microDICE™ System for Separation of SiC Wafer Using Thermal Laser Separation

- System Integration Technologies – Fraunhofer ENAS -
(Ronny Neubert, 3D-Micromac AG)

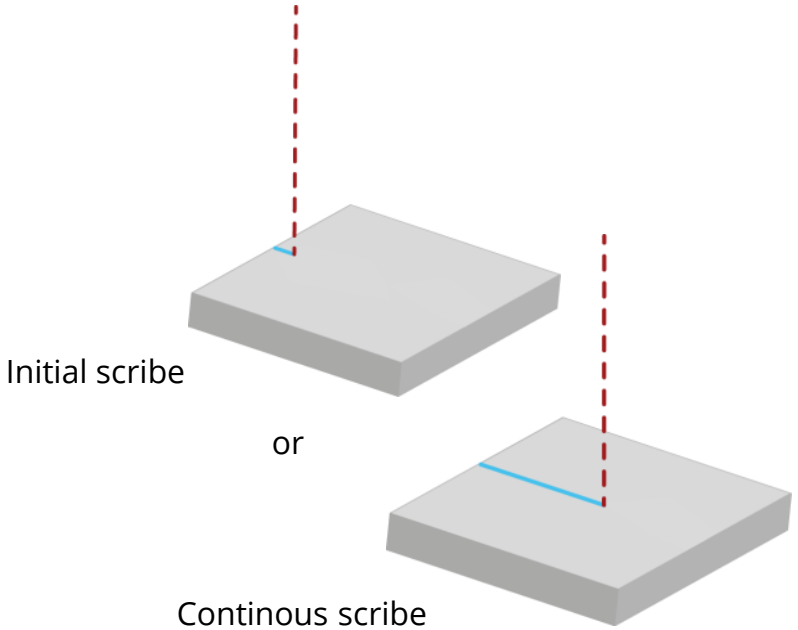
3D-Micromac – At a Glance

- Manufacturer and service provider for
  - Laser micromachining systems and
  - Production equipment for printing and coating technologies
- Design of complete machining systems including process development and service in-house
- Founded in 2002
- Founded US subsidiary in 2014

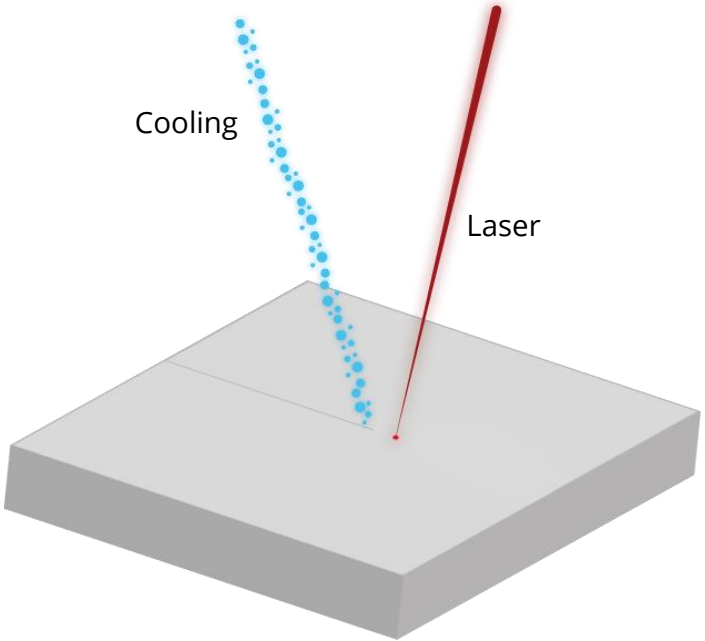
1. **Thermal Laser Separation (TLS-Dicing™)**
2. Application examples
3. microDICE™ system
4. Conclusion

Thermal Laser Separation (TLS)

