Defect Luminescence Scanner (DLS): Scientific and Industrial-scale Defect Analysis

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Cooperation partners:

Bayerische Forschungsstiftung*
Fraunhofer IISB
Infineon
FAU Friedrich-Alexander Universität Erlangen-Nürnberg

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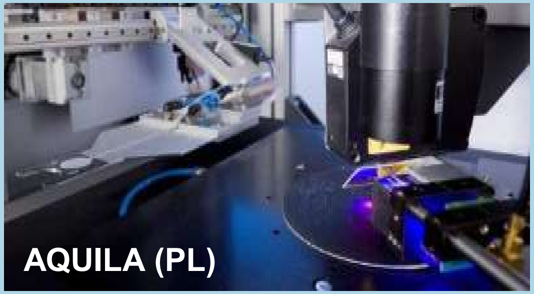
AQUILA PL – SiC Wafer Inspection

Overview



- Motivation of UV-PL Imaging*
- Measurement Setup
- PL Imaging of Bare Wafers, Epitaxial Layers and Partially Processed Wafers
- Customized Tool Options
- Summary
- Facts on Intego

** R. Stahlbush, K.X. Liu, Q. Zhang, J.J. Sumakeris, Materials Science Forum 556-557 (2007) p. 295-298.*

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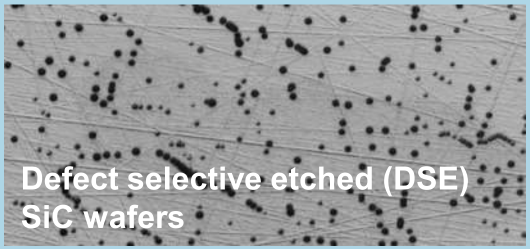
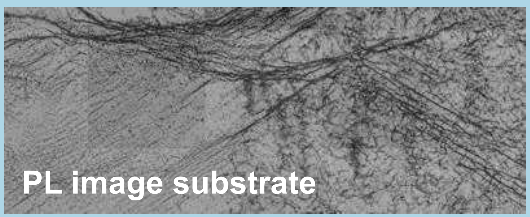
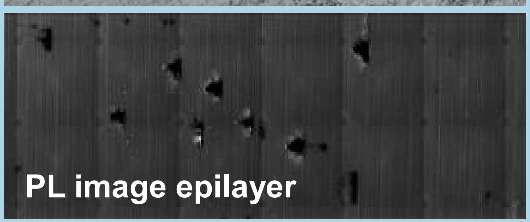
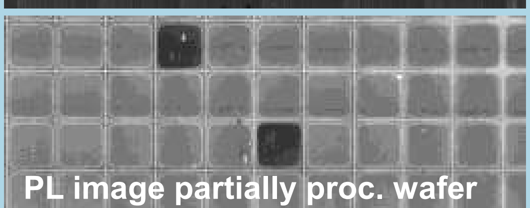
Motivation of UV-PL Imaging



