Enhanced fracture strength of thin wafers and chips due to Laser-Microjet technology

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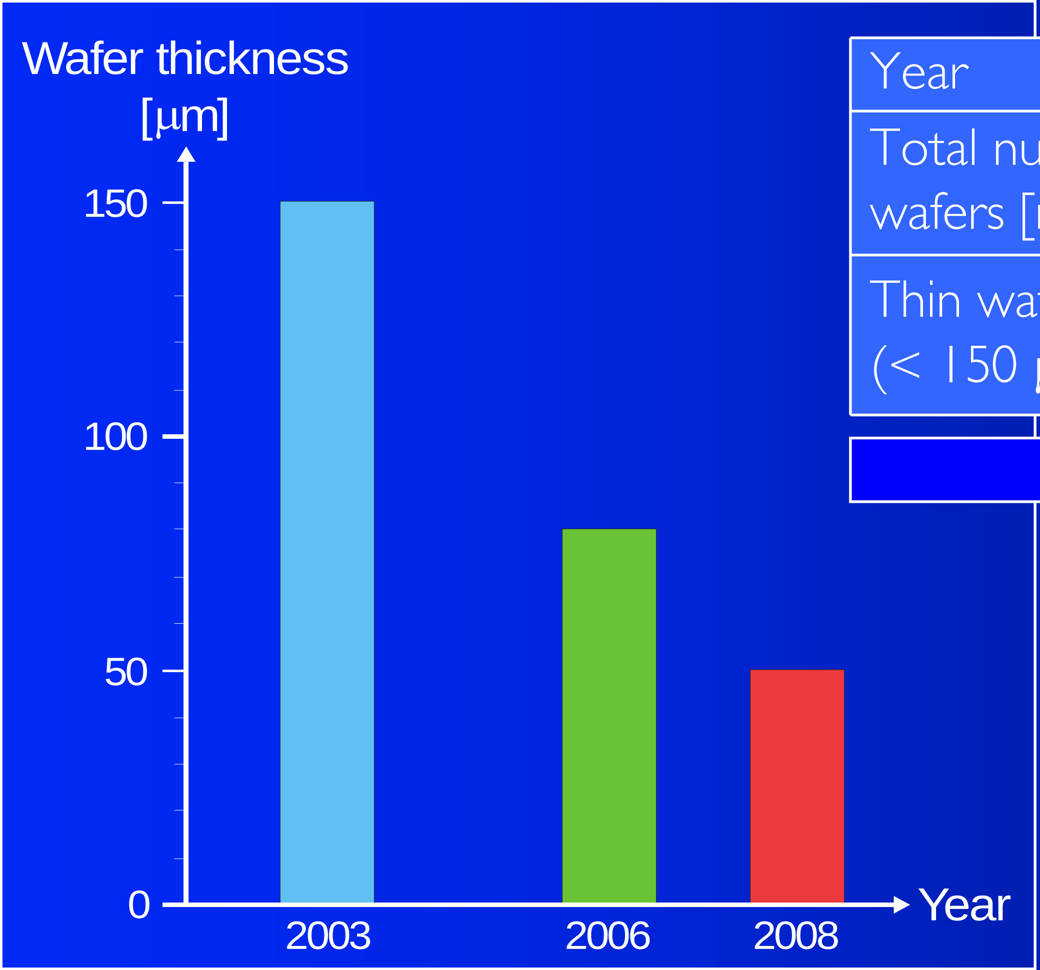
Thin Wafers – Market Trend



*Expected thickness evolution of silicon wafers**

Year		2004	2006	2008
Total number of wafers [millions]		140	140	140
Thin wafers (< 150 µm)	%	< 5%	20 %	30 %
	#	< 7	28	42

*Expected market evolution of thin wafers**

Use of thin wafers for:

- Smart cards
- Stacked packages
- Diodes

➔ The market of thin wafers is expanding!