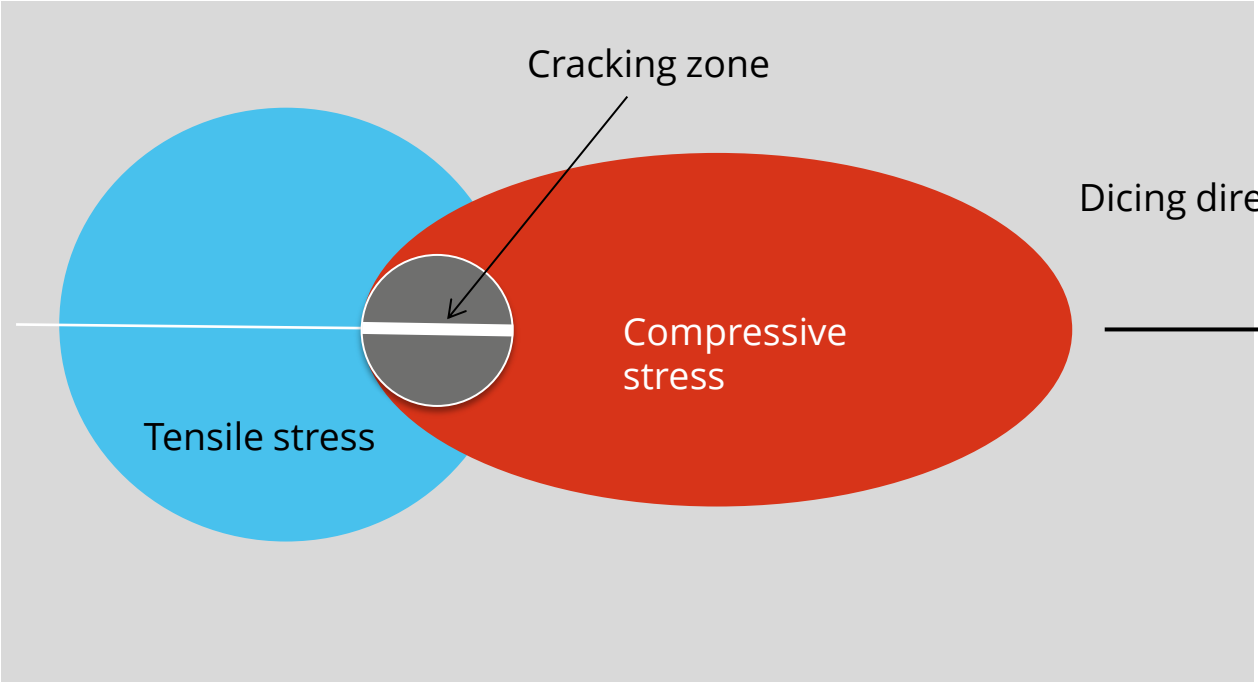
Starting point (and optional straightness) defined by scribe



TLS is a cleaving process, initiated by heat and cooling

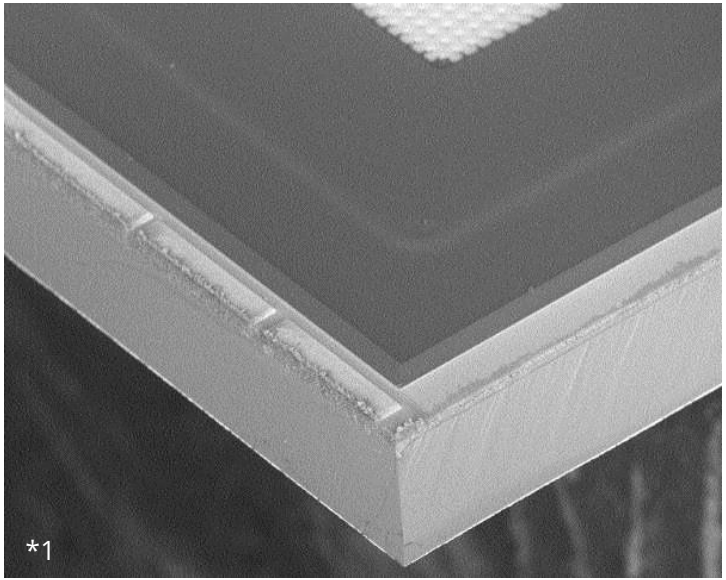


TLS-Dicing™ Technology



Main Properties of TLS-Dicing™

- Residue-free
- Zero kerf
- No chipping
- Nearly perfect sidewalls
- Works for back-side metal
- Works for:
  - **SiC**
  - Si (Semi & PV)
  - GaAs / Ge



JFET on 4H-SiC-Wafer, thickness 160 µm with PCM (left upper rim) and back side metal, Dicing speed 200 mm/s

