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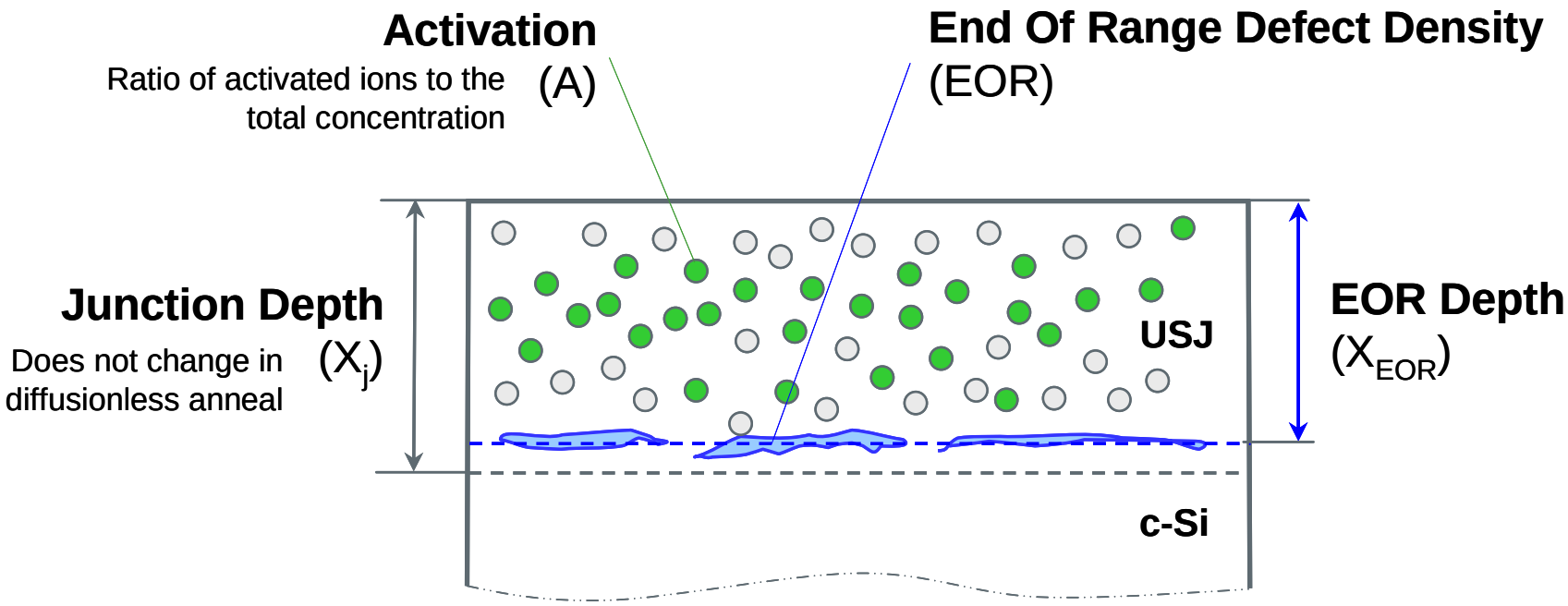
Accelerating Yield

