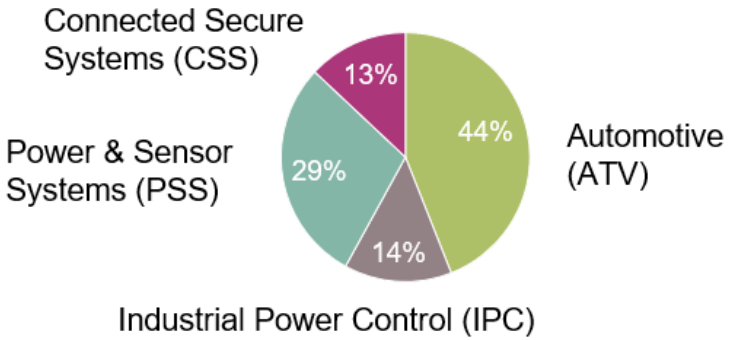
Laser Applications for Semiconductor Device Manufacturing: A Continuous Success Story

Benjamin Bernard

Laser World of Photonics 2022 – EPIC Meeting

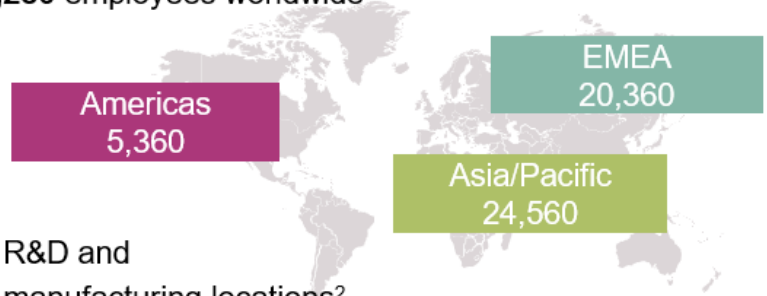
Infineon at a glance

Business segments revenue[1]



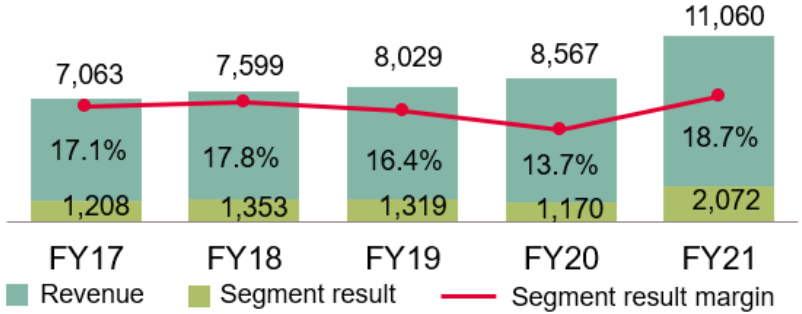
Employees[1]