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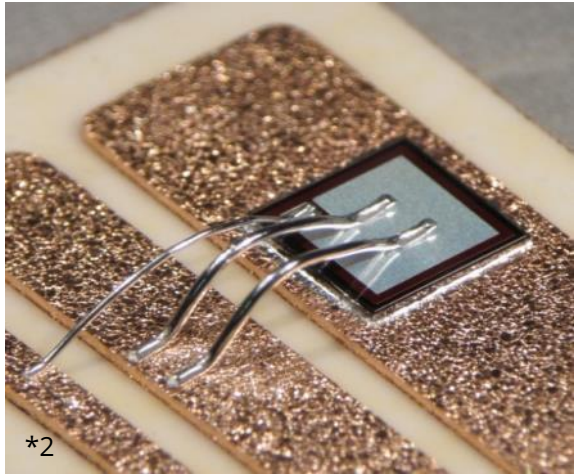
TLS-Dicing™ for SiC – Exemplary Results

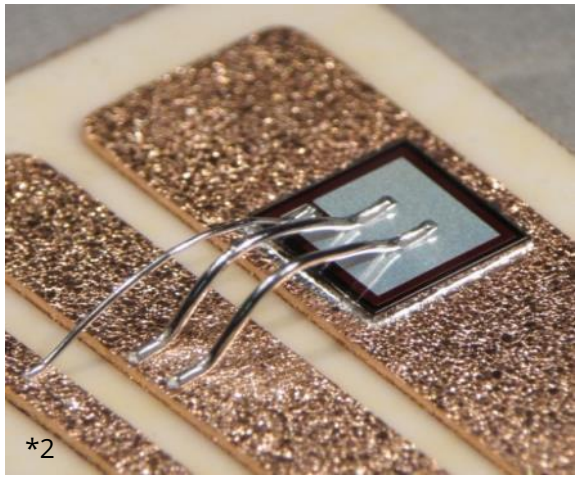
- Special USPs for SiC:
  - Dicing speed 200 mm/s
  - One cleaving pass per street
  - PCM in street acceptable (no design rules)
  - No tool wear
  - Perfect side wall

- Further USPs:
  - Back-side metal is separated w./o. pealing
  - Tape not damaged

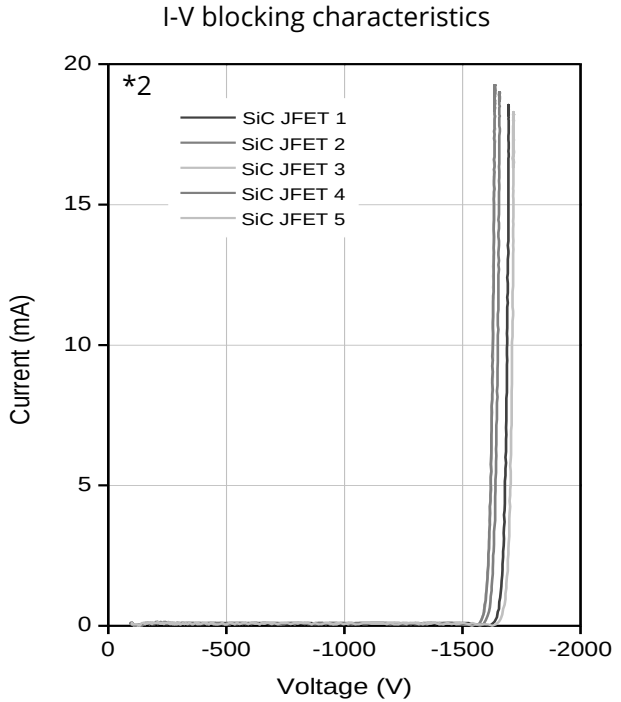


SiC-JFET, Wafer thickness 160 µm, Die size 3.16 X 3.16 mm², Back-side metal, mounted on DCB