Next generation



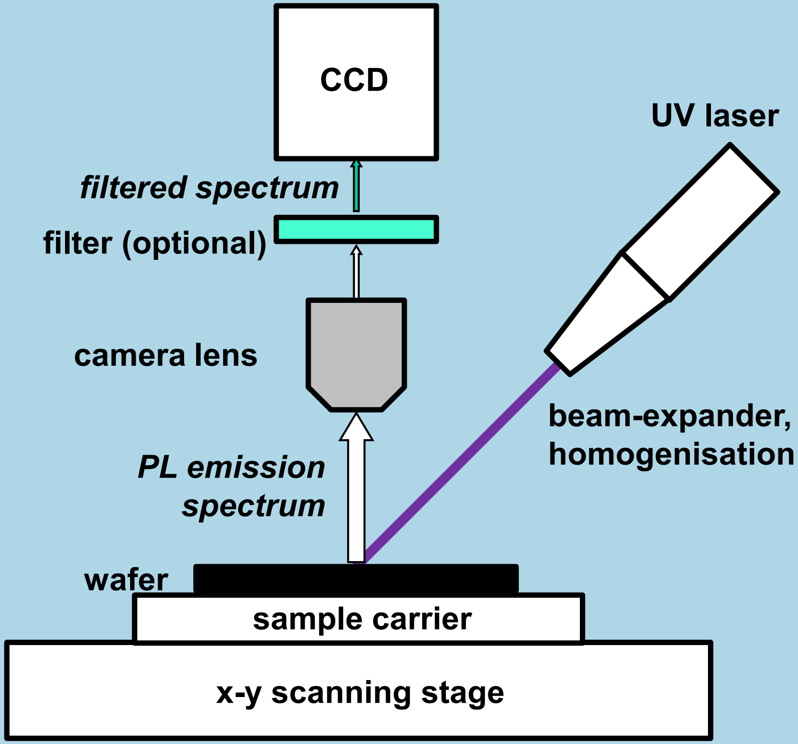




- Performance of SiC electronic devices limited by structural defects in substrates and epitaxial layers
- **Detecting critical surface and bulk defects** like stacking faults (SF) and basal plane dislocations (BPD)
  - in substrates, epilayers and partially processed 4H-SiC wafers
  - with a contactless, non-destructive, high-resolving and fast technique
  - for material characterization and inline monitoring along the device production chain.
- **Tracking defects** from substrate to epilayer and to device allows
  - to discard defective material before further processing (save time and reduce costs)
  - to improve the quality and reliability of devices

AQUILA PL – SiC Wafer Inspection

Measurement Setup



- UV excitation at e.g. 325 nm (100 mW)
- penetration depth of approx. 8 µm
- PL optimized microscope (< 5 µm)
- Sensitive CCD camera (400-1000 nm)
- Individual optical filters
- x-y scanning stage (up to 6“)