Activation & EOR Monitoring Using Therma-Probe

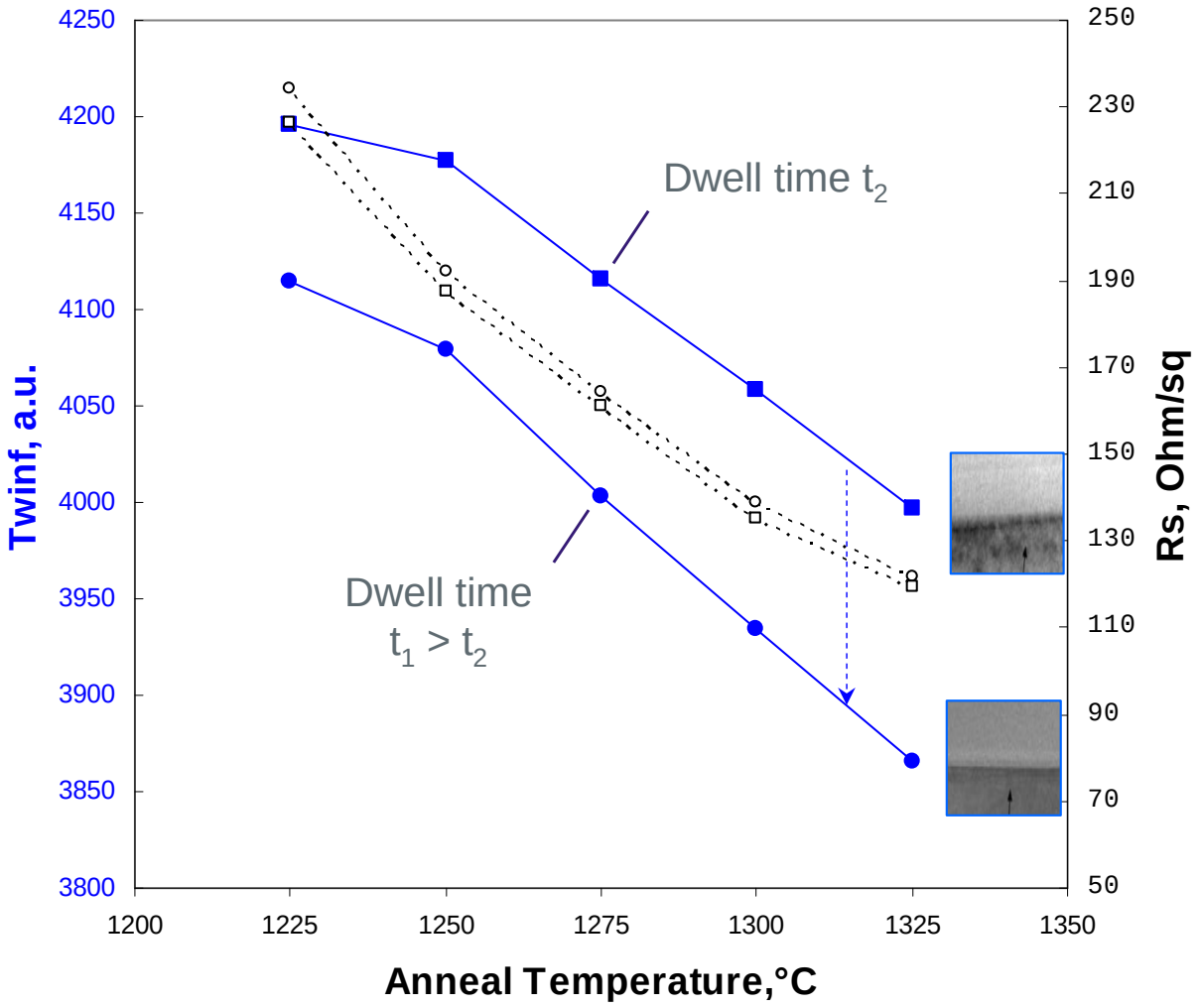
Junction Technology Group Meeting, July 16, 2009

TP USJ Applications: Parameters of Interest



Monitoring of EOR Damage: Laser Anneal

- Both Rs and TW signal are sensitive to ms anneal temperature (activation)
- In addition, TW is also sensitive to dwell time
- Longer dwell time results in less defects (lower TW signal)
- TP680 reaches ~ 1˚ in LSA temperature resolution required for control of anneal tools (~10˚ precision)