TLS-Dicing™ – Electrical Parameters for SiC



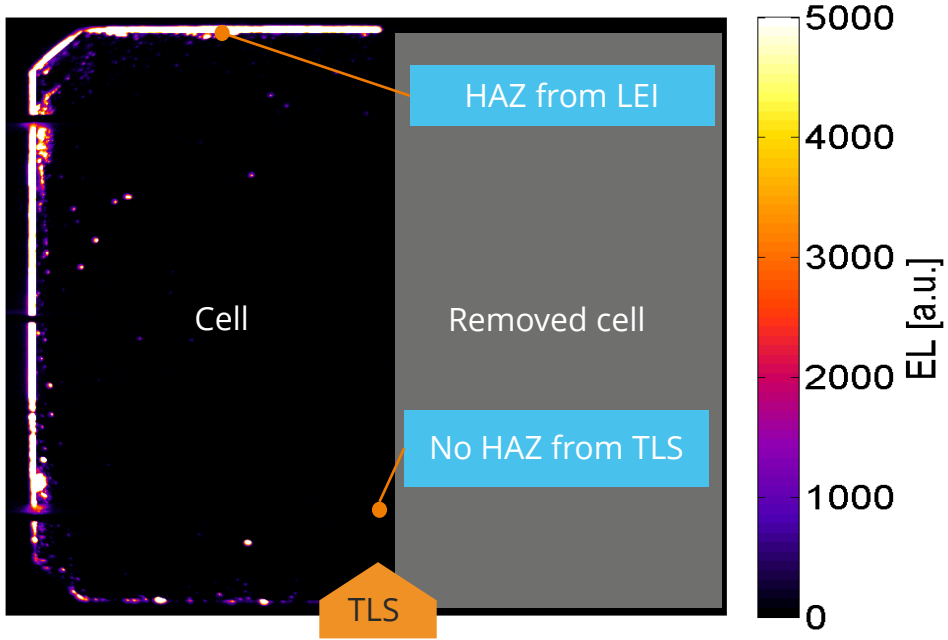
SiC-JFET, Wafer thickness 160 µm, Die size 3.16 X 3.16 mm², Back-side metal, mounted on DCB



→ No impact on electrical perfomance by TLS

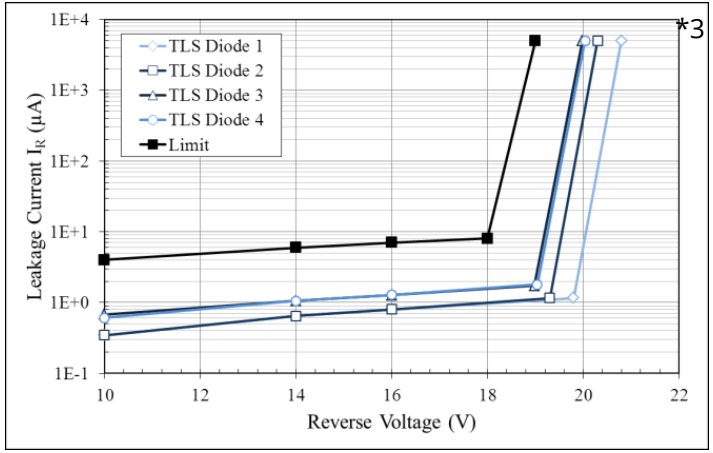
TLS-Dicing™ – Electrical Parameters for Si

- Project “A” – cutting solar cell



Electroluminescence measurement

- Project “B” – Dicing of power-diodes



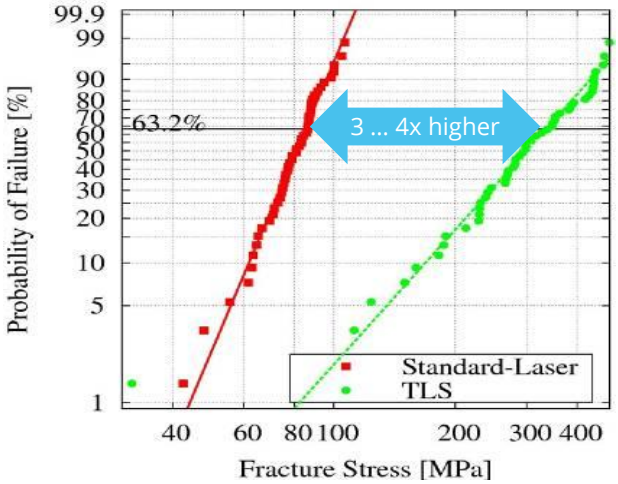
Leakage current of diodes is significantly reduced

→ **Damage free cutting through pn-junction is possible**

TLS-Dicing™ – Bending Stength

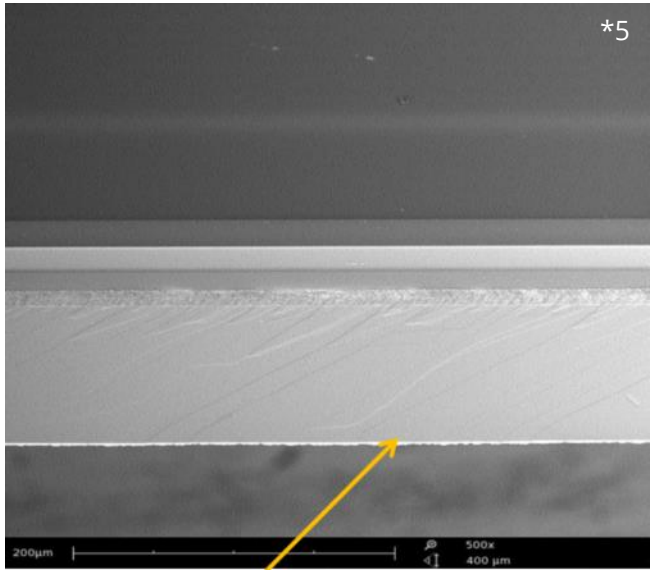
Resizing-ring (ø 300 to 200 mm, Si 775 µm)