50,280 employees worldwide



56 R&D and
20 manufacturing locations[2]

Financials



[1] 2021 Fiscal year (as of 30 September 2021)
[2] as of 30 September 2021

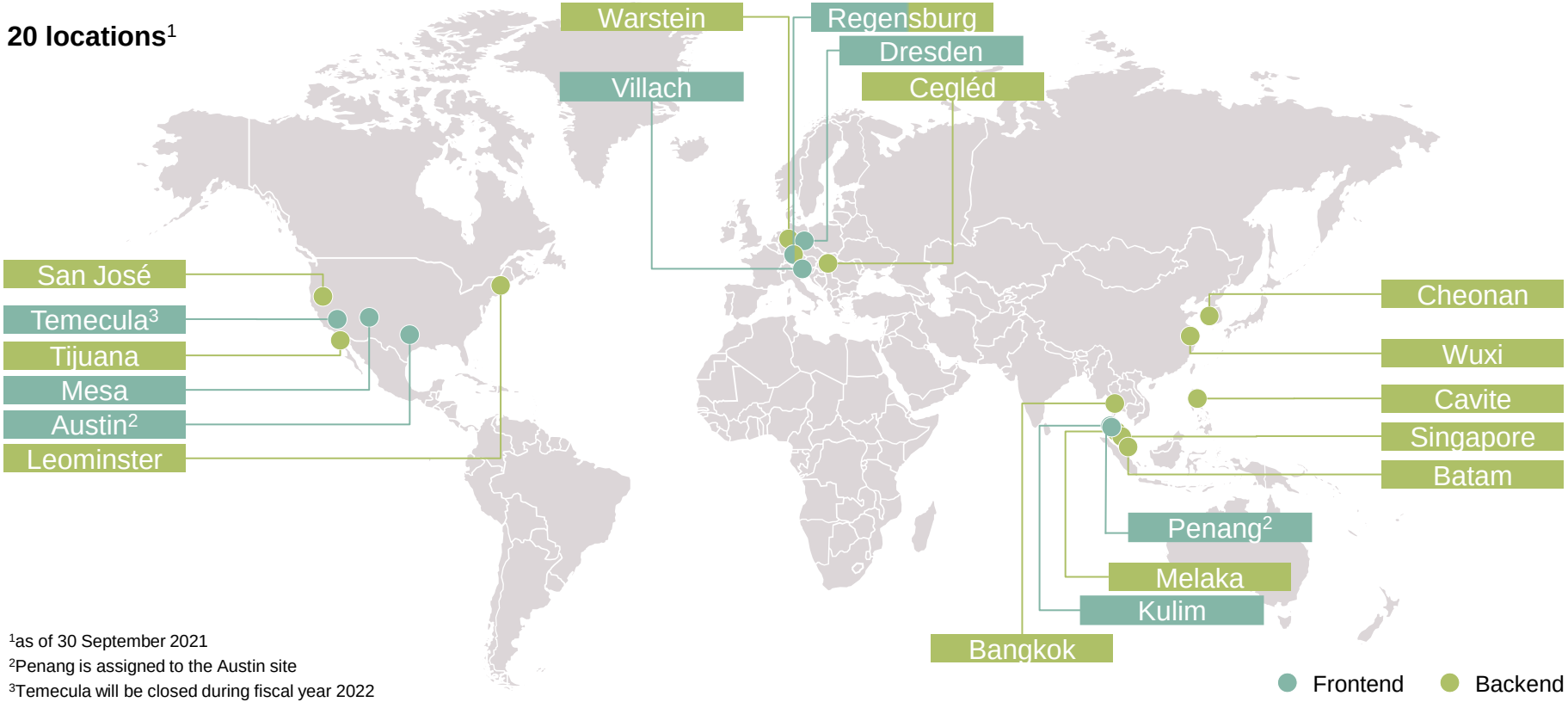
Market position

Automotive	Power	Microcontroller
		
# 1	**# 1**	**# 3**
Strategy Analytics, April 2021	Omdia, September 2021	Omdia, August 2021

For further information: Infineon Annual Report 2021

Infineon is globally positioned with its network of frontend and backend manufacturing facilities

20 locations[1]



[1]as of 30 September 2021
[2]Penang is assigned to the Austin site
[3]Temecula will be closed during fiscal year 2022

Business growth in the semiconductor market is driven by four areas

Energy efficiency

Mobility

Security

IoT and big data

Powered by Infineon

Internet Growth Drives Use of Energy Efficient Semiconductors

- 50% of all servers worldwide are equipped with Infineon chips
- Semiconductors for infrastructure, server capacities, end devices
- Global Internet data traffic grew more than 40% in 2020 alone. Energy consumption remains almost the same thanks to innovative chips.*

*IEA (2021): Data Centres and Data Transmission Networks

Innovation Fab Villach

- Competence center for extremely thin (up to 40µm) silicon wafers
- Series production of power semiconductors ("energy-saving chips") in 300-millimeter thin-wafer technology
- Manufacturing expertise for MEMS (microelectromechanical systems), e.g. tire pressure sensors
- Global competence center for silicon carbide (SiC) and gallium nitride (GaN) in the Group
- One virtual fab: Virtual mega-factory for 300-milimeter thin wafers together with Dresden

8.72 bn.

Chips produced (FY 20/21)

~2,000

Product types in process at the same time

~1,000

Individual processing steps per wafer

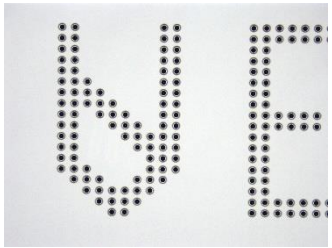
Laser – Basic Overview

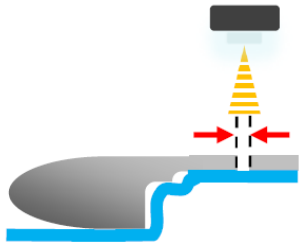
Advantages of laser processing....