➡ **Measurement time:**
approx. 5 - 30 min/filter/wafer

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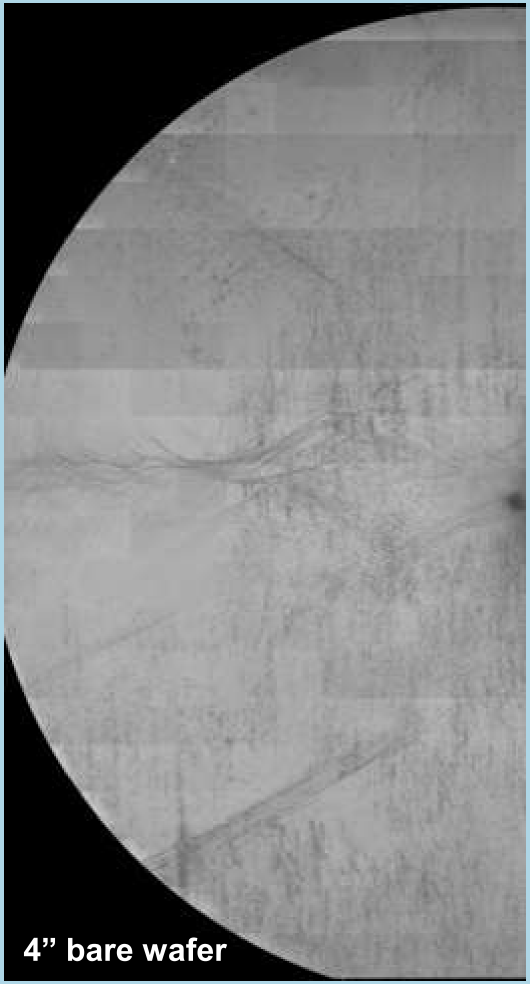
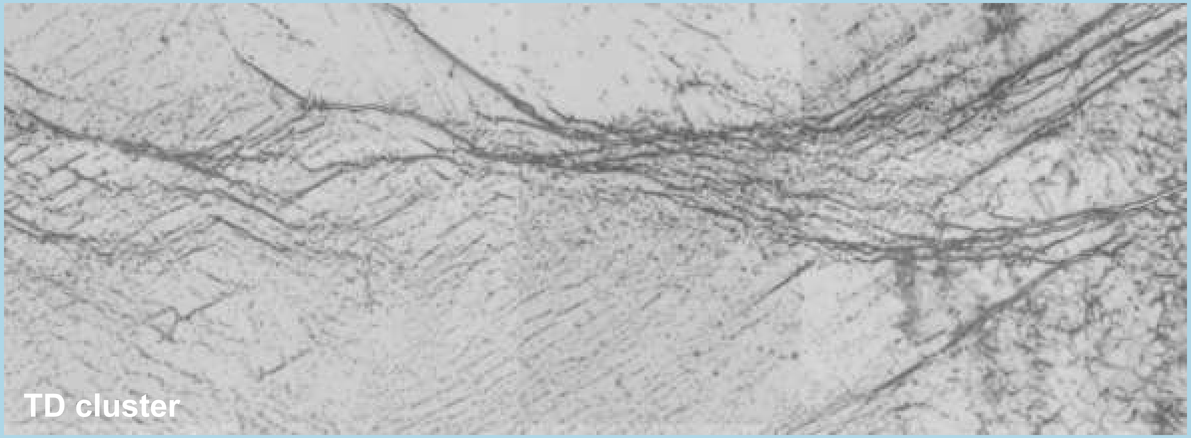
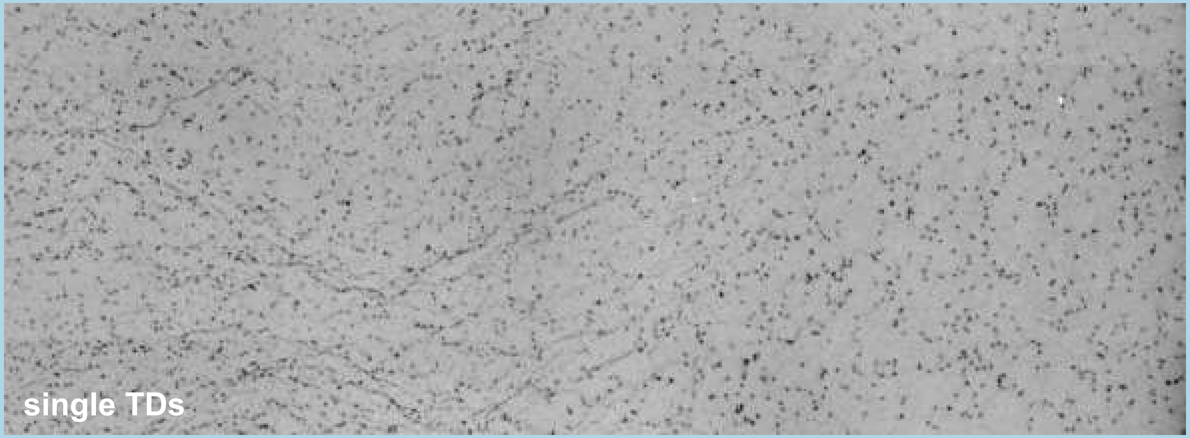
PL Imaging of Bare Wafers