* *Fraunhofer-Institute for Mechanics of Materials 2004*

Issues with Thin Wafers

Problems on wafer level

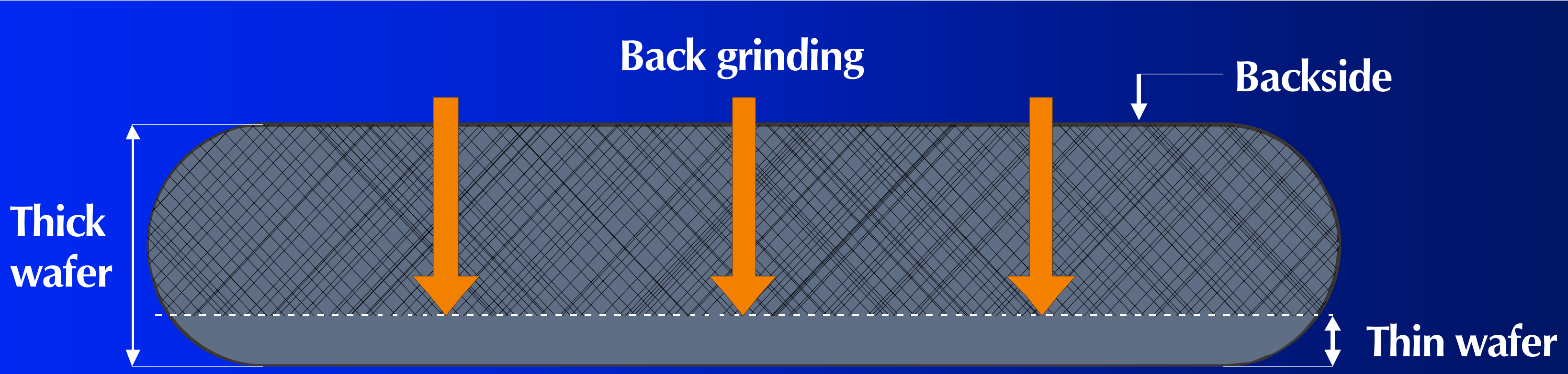
- Damage due to grinding
- Warping of wafer
- Cracking
- Wafer breakage
- Difficult handling

Problems on die level

- Damage due to dicing
- Chipping
- Micro-cracks
- Die breakage
- Difficult handling
- Low fracture strength

→ New solutions are needed!

Back Grinding Damages



Problem

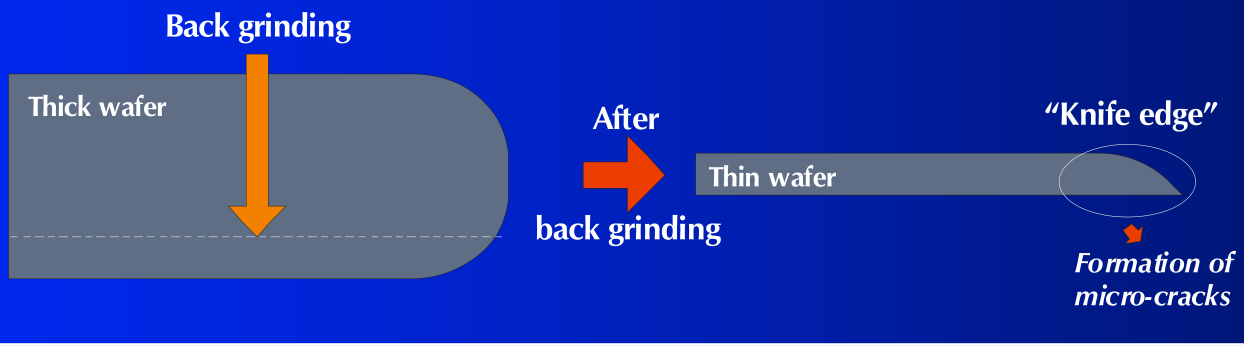
Back grinding induces **damages** on wafers ⇨ During handling, high risk of cracks propagation resulting in wafer **breakage**

Solution

Stress release method after back grinding ⇨ Improved **wafer surface** strength

Method	CMP	Wet etching	Dry etching	Dry polishing
Speed	Low	High	Low	Low
Productivity	Low	High	High	Medium
Running cost	High/Medium	High	Low	Very Low

Edge Damages



Problem

Grinding induces damages on edge

- Wafer breakage
- Irregular, undefined edge
- Micro-cracks

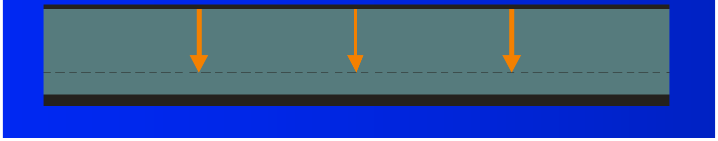
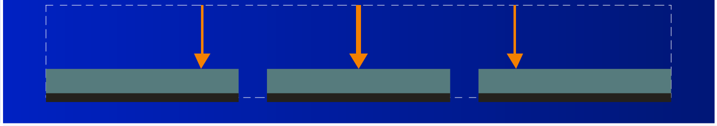
Solution

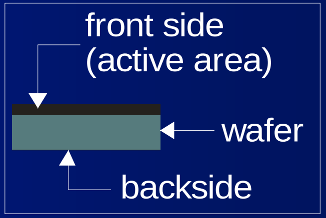
Today, no technology is able to grind or polish the sensitive edge of thin wafers