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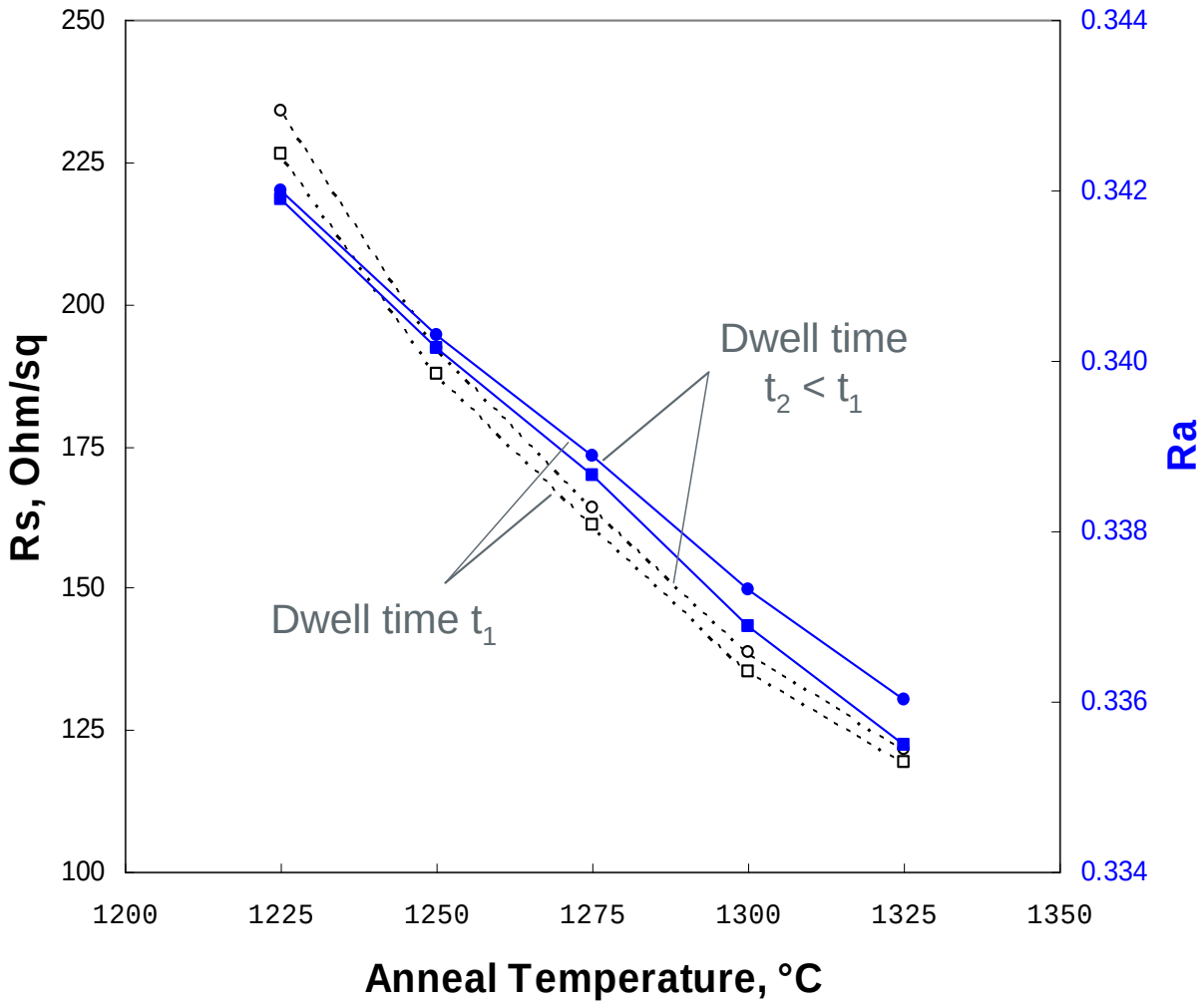
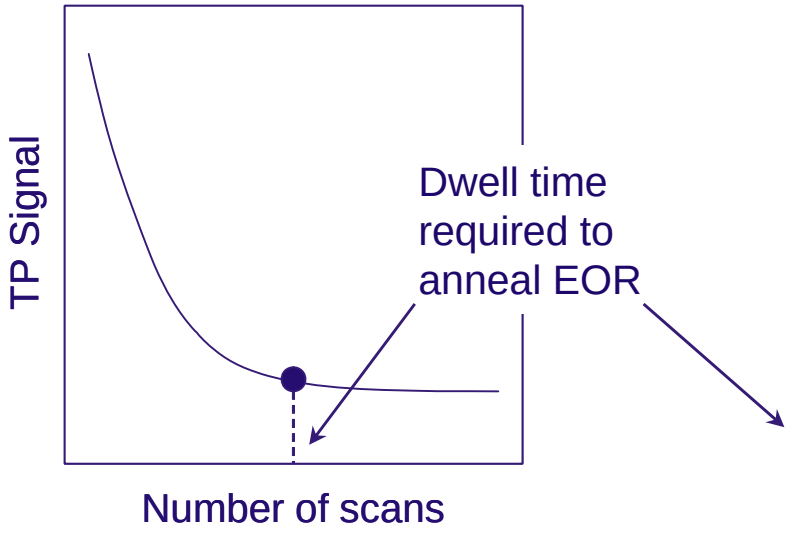
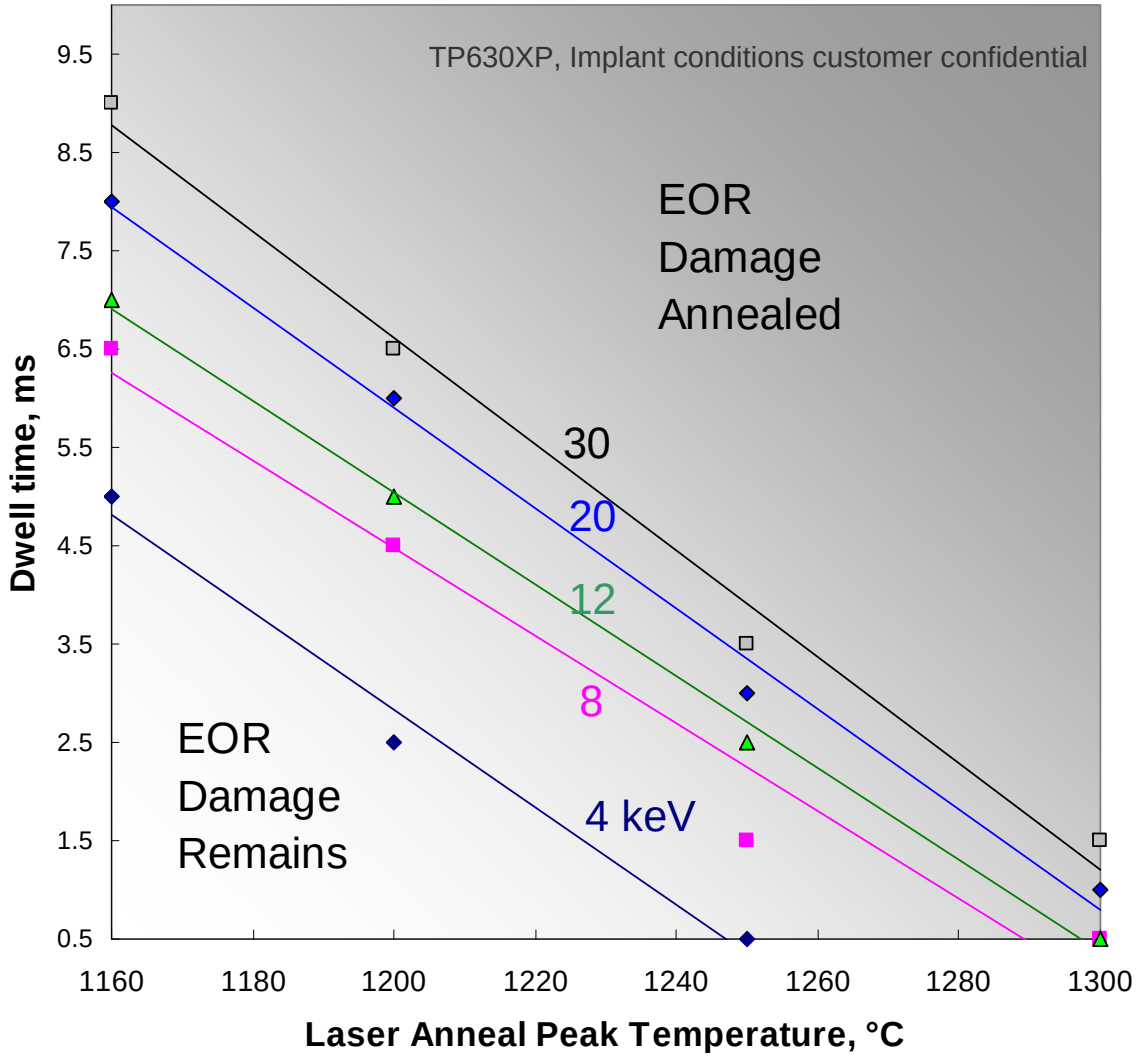
Anneal Temperature Control with Therma-Probe