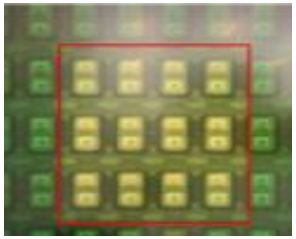
- Contact free processing
- All materials (Si, SiC, GaN, Metals, etc.)
- High flexibility (Beamshaping,Beamsplitting)
- Short interaction (precision)
- No mechanical tools
- Best controllability (CAD to product)

Examples of laser processing within semiconductor Industry

- Wafer Marking
- Adhesive layer removal
- Laser Thermal Anneal (LTA)
- Ablative Separation
- TAIKO-Ringcut
- SiC splitting
- Stealth Dicing
- Chip Trimming

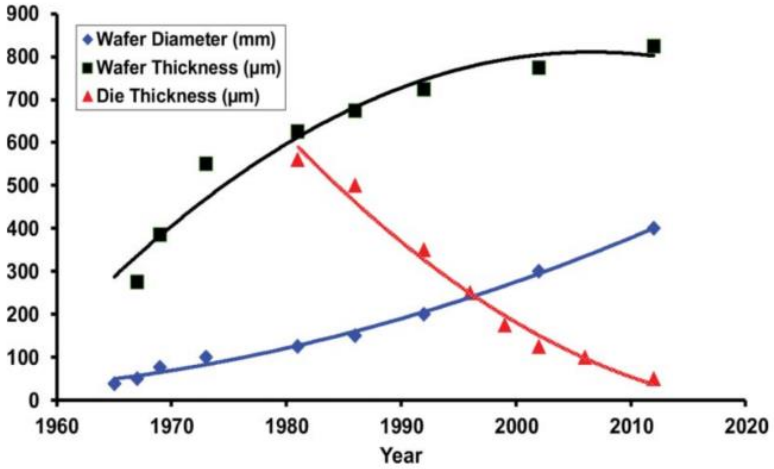




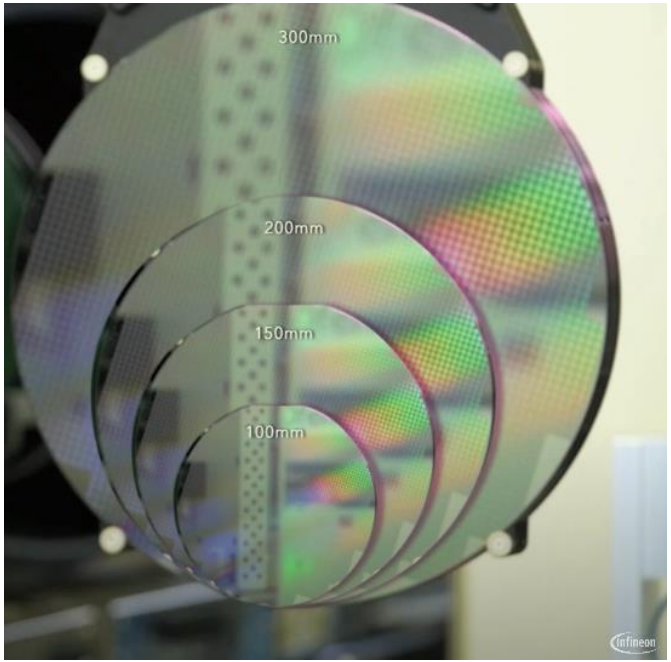


The wafer

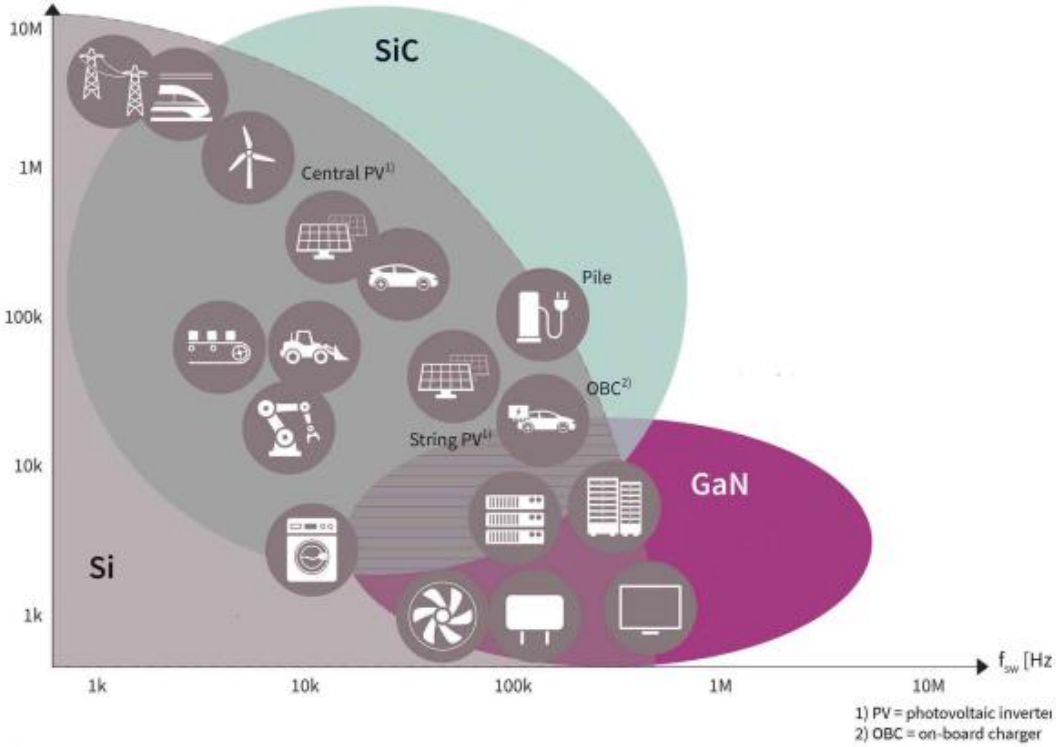