New damage-free edge grinding technology

Improved **wafer edge** strength

Dicing Damages

	Dicing after grinding	Dicing before grinding
Thick wafer	1) Back grinding 	1) Dicing (grooving) 
Thin wafer	2) Dicing (through cutting) 	2) Back grinding 



Problem

Dicing induces damages on wafers

- ➢ Low die edge fracture strength
- ➢ Chipping
- ➢ Micro-cracks

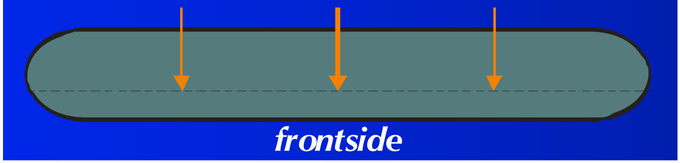
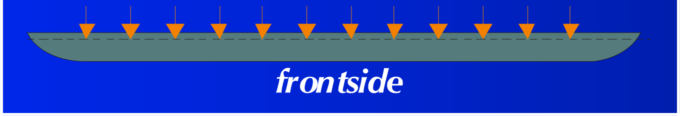
Solution

Today, conventional processes are not able to dice thin wafers

New damage-free dicing technology

Improved **die edge** strength

Complete solution for thin wafers

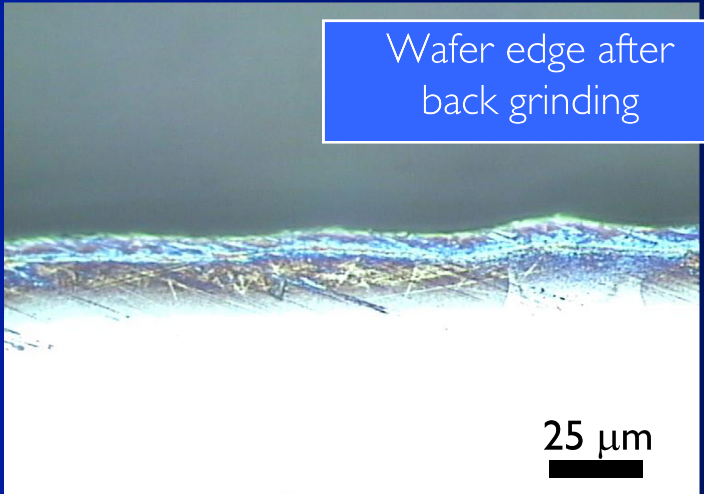
1	Back Grinding	**Grinder**  	• Reduces wafer thickness → thin wafer • Generates micro-cracks and stress
2	Stress Release	**Stress release method**  	• Polishes the thin wafer surface (backside) • Removes surface stress
3	Edge Grinding	**Laser-Microjet**  	• Takes off the thin wafer edge • Removes micro-cracks at the edge
4	Other Backside Processes		
5	Dicing	**Laser-Microjet**  	• Singulates the wafer into chips • Generates no additional damages

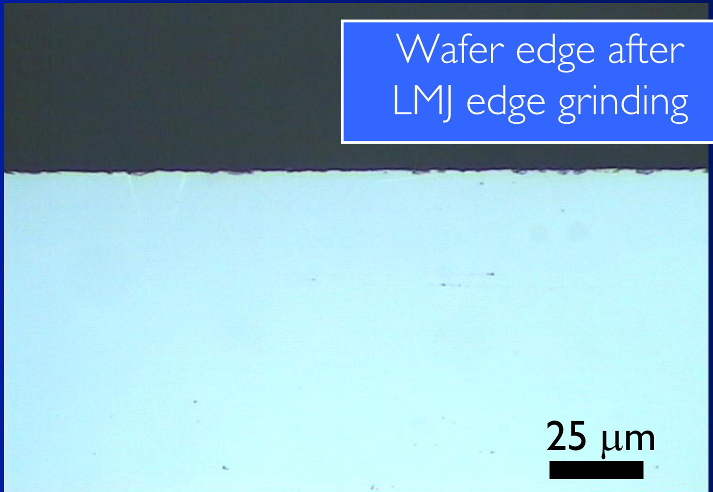
Edge Grinding – After Back Grinding

Patent pending

Cutting off the edge of the thin wafer

- The **knife-edge** containing the micro-cracks all around the wafer is **removed**
- Wafer **breakage** during the final steps (especially handling) is strongly reduced
- Edges are very **clean and well defined**
- **No** new **micro-cracks** in the edges


