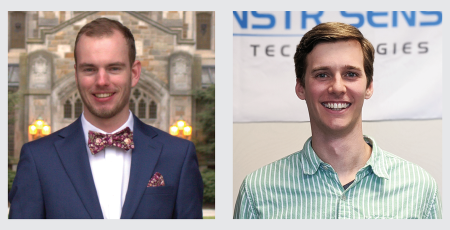
Ultrafast Imaging for Deep Defect Imaging Through Entire SiC Wafers

MONSTR SENSE TECHNOLOGIES



All optical, full-wafer defect detection for epilayers and substrates

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Inspection Method: Ultrafast Imaging

Multi-modal ultrafast imaging provides access to killer defects in SiC epitaxy and substrate, including polytype inclusions, stacking faults, basal plane dislocations, and threading dislocations.
With the all-optical approach, together with state-of-the-art algorithms, the KRAKEN™ SiC Inspection System provides defect information on wafers with high depth selectivity and penetration depth.

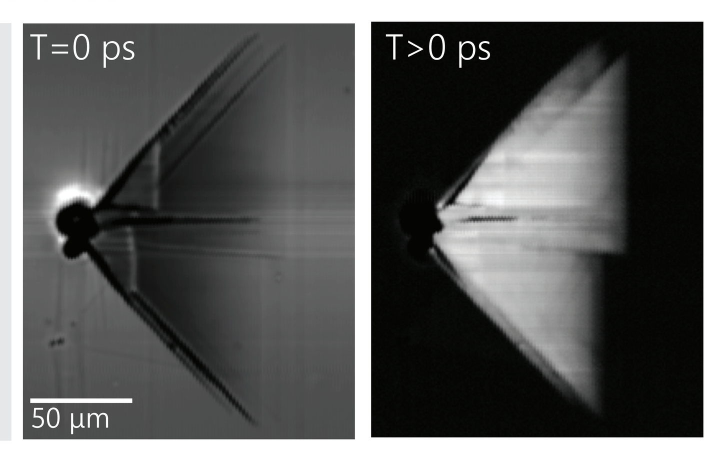
T.L. Purz et al., J. Chem. Phys. 156, 214704 (2022)
T.L. Purz et al., Opt. Express 30, 45008-45019 (2022)

Ultrafast Transient Absorption Imaging (TA), a third order nonlinear optical technique, is sensitive to changes in the semiconductor bandstructure, i.e., defects.
We acquire multiple modalities, including polarized linear absorption (PLA), photoluminescence (PL), and TA simultaneously, providing complementary data that enhances sensitivity and specificity.

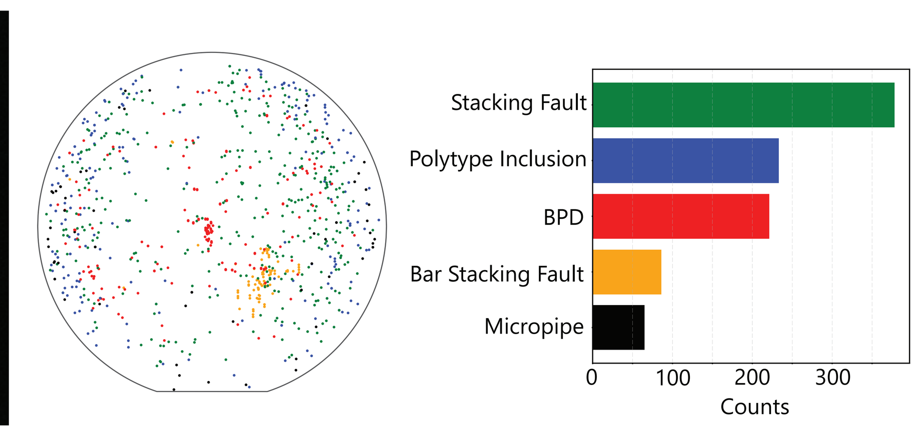
Wafer-scale ultrafast defect inspection

The ultrafast advantage: A sensitive measure of defects in epilayers and substrates

Ultrafast Imaging generates contrast for defects that impact the SiC bandstructure. Unlike photoluminescence, ultrafast imaging does not rely on excited states that radiatively decay, a limitation for photoluminescence in substrates. Ultrafast Imaging can be used in two modes: Bulk, and defect. For bulk mode, the pump and probe pulse are temporally overlapped and defects are detected through an absence of TA signal. For defect mode, the pulses are not overlapped and virtually background free images of the defect can be obtained via trapped defect states.