- Alternative TP signal, Ra is sensitive to activation as shown on the graph. Ra signal behaves similar to Rs
- Ra is sensitive to changes in variations in optical refraction index caused by activation



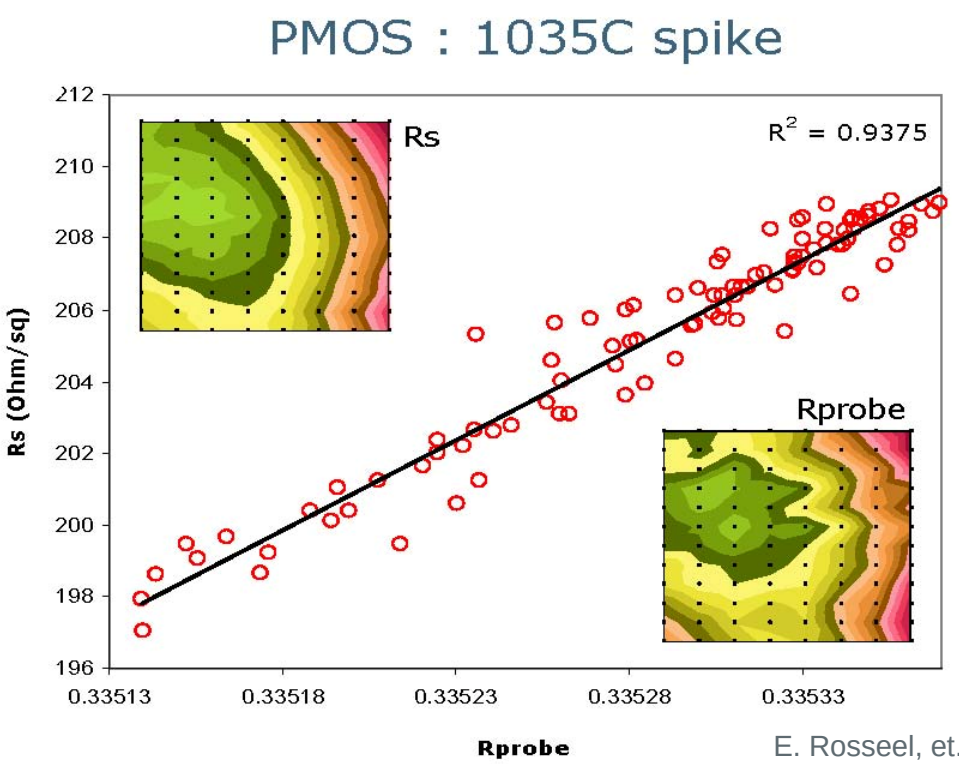
EOR Damage Phase Diagram (KT-IMEC)

