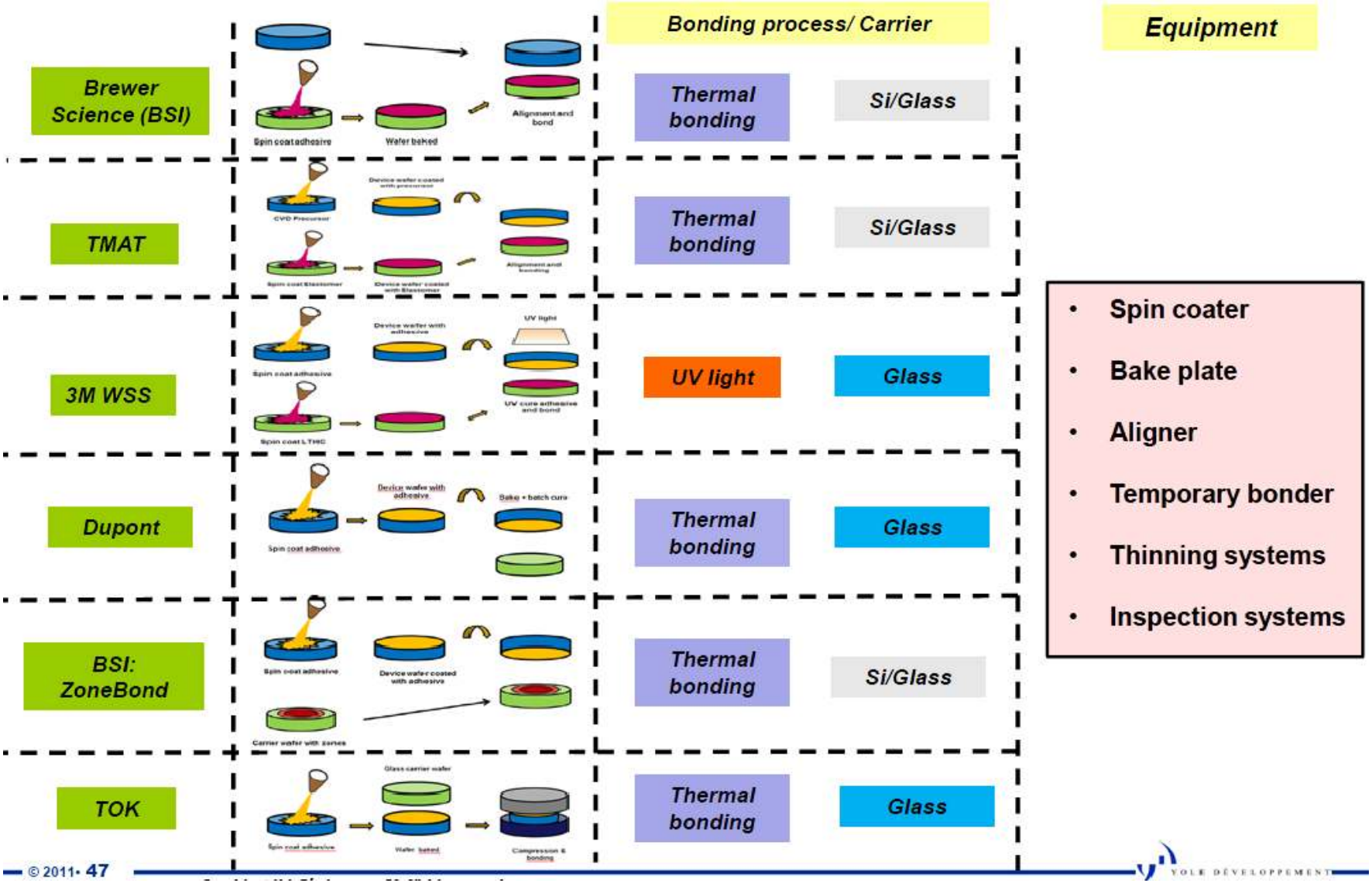




SAMPLE	Material	Silicon wafers	
	Dimension	Ø 100 - 300	mm
	Thickness	300 - 2500	µm

LMJ advantage vs. mechanical grinding: much better edge quality, much less chipping & cracks; any shape possible (incl. flat or notch)