Examples of critical defects in <u>bare substrates</u>





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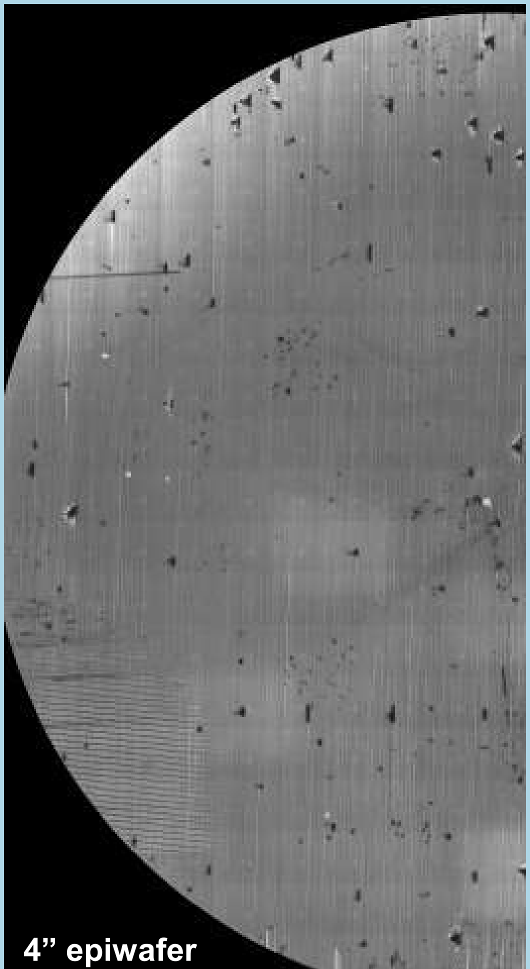
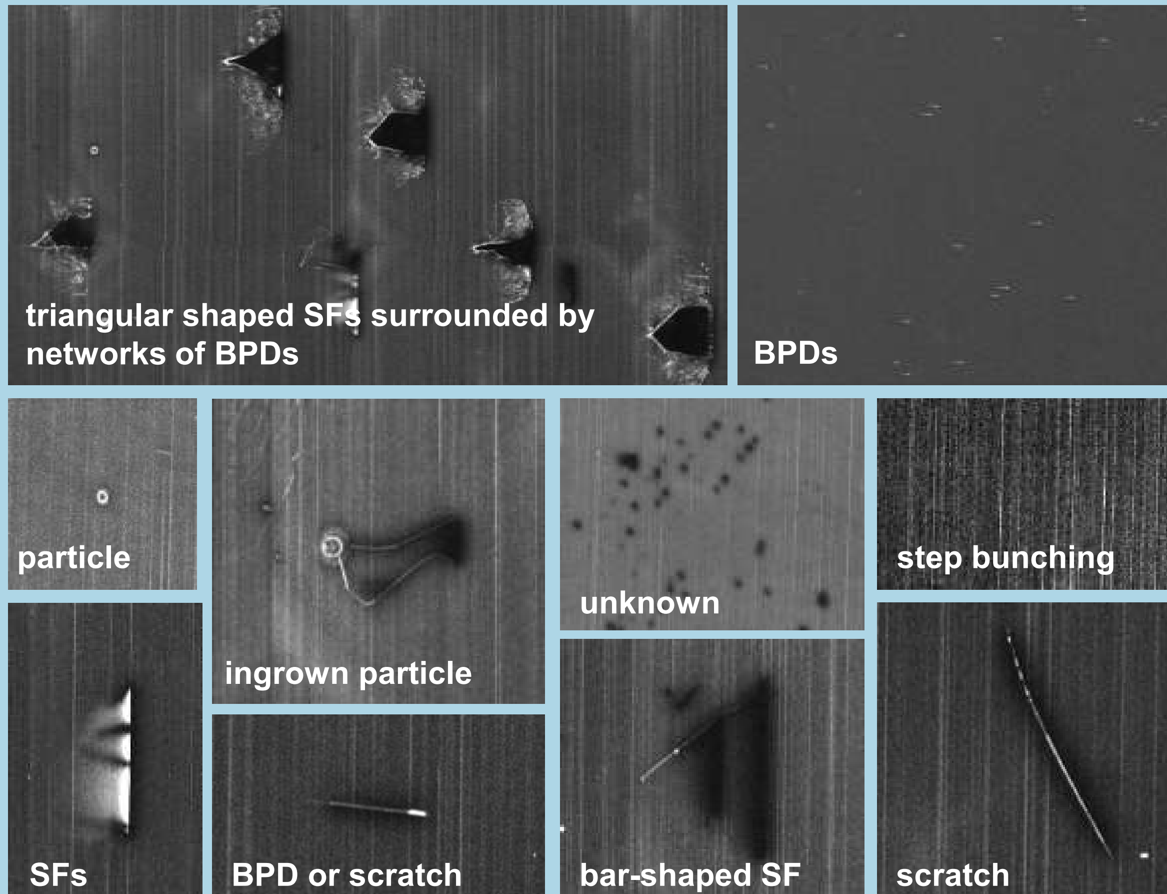
PL Imaging of Epilayers