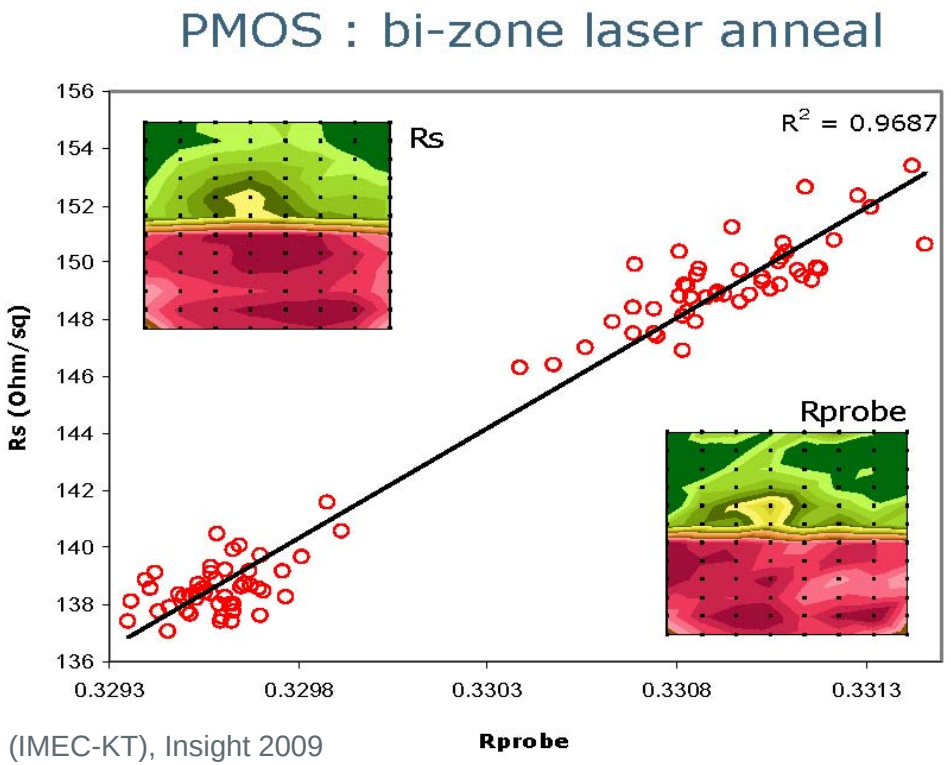




- Possible to determine boundary between EOR damage and damage-free regions in laser anneal using TP dependencies on peak temperature and/or number of scans
- With low implant energies, less thermal budget is required to anneal EOR