Wafer edge after back grinding

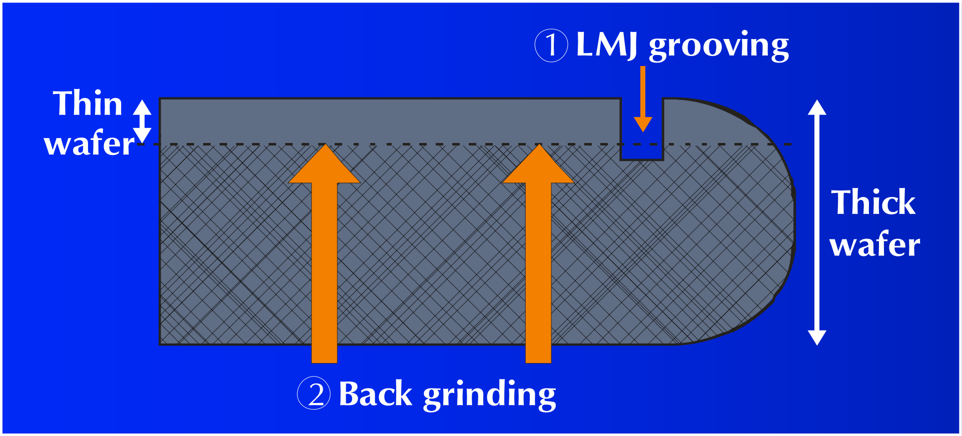

Wafer edge after LMJ edge grinding

(100-µm thick silicon wafer)

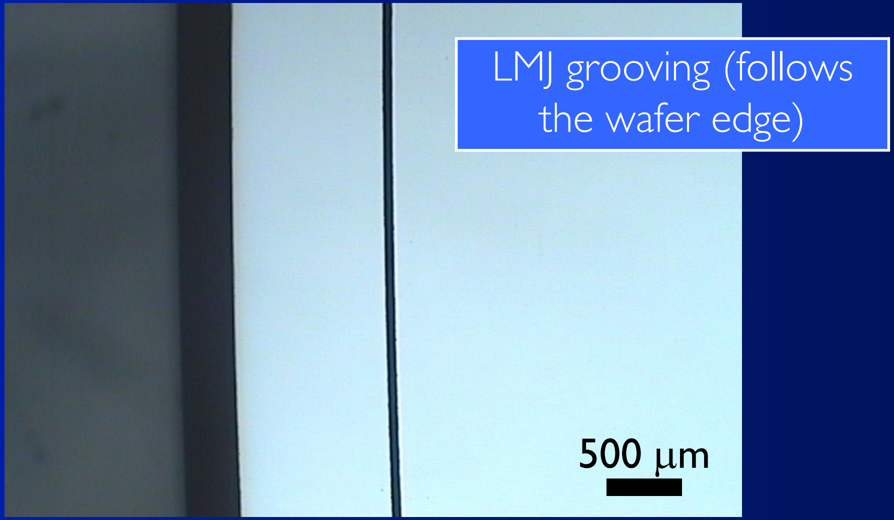
Edge Grinding – Before Back Grinding

Patent pending

Stopping the cracks before back grinding, on the thick wafer



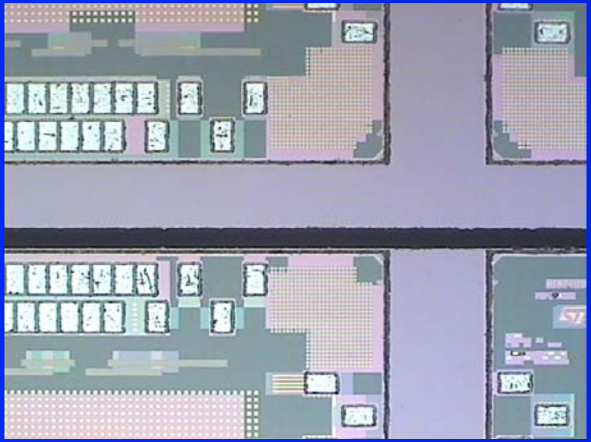
- **Reduced micro-cracks** since the sensitive edge is removed
- Wafer **breakage** reduced
- Very **clean** and **well defined edge**