- Wafer Size: 150mm / 200mm / 300mm
- Materials: Silicon / Silicon-Carbide / Gallium-Nitride
- Thin & Ultra Thin wafers (<150µm / <<100µm)



Ultrathin Wafer Pre-Assembly and Assembly Process Technologies: A Review; Michael Raj Marks



Si, SiC and GaN – Technology positioning



Silicon (Si)

- Targeting voltages ranging from 25 V to 1.7 kV
- The mainstream technology
- Suitable from low to high power

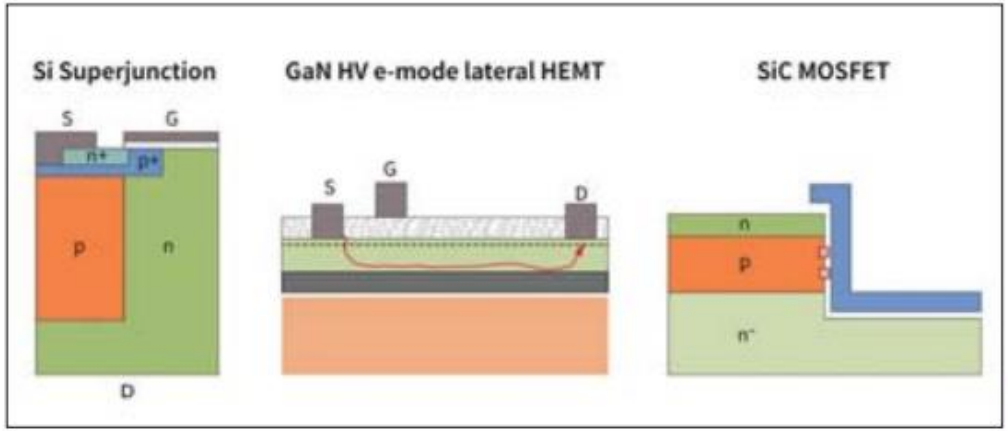
Silicon carbide (SiC)

- Targeting voltages ranging from 650 V to 3.3 kV
- High power from moderate to high switching frequency

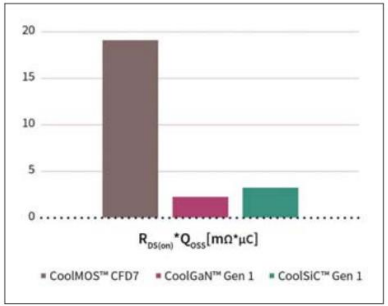
Gallium nitride (GaN)