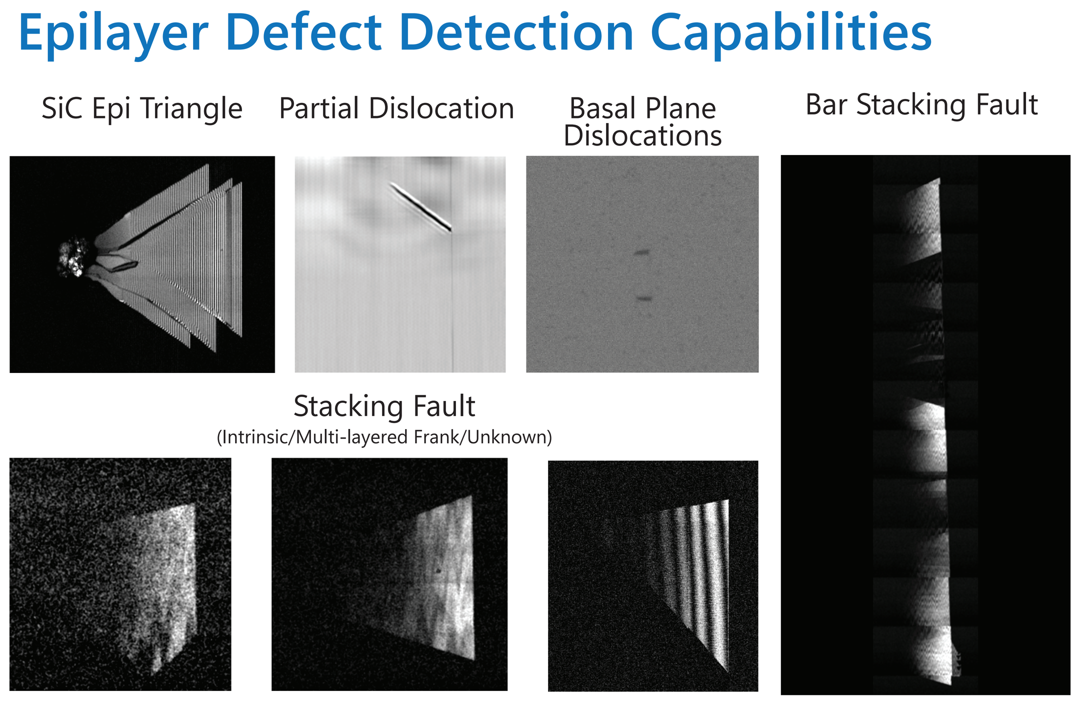


Full-wafer automated defect detection

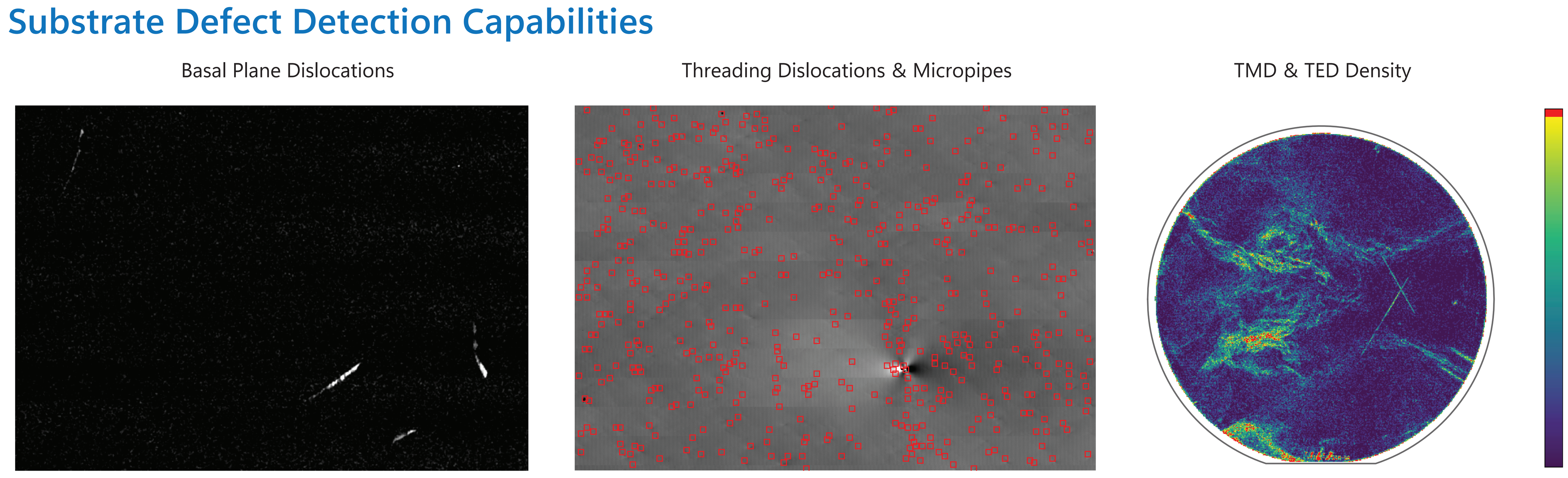


ML-enabled algorithms & multi-channel data fusion yield reliable full-wafer automated defect detection