Grooving of a 750-µm thick silicon wafer

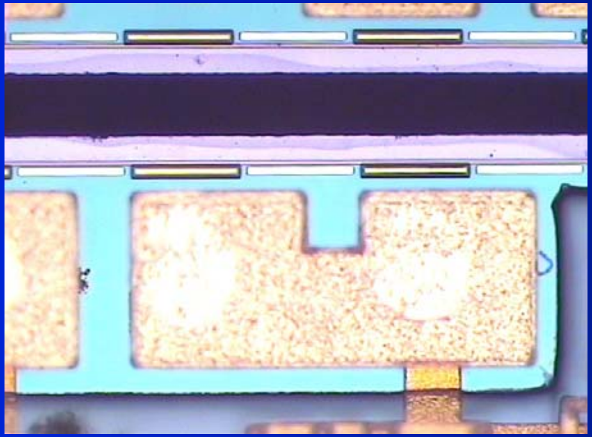
Laser-Microjet Dicing

Patented



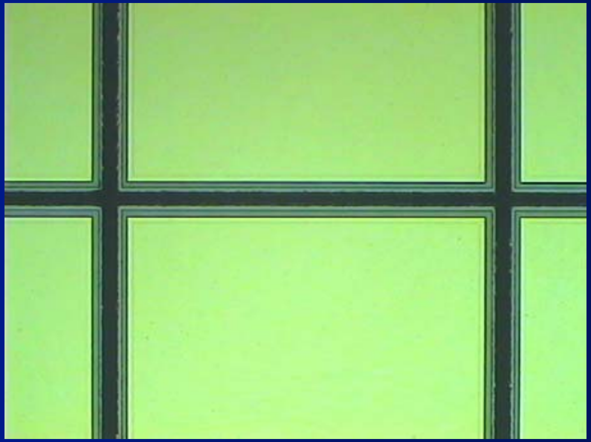
Low-k wafer

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



GaAs wafer

- Wafer thickness: 100 µm
- Through cutting
- Kerf width: 26 µm
- Cutting speed: 60 mm/s



SiC wafer

- Wafer thickness: 100 µm
- Through cutting
- Kerf width: 23 µm
- Cutting speed: 20 mm/s

➔ The water jet guided laser is ***the*** solution for any kind of semiconductor materials!

Advantages over conventional dry lasers

Laser-Microjet®	Conventional UV (or IR) Laser
Through-cutting	Scribing mainly, as through-cutting is slow
Unlimited wafer thickness (up to 20 mm)	Limited wafer thickness
Maintenance-free fiber lasers	Maintenance costs (diodes)
Robust, field-proven IR lasers	Delicate lasers (UV)
High dicing speed of up to 300 mm/s (for 50-µm thick Si)	Low scribing / dicing speed
Parallel kerf	V-shape kerf
Omnidirectional cutting (hexagonal chips, round chips, rounded corners…)	Omnidirectional cutting (with single beam)
No thermal damages, thanks to the waterjet	Thermal damages with any kind of dry laser

Advantages over conventional “dry” lasers

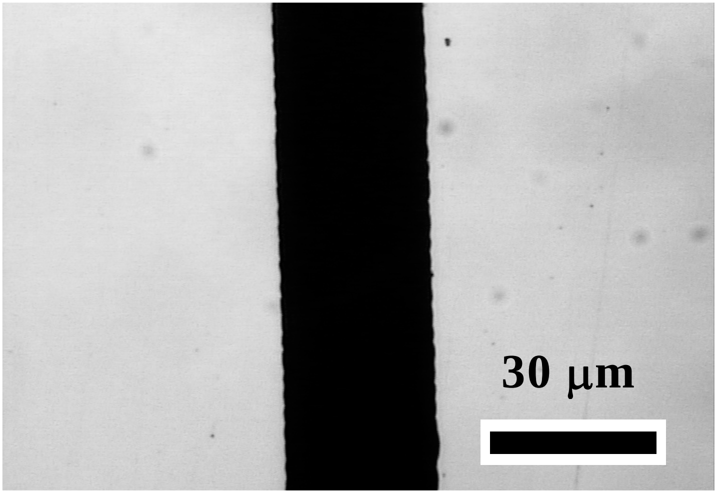
Laser-Microjet®	Conventional UV (or IR) Laser
No contamination thanks to the use of a water film	Always contamination; cutting through water impossible
No need of protective layer such as the conventional laser needs	Need of protective layer
Any semiconductor material (including III/V composites)	Dangerous with toxic III/V materials (arsen-oxides for example)
LaserTape® for through-cutting	No tape available
Low-k wafer compatible	Incompatible with low-k wafers
Highest fracture strength, higher than DBG with surface- and edge- stress release	Poor fracture strength, lower than standard dicing

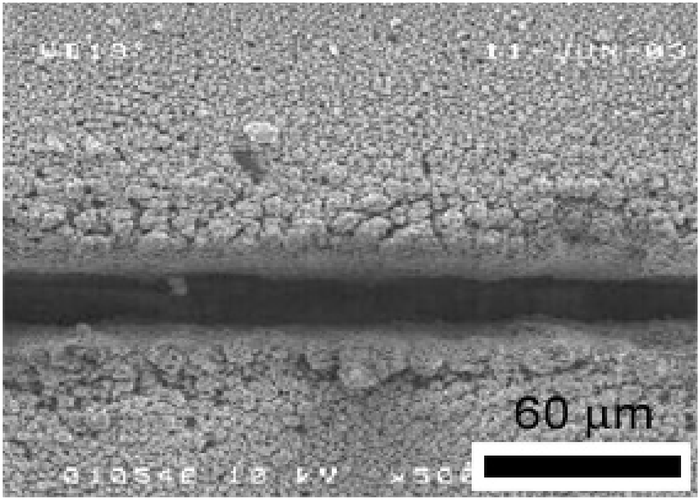
Advantages over conventional dry lasers

Laser-Microjet®

Conventional UV Laser

Through-cut in silicon (quality as cut)