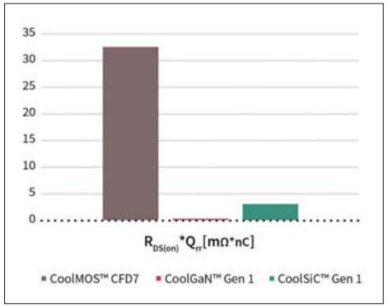
- Targeting voltages ranging from 80 V to 650 V
- Medium power at highest switching frequency

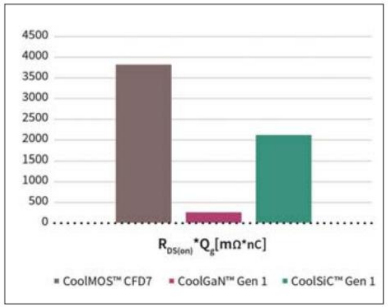
Si, SiC and GaN – Technology positioning

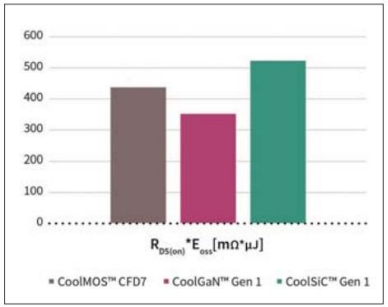


- Verical structure for Si- and SiC-MOSFETs
- Lateral structure for GaN-HEMTs
  (High Electron-Mobility Transistor)



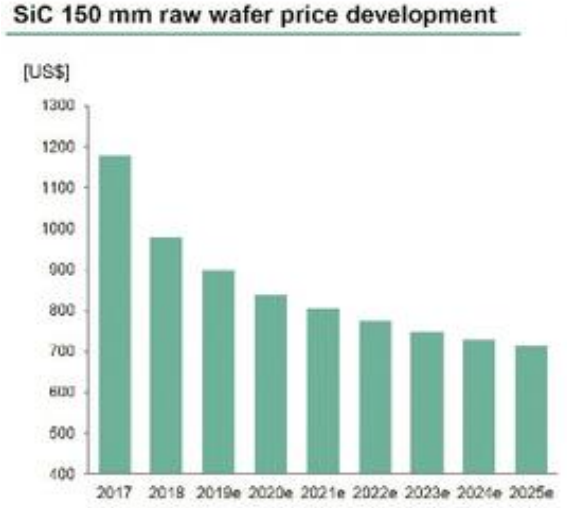


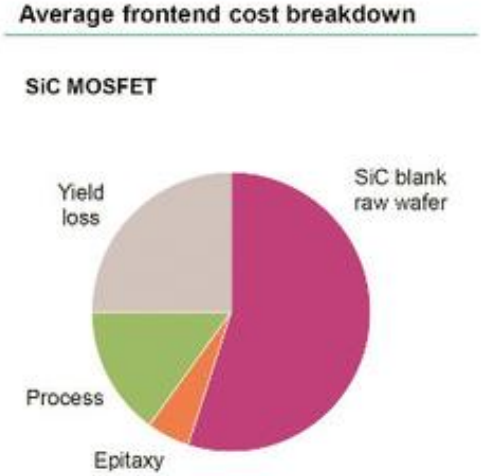




- Drain-Source on resistance $R_{DS(on)}$
- Drain-Source-Charge Q_{OSS}
- Stored Charge Q_{rr}
- Gate Charge Q_g
- Stored Energy E_{OSS}