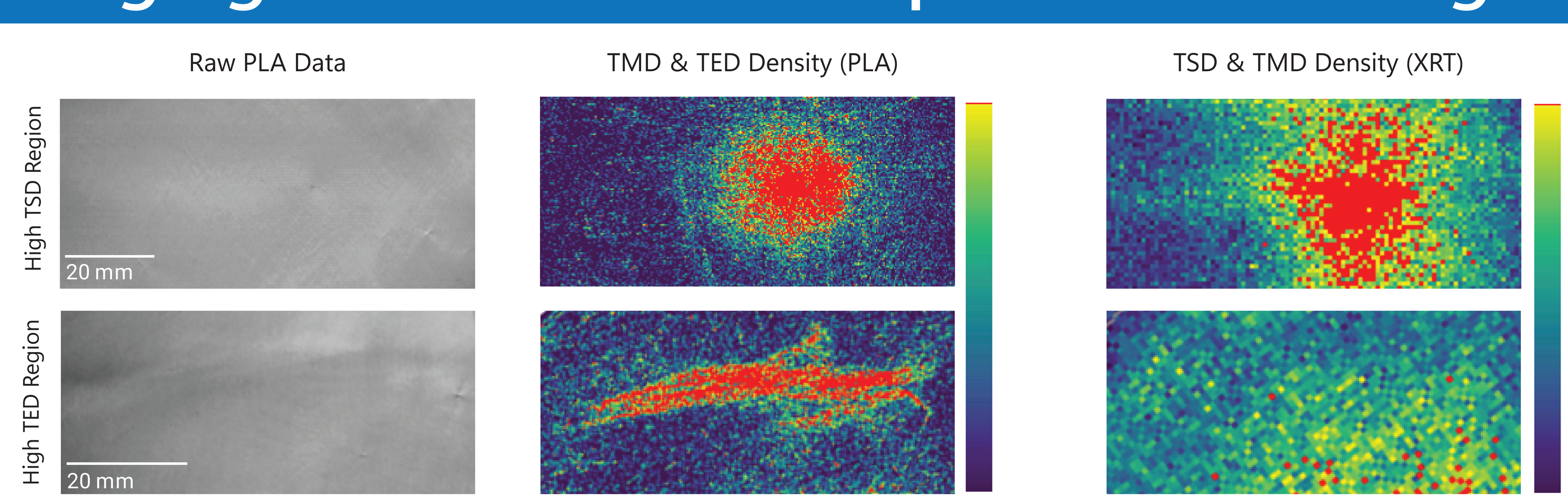
Epilayer Defect Detection Capabilities

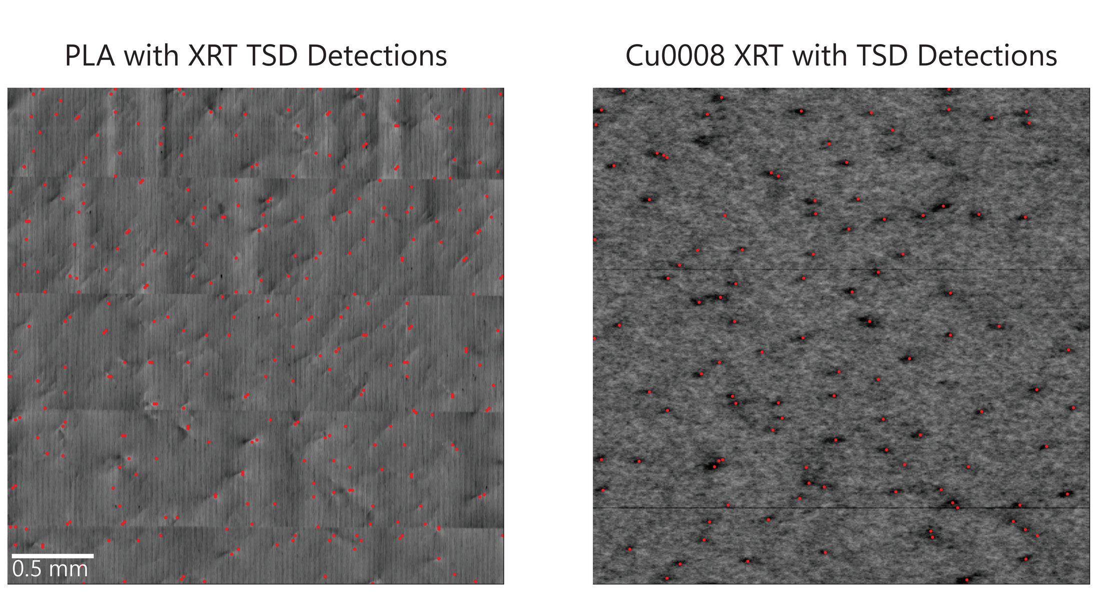


Substrate Defect Detection Capabilities



Imaging of Substrate and Epi Defects through the entire wafer





Category	Counts
Total counts in XRT	105
True Positives in PLA	79
False Negatives in PLA	26
False Negatives in XRT	96