Comparison to ablative laser dicing



TLS-Dicing™ – Separation of Back Side Metal

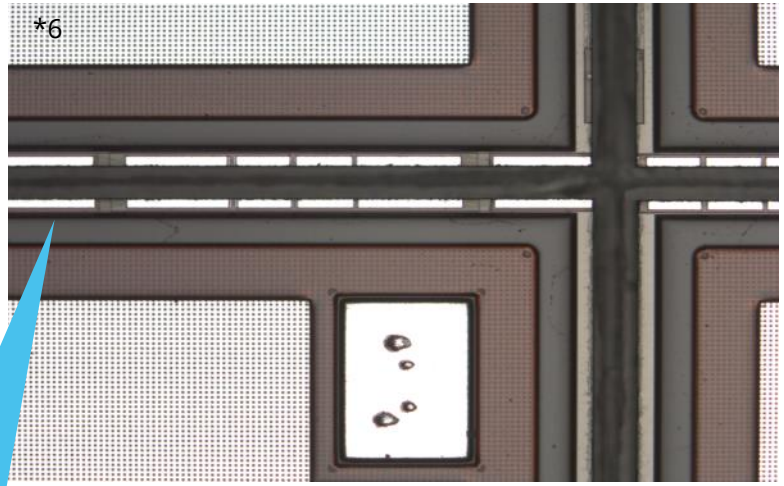
- Works with back side metal (up to 10 µm)
- Recommended: ratio metal to bulk: < 1 : 100
- No peeling!



Si-Wafer with back side metal

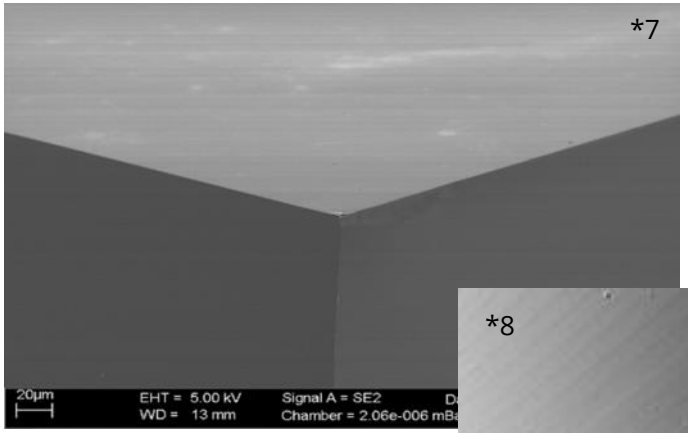
TLS-Dicing™ – Optical Properties

- One NIR cleaving-laser for all substrates
  - For Si / Ge / GaAs / doped SiC a NIR-laser is optimal
  - Different dopants are acceptable
- Scribing process option for PCM available