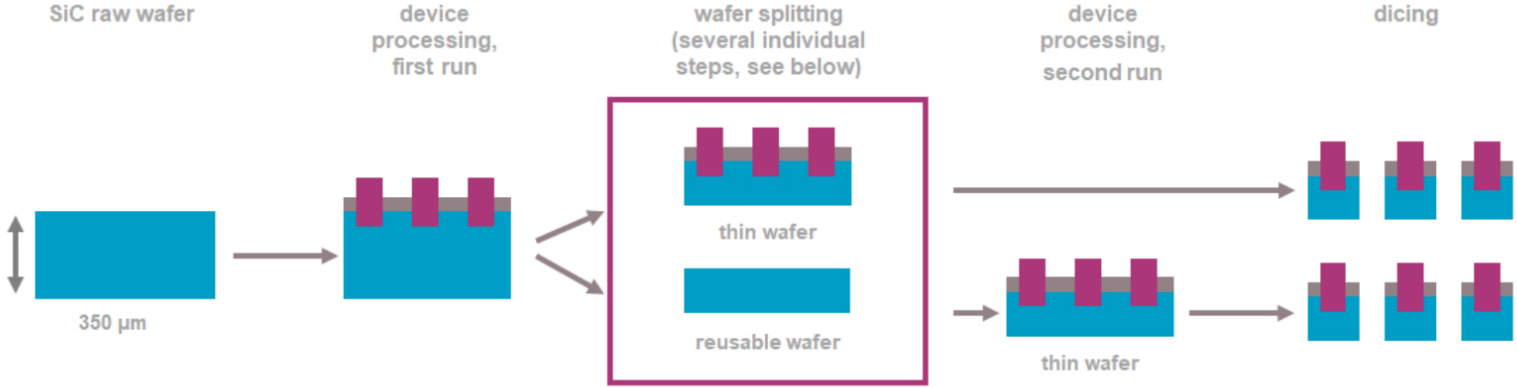
SiC – High raw material costs

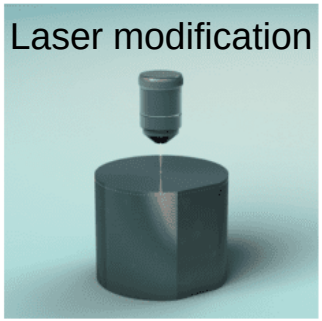


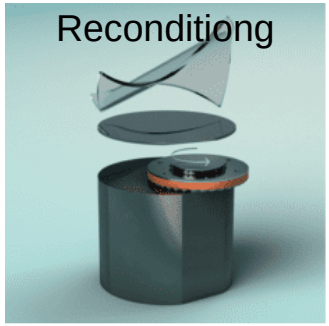


- Slight decrease of raw wafer cost
- BUT: Still more than 50% of overall costs

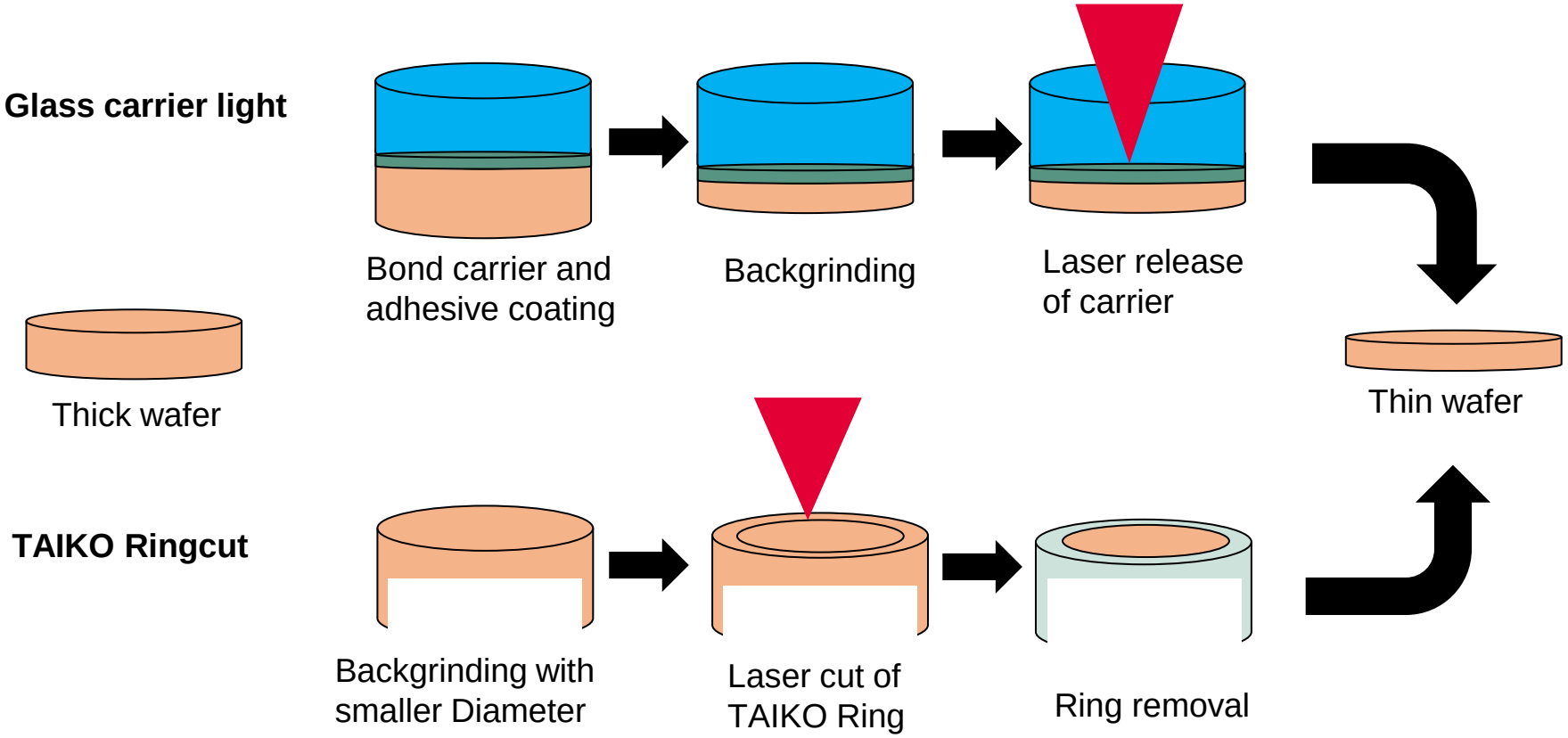
Siltectra – SiC Wafer Splitting Process



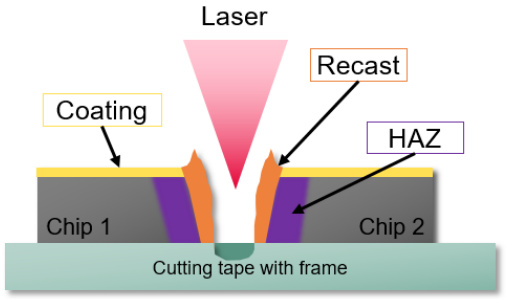




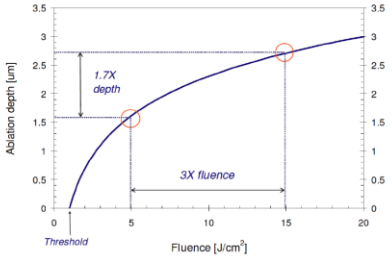
Wafer Carrier Systems for thin wafer handling



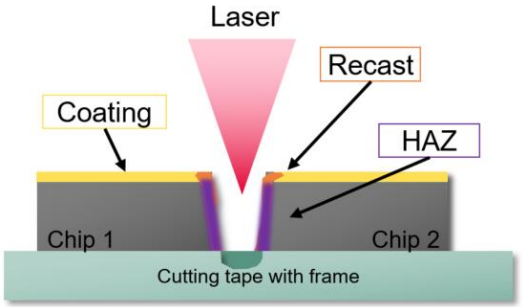
Wafer separation – Laser Dicing



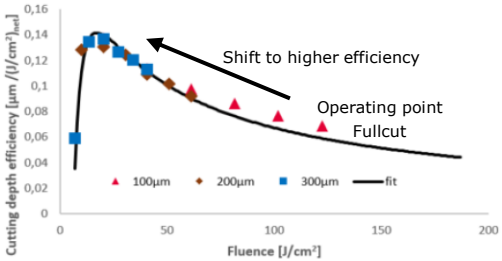
- Thermal driven process
- Heat Affected Zone (HAZ)
- Reduced mechanical stability



Highest-speed dicing of thin silicon wafers - James M. Bovatsek, Rajesh S. Patel



- Min HAZ
- Shift to higher efficiency
- Higher mechanical stability



Summary and Outlook

- New materials and advanced layer-stacks are promising candidates for laser processing
- Many laser based applications already in use for 24/7 semiconductor mass production
- Several technology releases was just possible due to laser processing
- Latest developments in high power laser systems combined with advanced beam shaping and motion systems will further improve quality and/or throughput

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