Examples of critical defects in epitaxial layers



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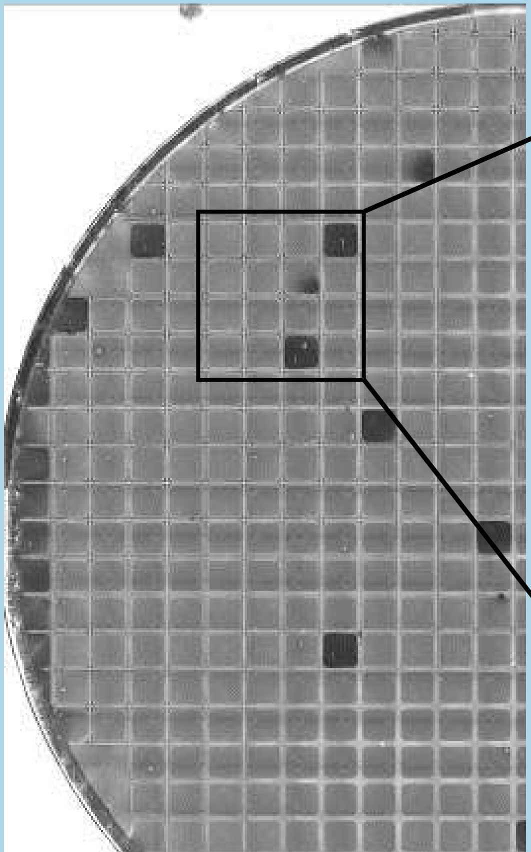
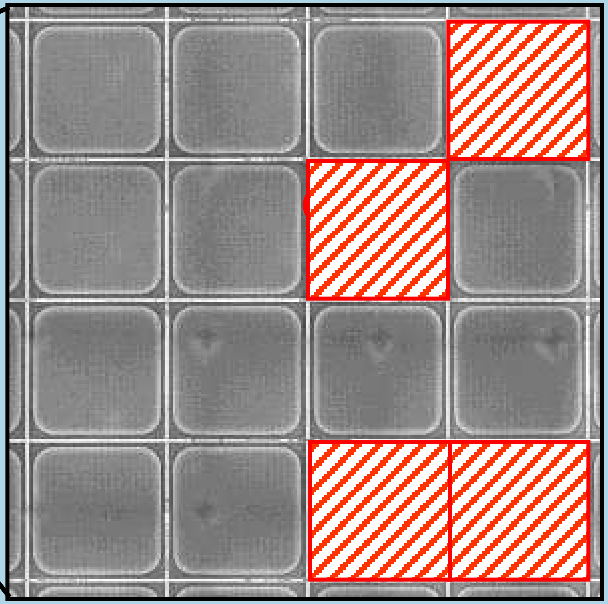
PL Imaging of Partially Processed Wafers



4" wafer with 6.5 kV pn-diodes after p-implantation and high-temperature annealing

Examples of critical defects in <u>partially processed wafers</u>

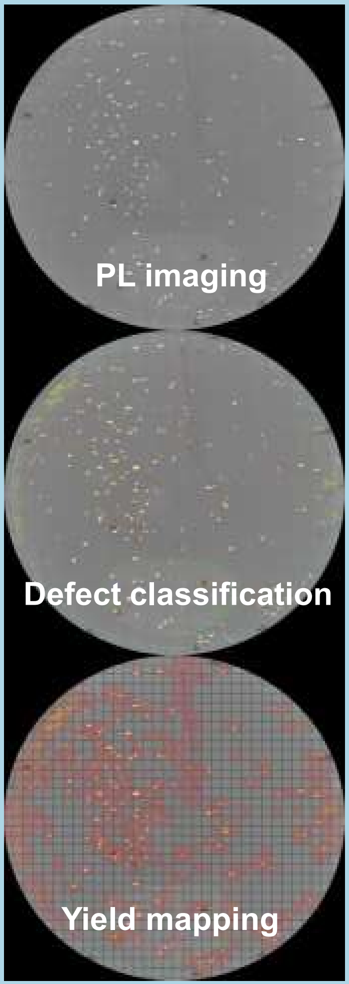


- All red labeled devices show clearly visible defects in the PL imaging and therefore exhibit a significantly increased probability of bipolar degradation.

→ *L. Wehrhahn et al.: Bipolar degradation of 6.5 kV SiC pn-diodes: result prediction by photoluminescence;* ***Th-2B-4***

AQUILA PL – SiC Wafer Inspection

PL Imaging of Bare Wafers, Epilayers and Partially Processed Wafers



1. Fast UV-PL imaging

- PL mapping of SiC wafer
- Calibration and contrast adaptation

2. Automated defect classification

- Defect recognition and classification
- Generation of individual defect mappings (SF, BPD, etc.)