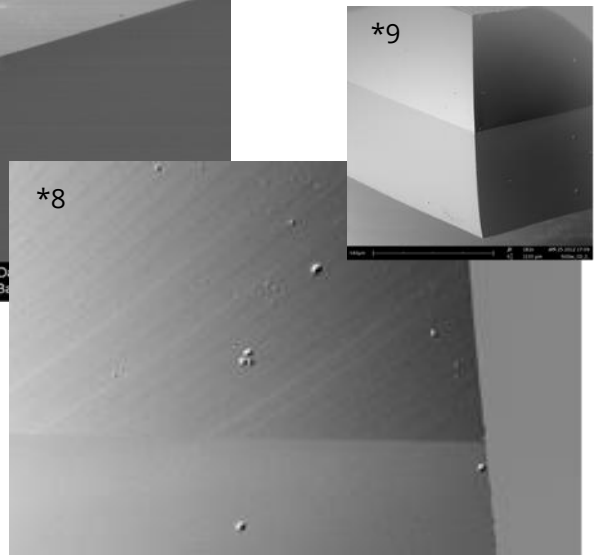


JFET- on 4H-SiC

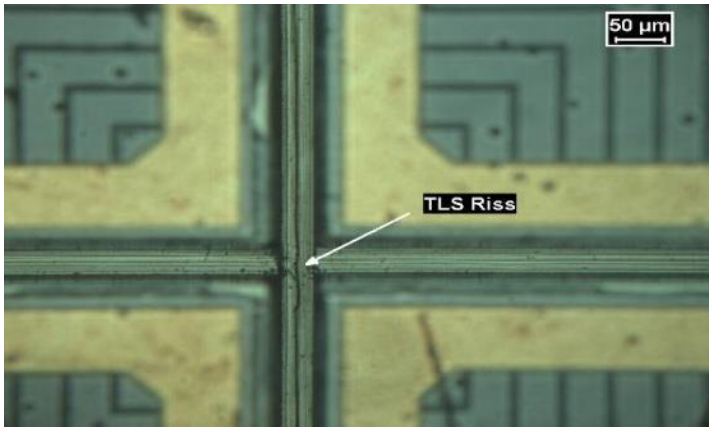
TLS-Dicing™ for Other Materials



Si-Wafer



Si on glass



Ge

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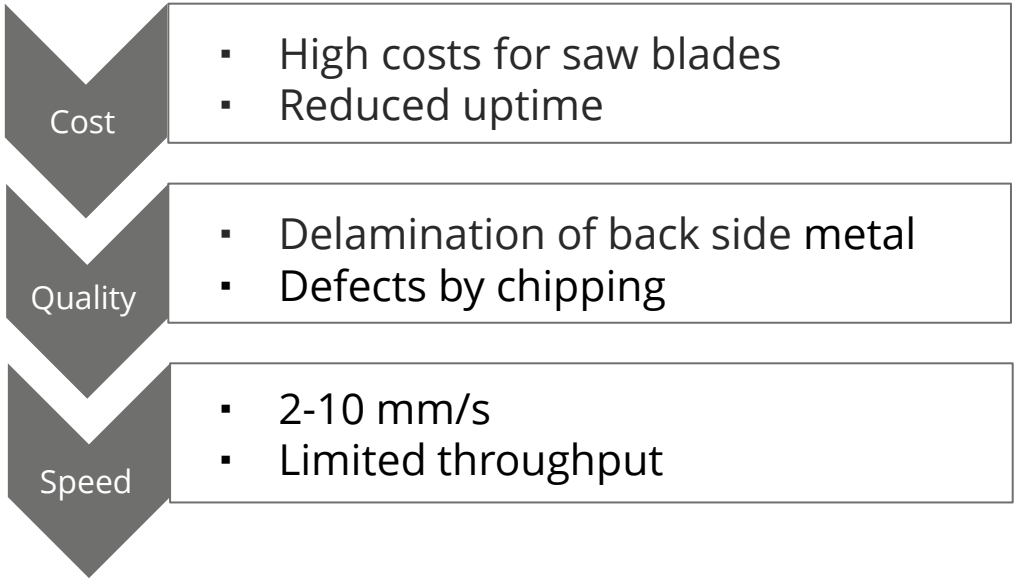
TLS-Dicing™ - Motivation

- SiC Dicing is a hard job (hardness 9.2 on Mohs scale)