PLA Sensitivity to XRT Detections: 75%
XRT Sensitivity to all TDs: 52%
PLA Sensitivity to all TDs: 87%

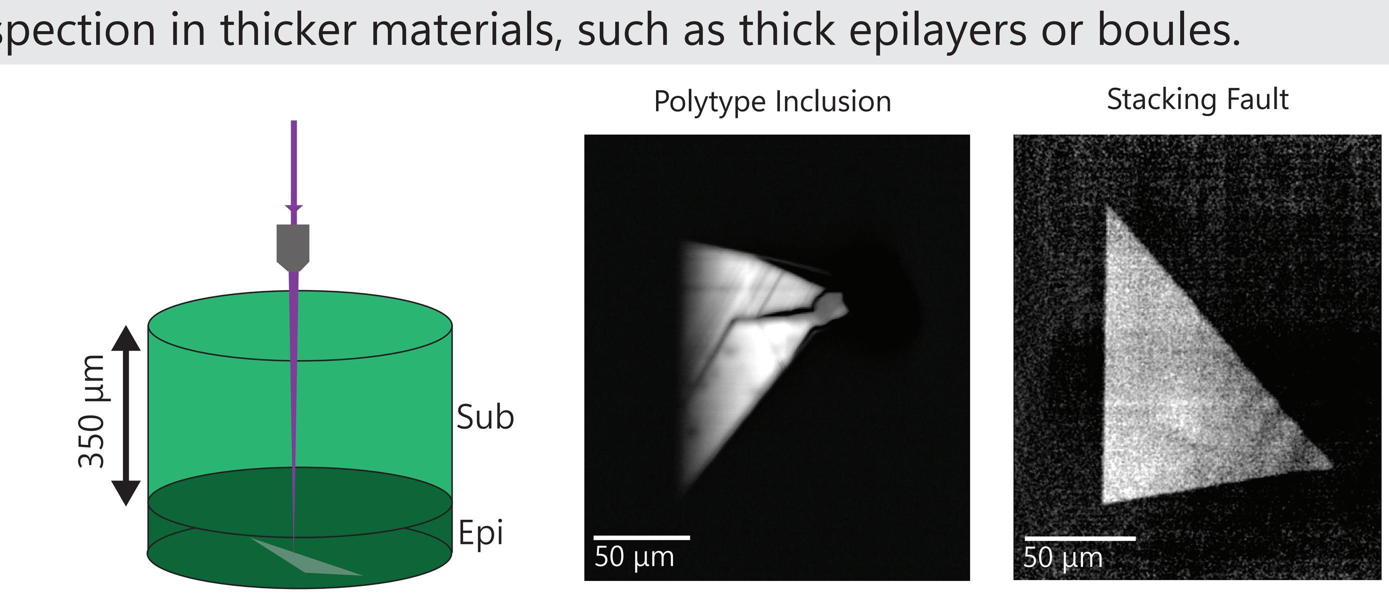
PLA is sensitive to most threading dislocations, except TSDs. TEDs, which are typically only detected through KOH etch, are only visible in PLA. The TA Channel detects micropipes through an absence of TA signal.

Threading Dislocation Detection

Threading dislocation densities in PLA are derived from rapid in-line algorithms.
Threading dislocations (TMDs, TEDs) detected via PLA follow a similar radial pattern as threading dislocations detected via XRT, with threading screw and threading mixed dislocation densities highest in the center. However, XRT misses threading edge dislocations, which are clustered at the top and bottom of the wafer. PLA can detect these dislocations. Threading Dislocation densities in PLA are generally higher, due to the prevalence of threading edge dislocations.

Imaging of "deep" epi defects through the substrate

When using excitation light tuned below the bandgap, ultrafast imaging can excite hundreds of microns deep into the material. This enables measurement of defects throughout entire wafers, as illustrated below for a polytype inclusion and a stacking fault, which were measured for an epi wafer with the epi side facing down. These capabilities are crucial for defect inspection in thicker materials, such as thick epilayers or boules.



A volumetric sideview of the stacking fault reveals growth at a 4° angle, consistent with the basal plane. It also provides depth information about the origin of the stacking fault. The thickness of the stacking fault is limited by the axial resolution (<4.5 µm) of the optical measurement.

Volumetric Sideview of Stacking Fault