

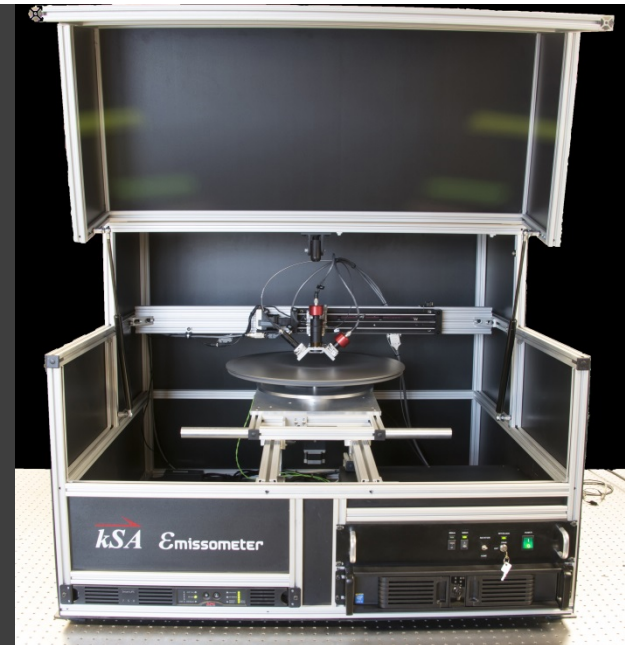


k-Space Associates, Inc.

Wafer Carrier Evaluation with the kSA Emissometer

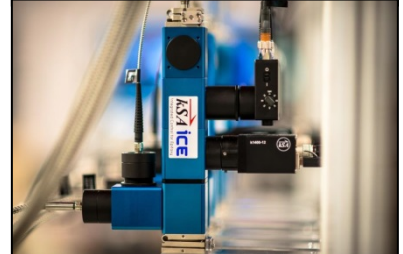
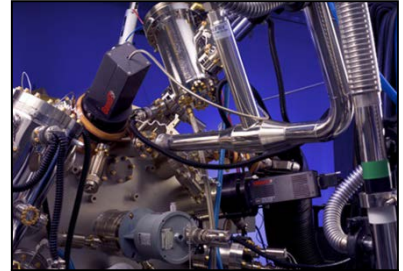


Darryl Barlett
May 17th 2016
CS Mantech



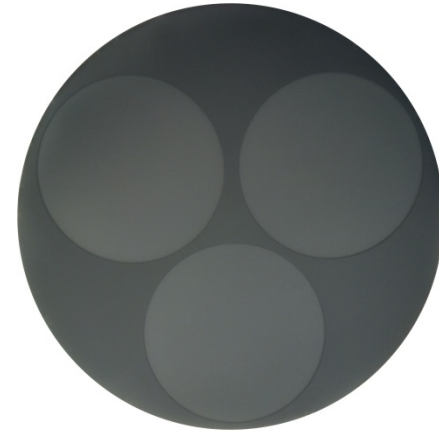


- Founded in 1992
 - Headquartered in Dexter, MI USA
 - Advanced thin-film and wafer characterization products for use with MBE, MOCVD, CVD, PVD, sputtering and evaporation systems
 - Staff of physicists, optical engineers, and software specialists
- Products
 - Wafer/Film Temperature Measurement
 - Analytical RHEED and Surface Imaging
 - Thin Film Stress, Bow, and Curvature
 - Film Thickness, Deposition Rate, Optical Constants
 - Semiconductor Optical Band Gap
 - *In situ* and *Ex Situ* Mapping Systems
 - Photovoltaic Metrology
 - **Wafer Carrier Characterization**



Wafer Carriers/Susceptors

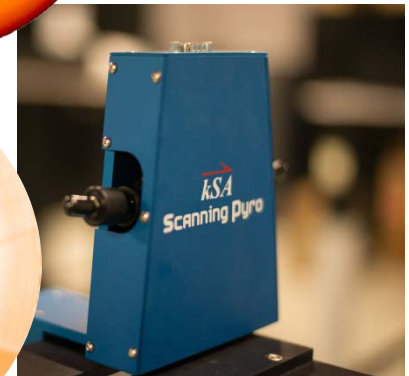
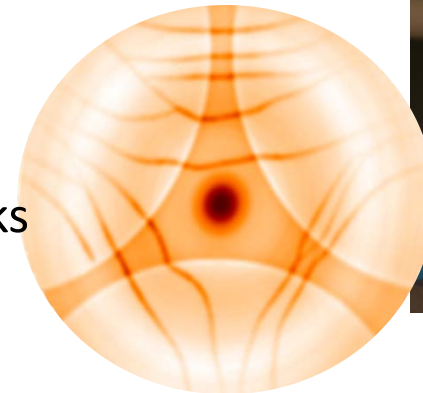
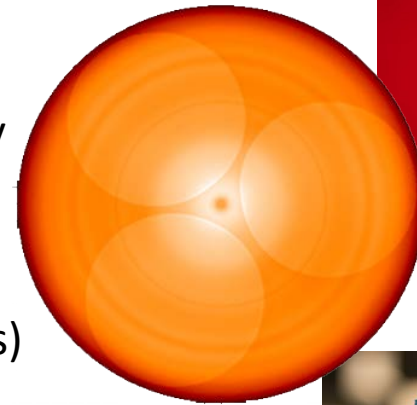
- SiC coated Graphite
 - Holds wafers in MOCVD reactors
 - Transfers heat to wafers
- Requirements
 - Consistent manufacturing carrier to carrier to ensure reproducible production process (RUN to RUN and REACTOR to REACTOR)
 - Consistent manufacturing across a single carrier to ensure production uniformity (RUN YIELD)
 - Clean and bakeable for repeat use (REDUCE COSTS)