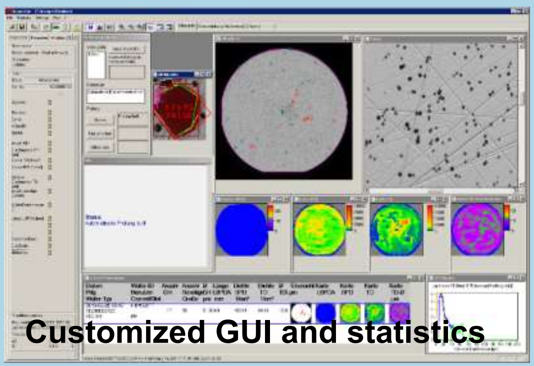
3. Reliable Yield prediction

- according to selected defect classes and die sizes
- Generation of individual yield mappings

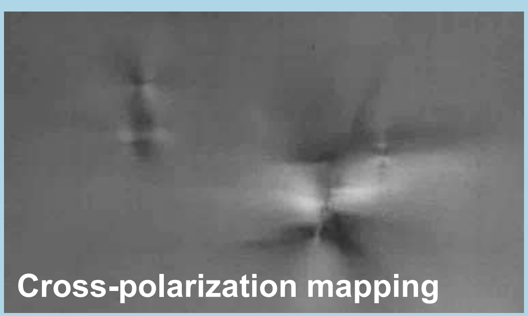
AQUILA PL – SiC Wafer Inspection

Customized Tool Options (I)

Customized wafer handling



Customized GUI and statistics



Cross-polarization mapping

Additional Tool Options

+ **Other excitation wavelengths** for more bulk information
+ **Higher resolution** for more detect details
+ **Surface defect detection and etch pit analysis** (e.g. dark field, DIC)
+ **Customized defect evaluation and classification**

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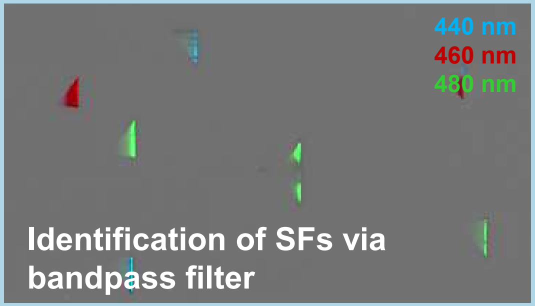
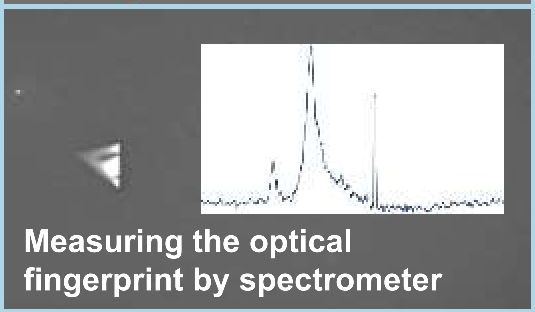
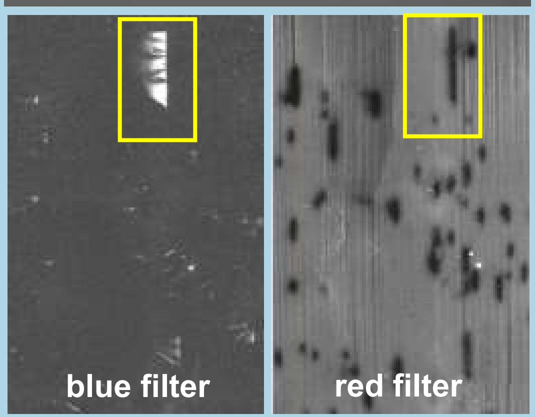
Customized Tool Options (II)







Additional Tool Options

+ Set of individually selected **filters for spectral analysis of SFs*** (optimizing the epitaxy and crystal growing processes)

+ **Spectrometer** (spectral fingerprint of defects)

** Thierry-Jebali, C. Kawahara, T. Miyazawa, H. Tsuchida, T. Kimoto, 4◦-off 4H-SiC epilayers”, AIP ADVANCES 5, 037121 (2015).*