Correlation To Rs



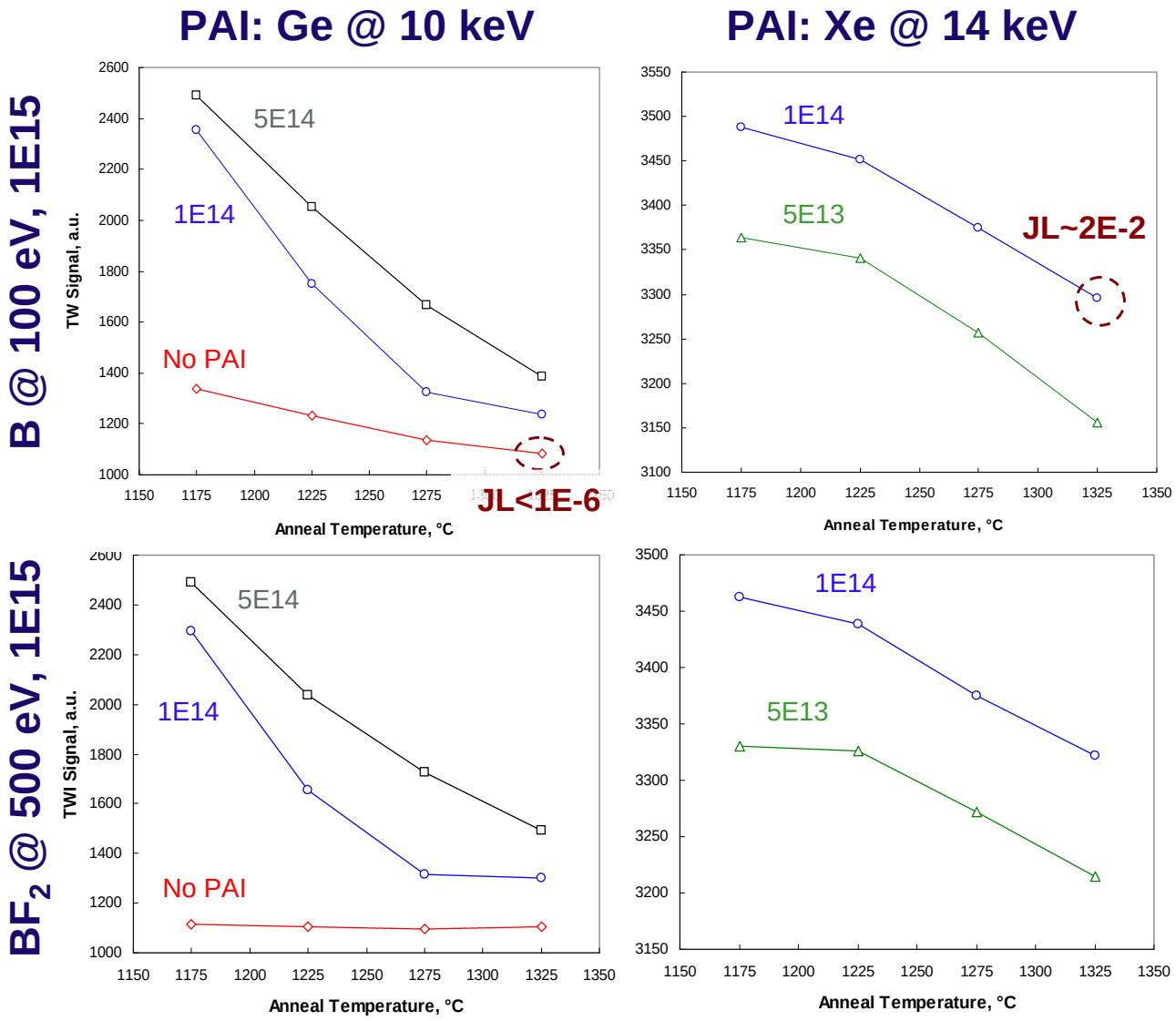


E. Rosseel, et. al., (IMEC-KT), Insight 2009

- TP Probe reflectance correlates well with resistivity parameters in E-test on product wafers (PMOS example) for both Spike and Laser anneals.

Laser Anneal of ULE Implants: EOR Study

- Without PAI, TP signal is low indicating low EOR
- Increase in PAI dose results in stronger TW signal (larger EOR concentration)
- TW results correlate with RsL junction leakage data (JL, where available)
- Xe PAI results in stronger TW signal and slower decay with anneal T°C compared to Ge PAI regardless of the dopant species
- EOR damage may be quantified using correlation of TP signal to total damage density (TTD) as shown next



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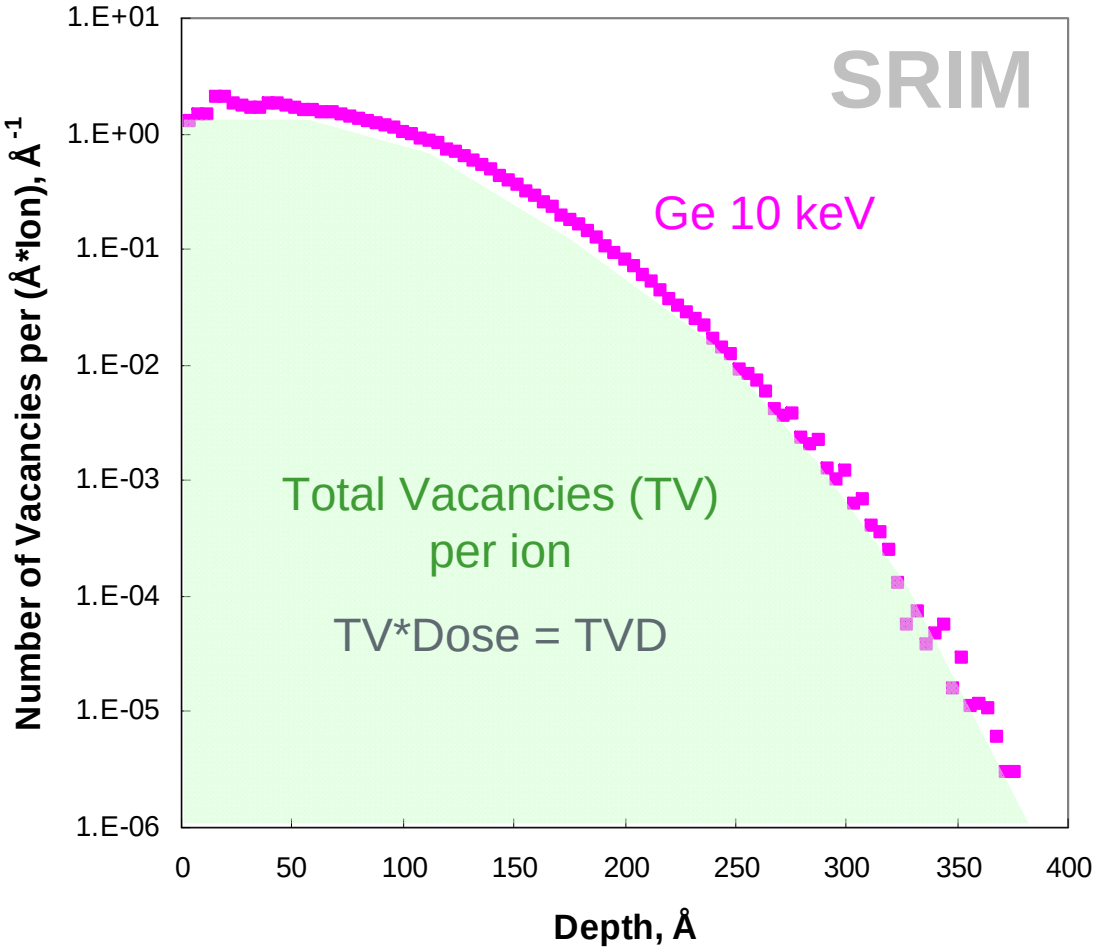
SRIM Calculation of Total Vacancy Density (TVD)