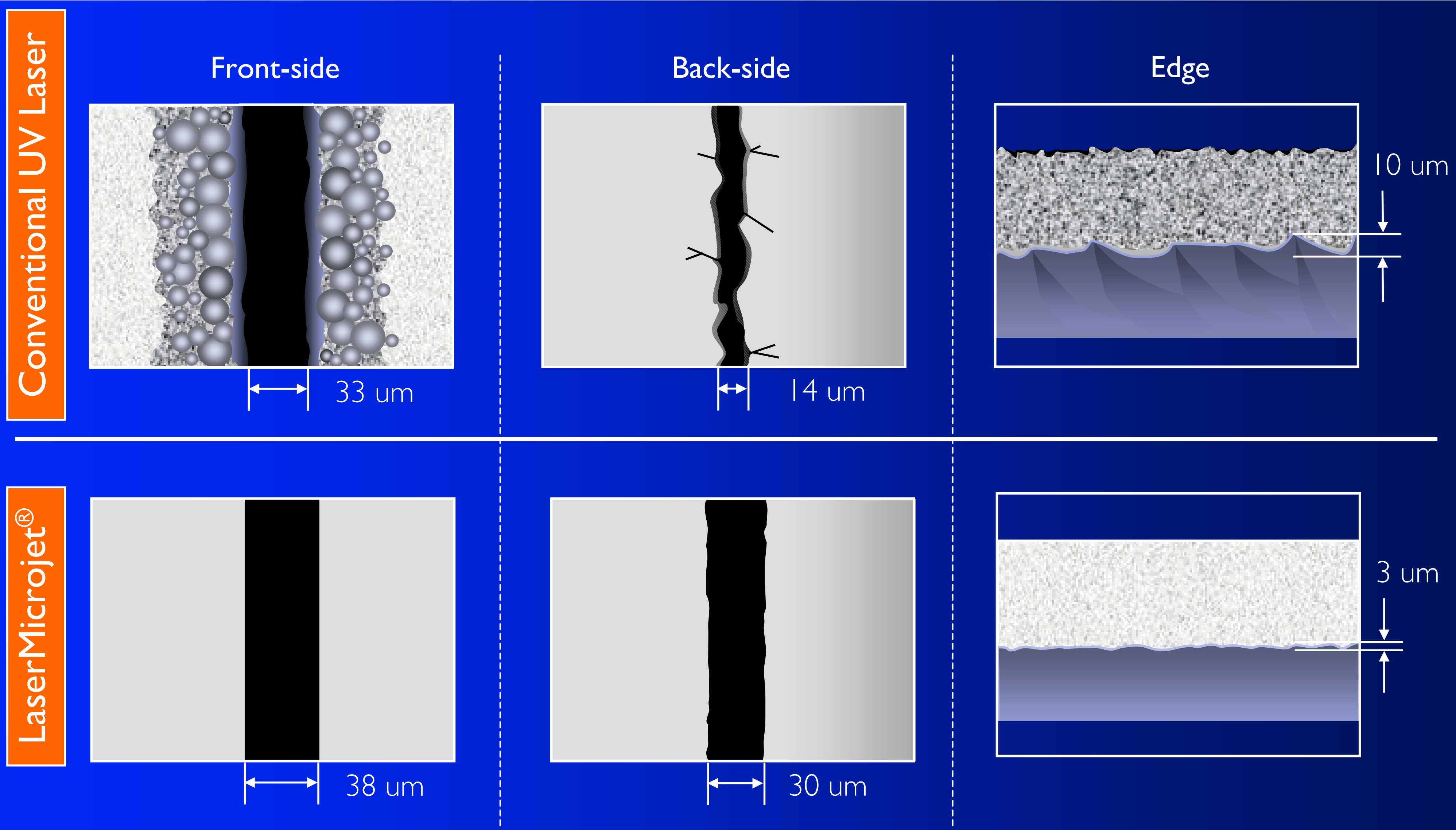




Wafer thickness	150 µm
Kerf width	26 µm
Cutting speed	80 mm/s

Wafer thickness	150 µm
Kerf width	10-30 µm
Cutting speed	6 mm/s

Advantages over conventional dry lasers



Conventional UV Laser

Front-side

33 um

Back-side

14 um

Edge

10 um

LaserMicrojet®

38 um

30 um

3 um

Fracture Strength Test - Setup

3-beam bending test

→ measuring the influence of edge damage

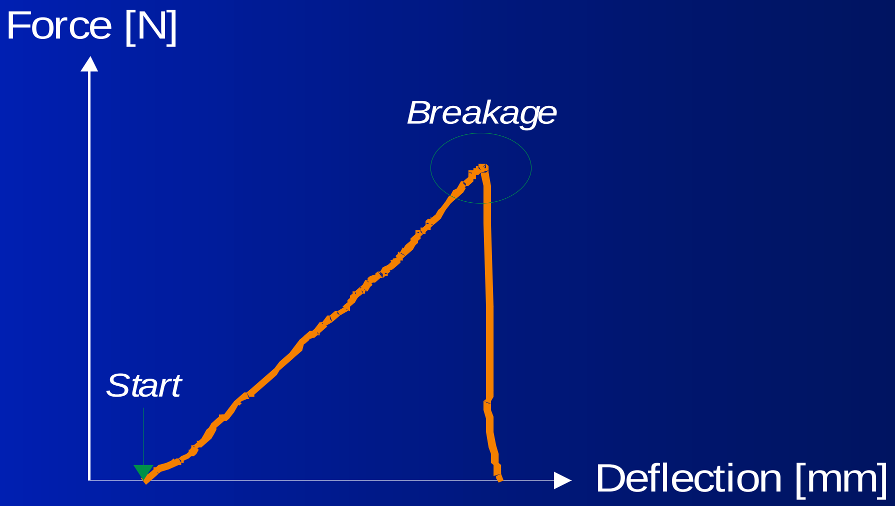
Samples

- 125-µm thick production silicon wafers
- same batch