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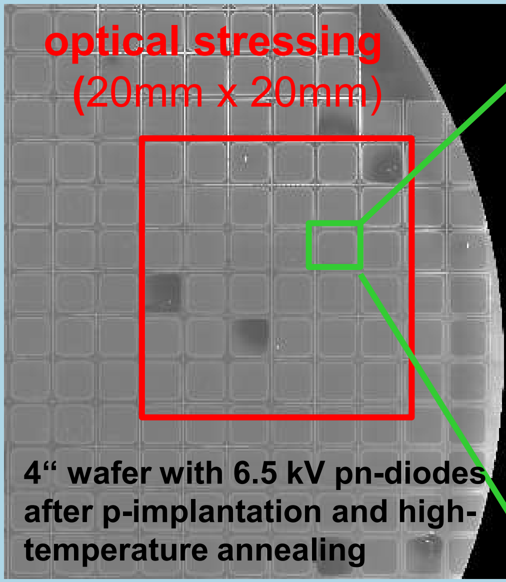
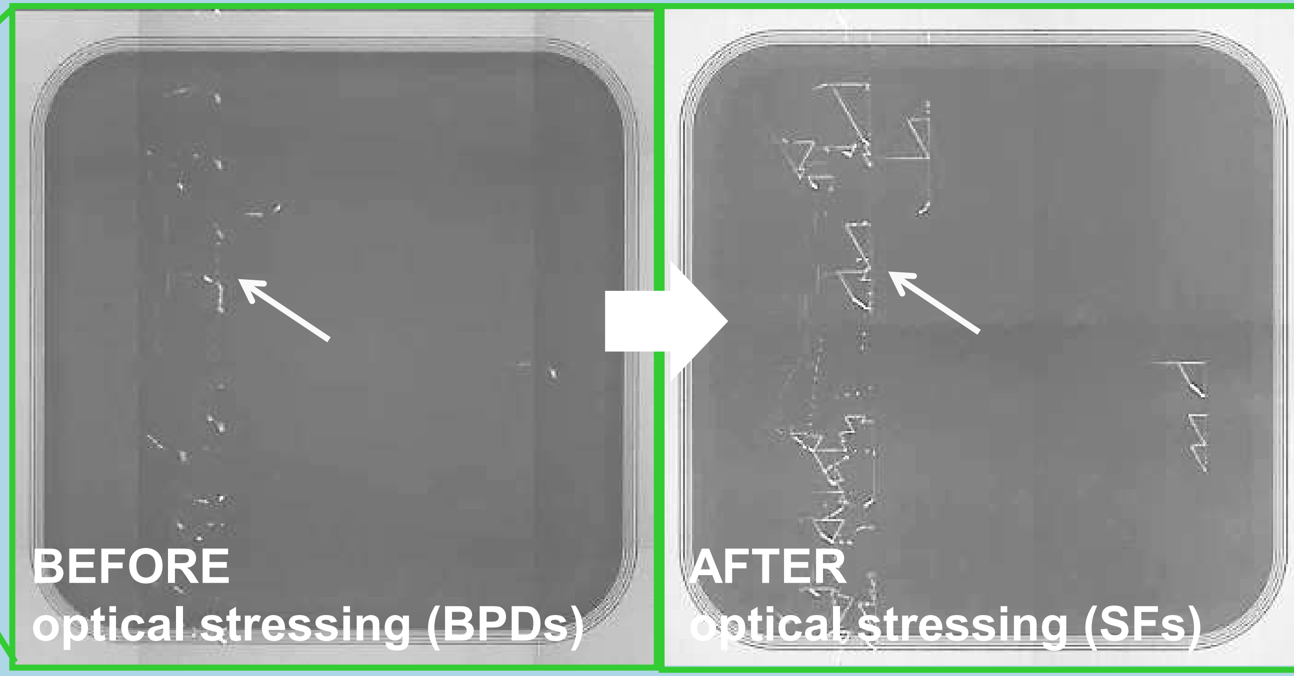
Customized Tool Options (III)

NEW!