- SRIM calculates the Total Vacancies per Å per ion created by implant ions and recoils.
- An integral (area) of the TV profile gives the Total Vacancies (TV) per ion
- A product of TV and implant dose gives the Total Vacancy Density (TVD) in cm^{-2}
- TV values for most common implants and structures are known. For example, integrating the area under SRIM calculated TV profile for Ge 10 keV gives 198 vacancies/ion. Total target vacancies is also 198.



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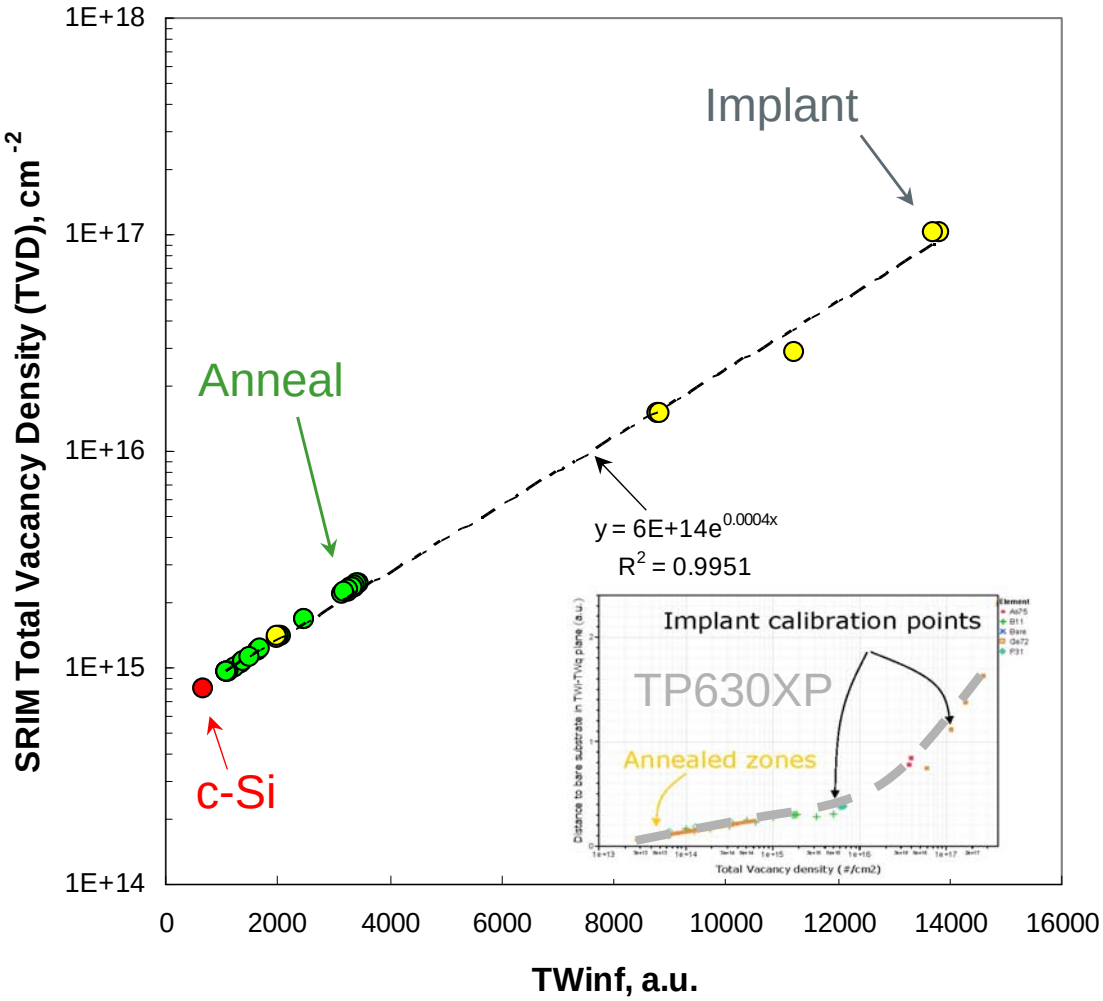
TW Signal Correlation To Total Vacancy Density

- Note all experimental TW points are lying on the same line (both implant and anneal)
- Functional dependence of TVD on TW signal is established for implanted wafers
- The same dependence is applied for laser annealed wafers.
- With increasing LSA temperature, TVD is decreasing gradually to its level in crystalline Si (c-Si) material
- For samples studied, the dynamic range of TVD variations is larger than 2 orders of magnitude.