Temporary Bonding Processes

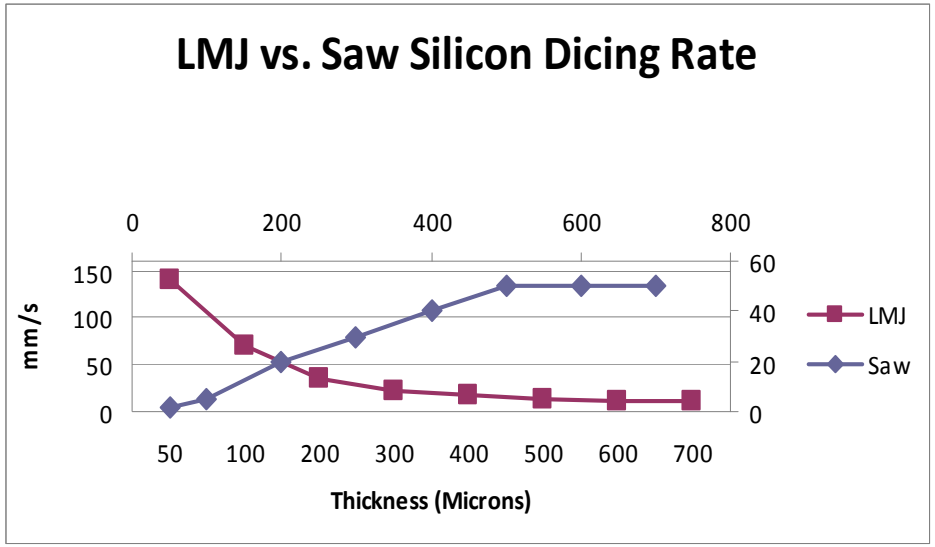


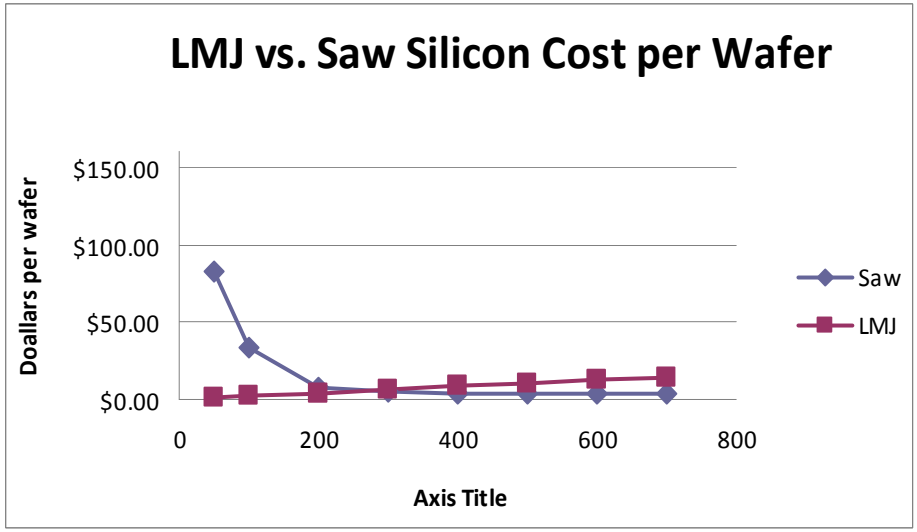
Advantages – Thin Silicon Wafers

	SAW	Laser	**LMJ**
Cost of Ownership	✗	✓	✓
Speed	✗	✓	✓
Edge quality	✗	✗	✓
Tool wear	✗	✓	✓
HAZ	✓	✗	✓
Flexibility	✗	✓	✓
Kerf width	✗	~	✓
Wide range of materials (SiC, GaN)	✗	✓	✓

Benefits for Thin Wafers

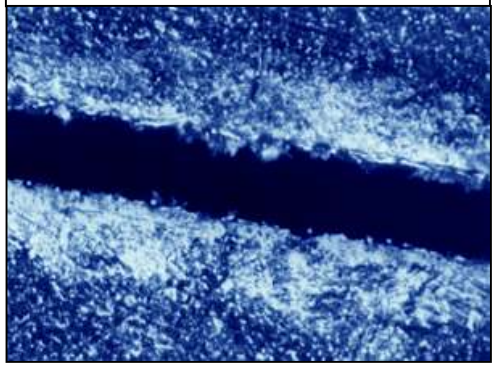
- Mechanical Saws need to slow down dramatically for Thin Wafers. Tool costs also increase. They cannot do Wafers with Flat Notches.
- Dry Lasers need larger Kerfs because of the Heat Affected Zones
- It is possible to do Edge Cutting and Dicing on same machine



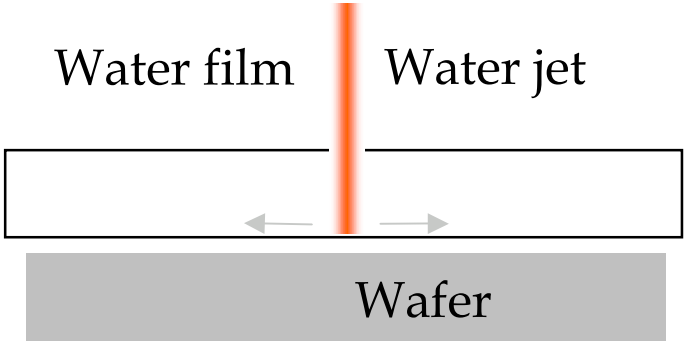


Clean and No Thermal Damage Laser Cutting

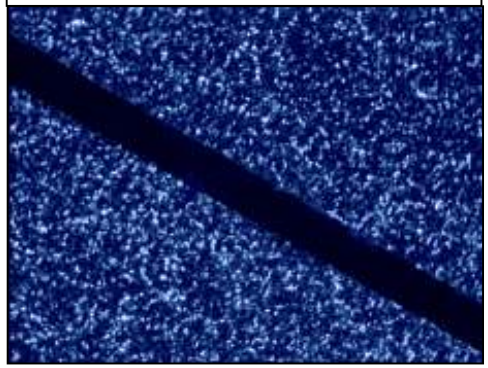
Conventional Laser



As cut – need of protection



Laser-Microjet



As cut – no need of protection

Enables to get clean post cut surface
Ensures Higher Break Strength

Summary for thinner Wafers

- The Laser Microjet technology improves the quality of the cut:
  - Less Mechanical and Thermal stresses than the Mecahnical saw or the Dry laser
- Synova is also cost effective:
  - Saws need to slow down dramatically for thinner wafers and requires more consumable costs
  - Dry lasers are equivalent in terms of speed but they have a lower yield and wider kerf due to thermal stresses
- Synova has done both Edge Cutting for raw wafers and Taiko type Wafers as well as dicing