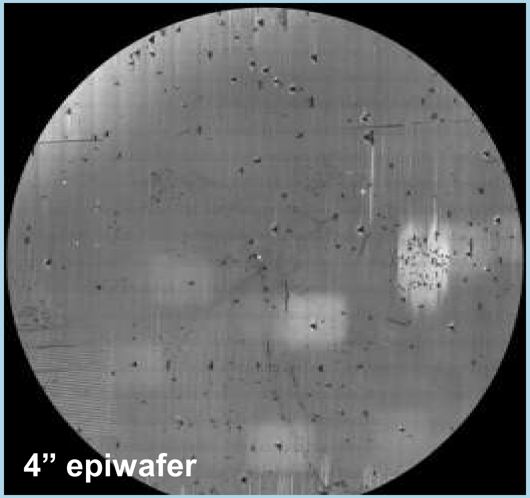


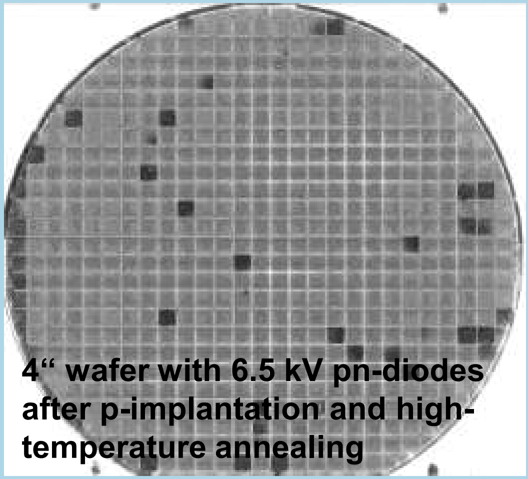


- + **Optical stressing of the material**
- + provoke “**bipolar degradation**” on wafer level
- + BPD converts to stacking fault
- + improved detection rate of critical BPDs which lead to defective devices

AQUILA PL – SiC Wafer Inspection

Summary





AQUILA PL - Customer’s benefits

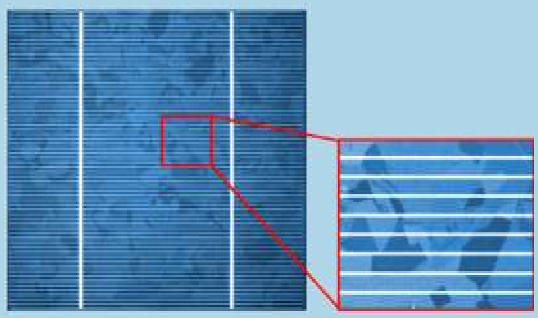
- Detecting critical defects like SFs and BPDs
- PL mapping of substrates, epilayers & partially processed wafers
- Suitable for laboratory and production environment
- Fast, reliable and automated defect recognition and classification including defect and yield maps

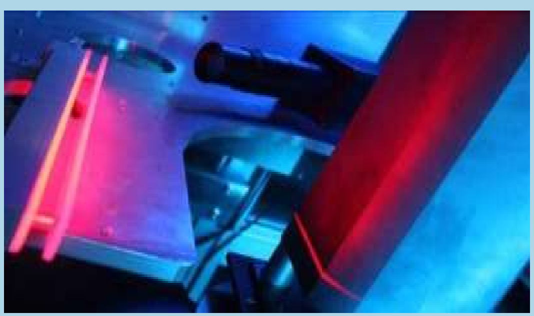
- optimizing the epitaxy and crystal growing processes
- Defective electronic devices could be reliably detected and directly sorted out

- Identification of SFs by their optical fingerprints
- Optical Stressing of the material

Intego GmbH – Vision Inspection Systems

Facts on Intego





History

- Established in 1999 in Erlangen, Germany
- 50 employees (mostly scientists and engineers)
- Since 2009 a site established in Singapore

Industries, customers in

- Solar and Semiconductor
- OLED and Sapphire

Core business

- Deliver fully-automated inspection systems based on cameras
- Development of individual systems (prototypes) for customized measurement and inspection issues
- Special solutions for loading, unloading and sorting tasks
- Since 2009 over **130** vision systems installed in Singapore
- Since 2014 over **50** vision systems installed in the US

Intego GmbH – Vision Inspection Systems

Optical Inspection Systems for SiC Materials

Defect Luminescence Scanner (DLS):
Scientific and Industrial-scale Defect Analysis

Booth no. 17

… Thank you for your attention!