- ground and etched

Process

1. Dicing into 10 x 10 mm chips
2. Testing on 3-beam bending set up

(around 25 dies were tested for each parameter)

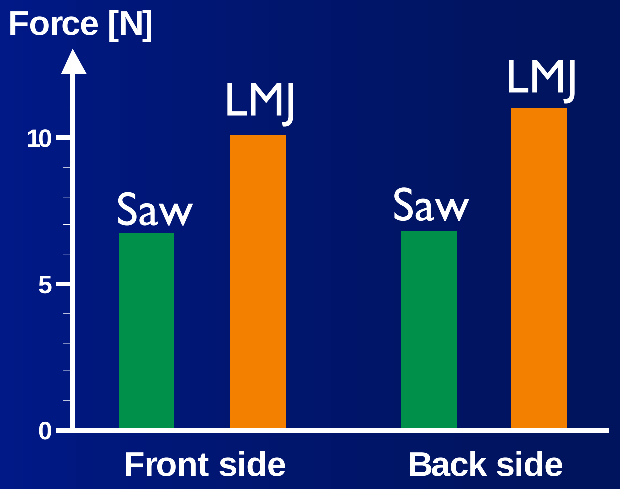


High force → High die fracture strength

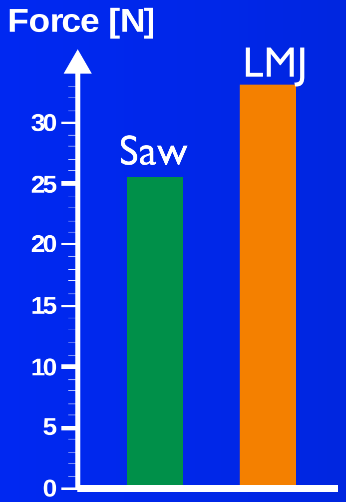
Fracture Strength Tests - Results

1) Tests from Synova SA

Dicing technology	Dicing speed	Kerf width	Fracture strength (average force [N])	
			Front side	Back side
🟩 Saw	25 mm/s	45 µm	X (6.7)	Y (6.8)
🟧 LMJ	50 mm/s	46 µm	1.5 X (10.1)	1.6 Y (11)