Our Solution – microDICE™ System for TLS-Dicing™

Lower cost, excellent cleaving results, and higher throughput

Advantages of TLS-Dicing™ Technology

Cost reduction

- Minimal CoO due to contactless processing
- Increased yield by zero kerf

Function

- Excellent back-side metal separation
- Higher bending strength

Speed

- Dicing speed up to 300 mm/s
- Significant higher throughput

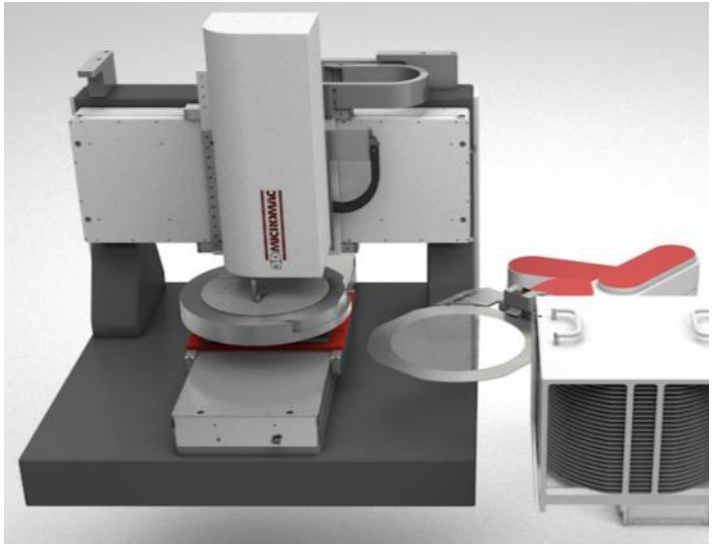
microDICE™ System

- Up to 300 mm (12”) wafer size
- Integrated laser sources with long lifetime
- Integrated patented micro stretching function
- Automated wafer handling
- SECS / GEM interface
- Compatible with common SEMI standards
- Consumables: only DI-water

microDICE™

microDICE™ - Major Components

- Processing unit (left side)
  - Scribing function (by pulsed fiber laser)
  - Cleaving function (cw laser and cooling)
  - Alignment system
  - Vacuum chuck
- Handling unit (right side)
  - 2 x 200 mm or 1 x 300 mm cassette
  - Fault detection

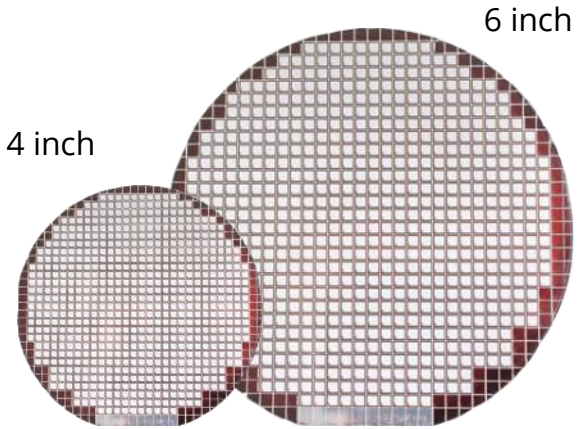


Major components

TLS-Dicing™ on microDICE™ - a Case Study for SiC

Current trends for SiC-products:

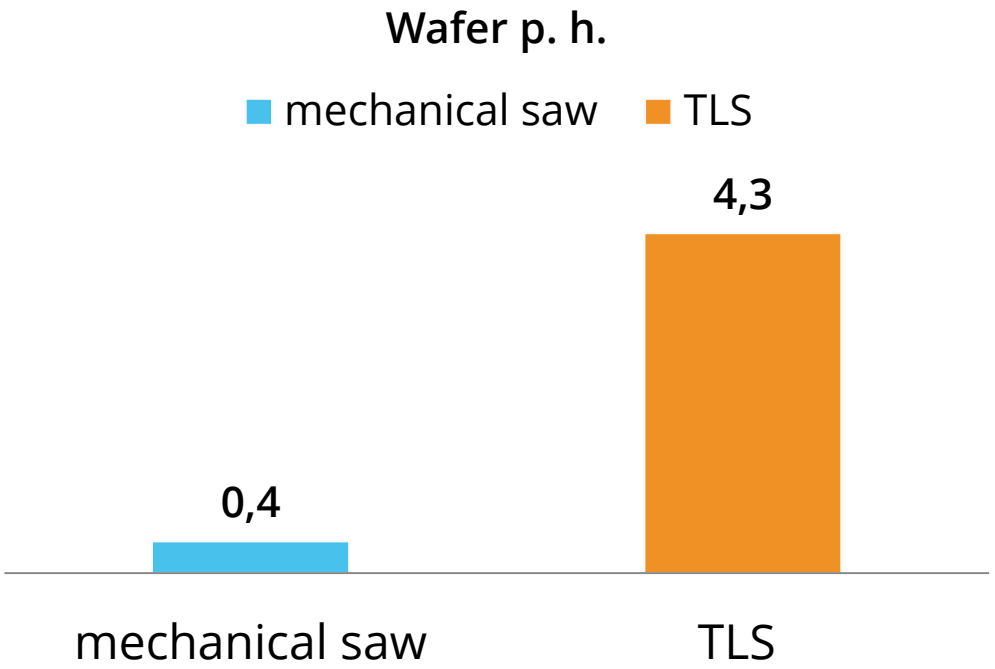
- The market volume of SiC is growing with CAGR of 25%
- One saw blade can’t saw one 6 inch wafer