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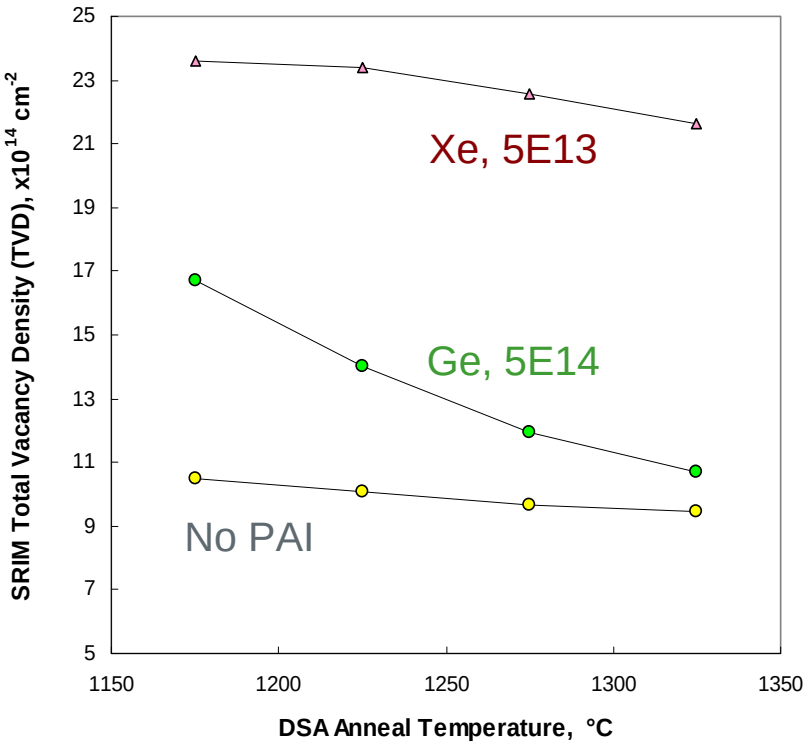
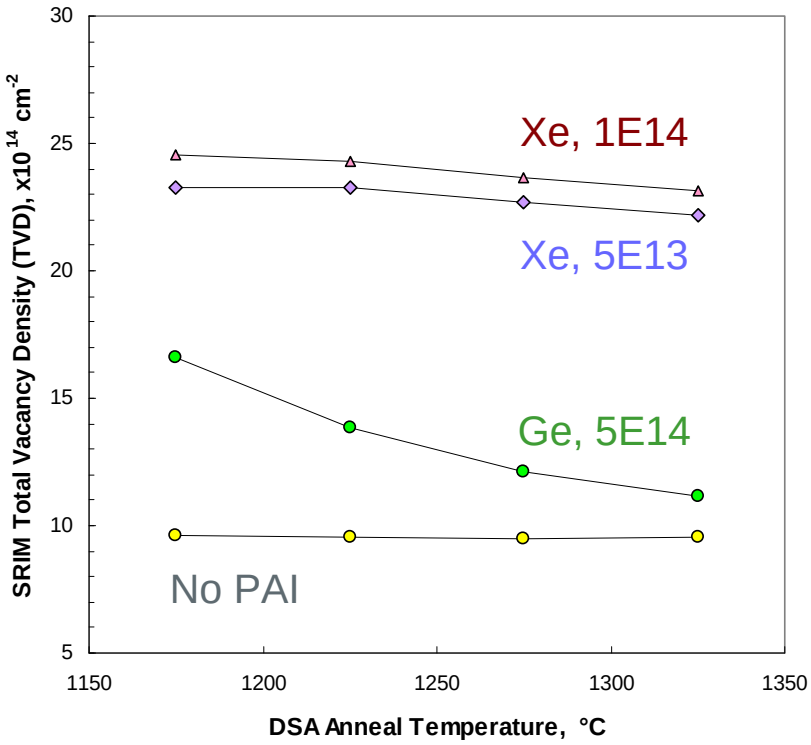
Monitoring of EOR Removal With LSA Anneal

B @ 100 eV, 1E15



BF_2 @ 500 eV, 1E15



- Calibration of TW units to TVD allows to quantify EOR damage removal with LSA as measured by TP

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What Therma-Probe Is Used For Today ?

	Demonstrated	In Development
Implant Monitoring	Implant Dose	Implant Depth Profiling
	Implant Energy	
	Angle of Incidence	
	μ-Uniformity Analysis	
Anneal Monitoring	USJ Depth	Carrier Concentration
	Anneal Temperature	Carrier Depth Profiling
	Carrier Activation	EOR Damage
	μ-Uniformity Analysis	Activation Monitoring
Process Improvement	Uniformity Improvement	Correlation to Device

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