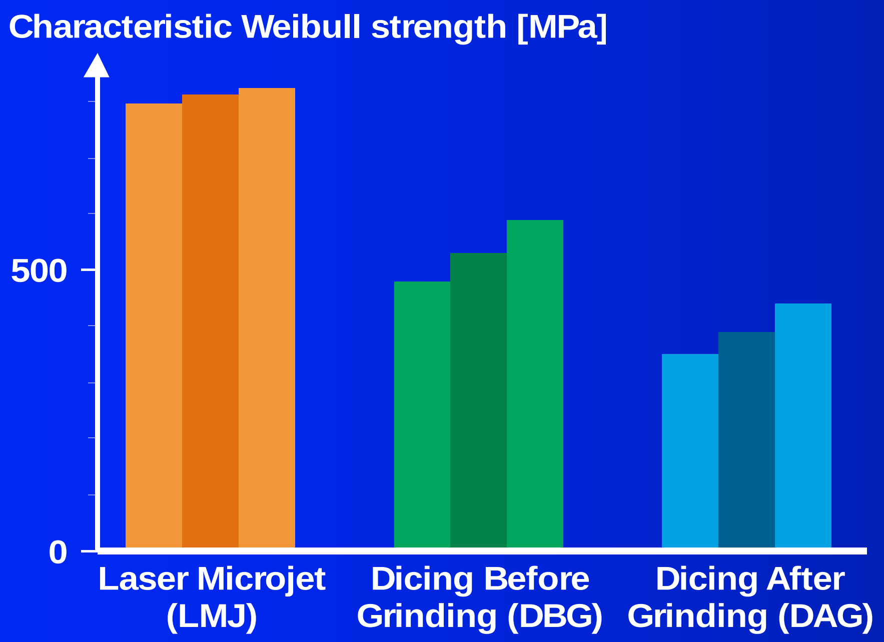
2) Tests from Infineon Technologies AG



Dicing technology	Fracture strength (average force [N])
🟩 Saw	X (25.5)
🟧 LMJ	1.3 X (33.2)

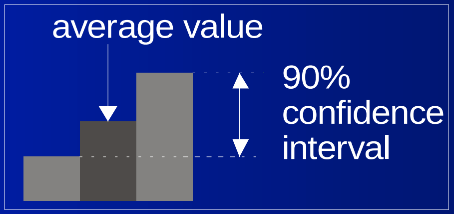
Fracture Strength Tests - Results

3) Tests from Fraunhofer-Institute for Mechanics of Materials



Dicing technology	Average Weibull strength [MPa]
🟦 DAG	X (390)
🟩 DBG	1.3 X (530)
🟧 LMJ	2 X (810)

1.5



Conclusions

Same results from
3 different analysis

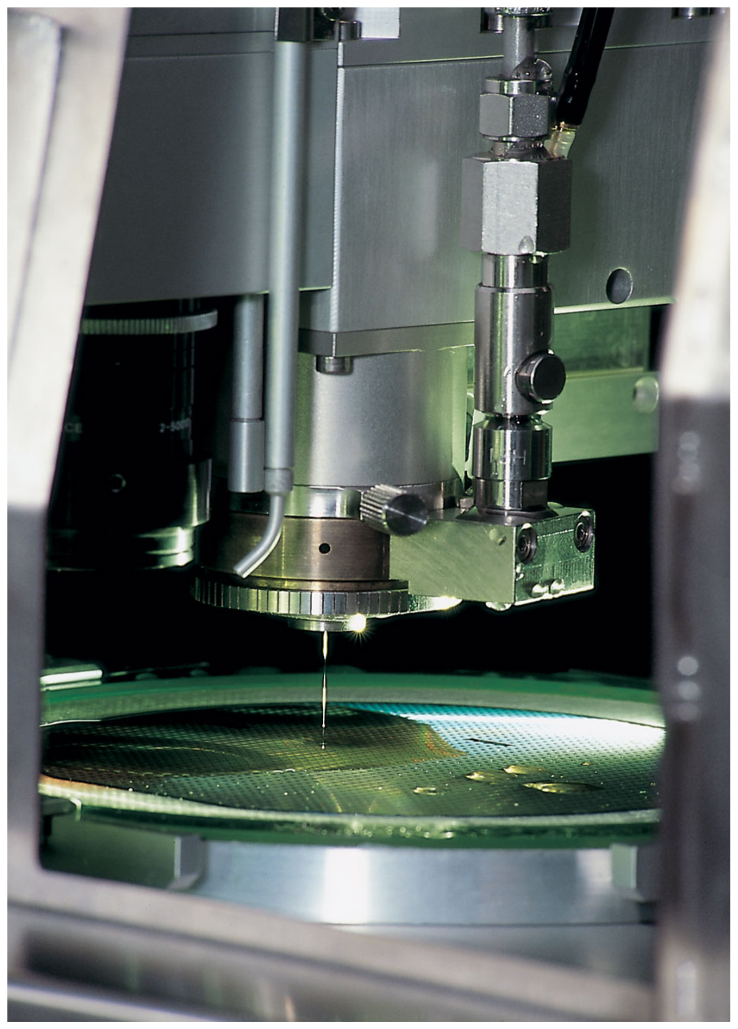
Laser-Microjet process allows highest die fracture strength

Conclusions

Operations on thin wafers

- ✓ Edge grinding
- ✓ Dicing

Laser-Microjet process allows a perfect processing of thin wafers and dies without damages, generating wafers and dies with highest fracture strength!



The Water Jet Guided Laser