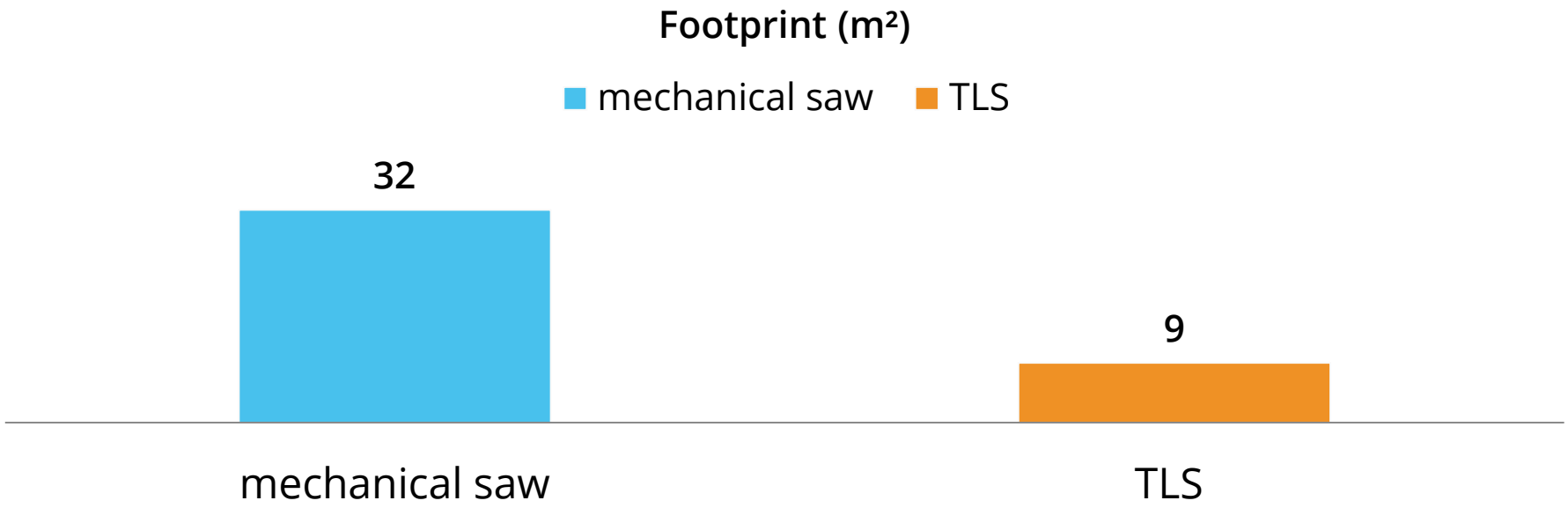
Transition from 4“ to 6“ has been started

Advantage I - Throughput

- Wafer:
  - 150 mm SiC
  - Back side metal
  - 160 µm thickness
  - 1 mm die edge length
  - PCM in street
  - 70 µm street with
- Parameter:
  - Speed 200 mm/s



Advantages II – Reduced Footprint Saves Cost



Footprint for sawing 4 pieces 150 mm SiC-Wafer p.h
(9 saws vs. 1 microDICE™)

Assumptions for Cost Calculation

- Considered:
  - Throughput: 4 wafer per hour
  - Consumables (saw blades)
  - Invest/depreciation for tool
  - Footprint
- Not considered:
  - Benefit in terms of yield
  - Reduced operator costs

mechanical saw: 37 € TLS-Dicing™: 2.40 €

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Conclusion

- Minimal cost of ownership
- Clean process
- Better electrical properties
- High throughput
- Less breakage
- Increased yield
- Damage-free backside metal

TLS-Dicing provides excellent cleaving results in combination with high yield and throughput.

TLS-Dicing™ - Cooperation with Fraunhofer IISB

- More then 8 years of successful cooperation
- Experienced scientists
- Wide range of measurement tools
- Equipped with the latest version of TLS-Dicing™ tool in clean room

Fraunhofer IISB

TLS-Project partly funded by European – contract 611332 “SEA4KET”

3D MICROMAC

Image sources

*1	Courtesy Fraunhofer Gesellschaft
*2	Dohnke et. al: Comparison of different novel chip separation methods for 4H-SiC, Proceedings of ECSREAM conference, Grenoble 2014
*3	Koitzsch et. al.: Improving Electric Behavior and Simplifying Production of Si-Based Diodes by Using Thermal Laser Separation, Proceedings of ASMC2013, Saratoga Sprigs, (NY) 2013.
*5	Karl Dohnke
*4, 6 -10	Courtesy Fraunhofer Gesellschaft

Thank you for your attention!

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