Is there a way to determine if these requirements are being met?

Wafer Carrier/Susceptor variations can cause:

- **Wafer temperature non-uniformity**
 - Emissivity variation caused by:
 - Varying surface roughness/morphology
 - Defects in SiC
 - Inhomogeneous SiC material quality
 - Surface nodules (small surface particles)
 - Residual material after bake
- **Epi-layer contamination**
 - Carbon outgassing from microcracks



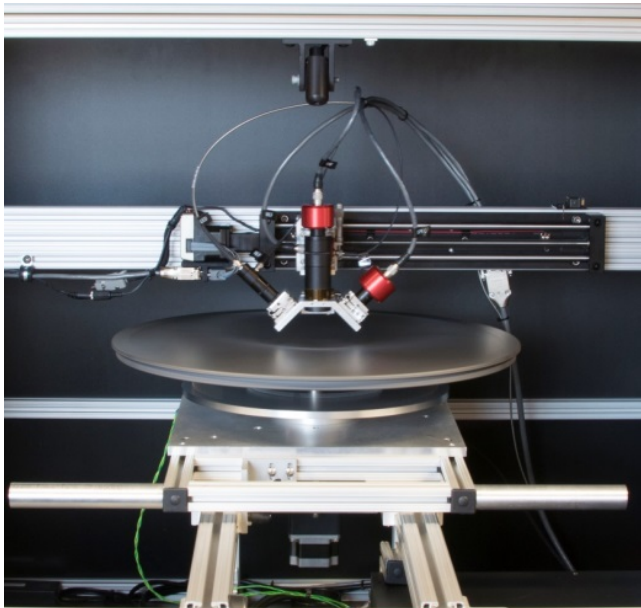
* Wafer carrier temperature maps measured *in situ* using the KSA ScanningPyro.

Solution: Automated Measurement of Carrier Emissivity and Reflectance

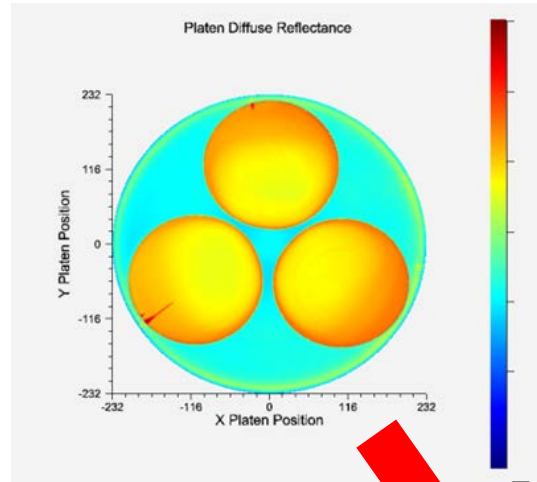


Carrier Reflectance and Emissivity

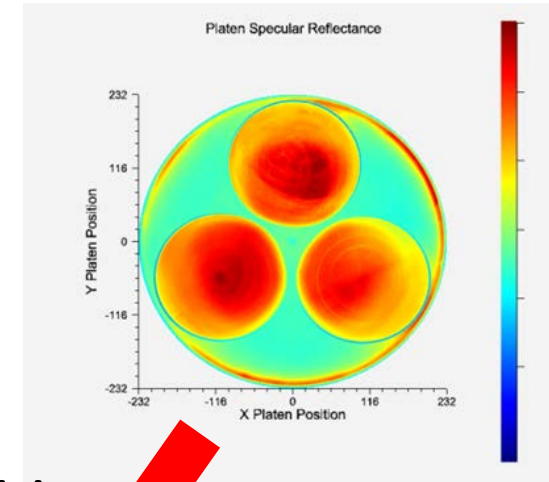
kSA Emissometer



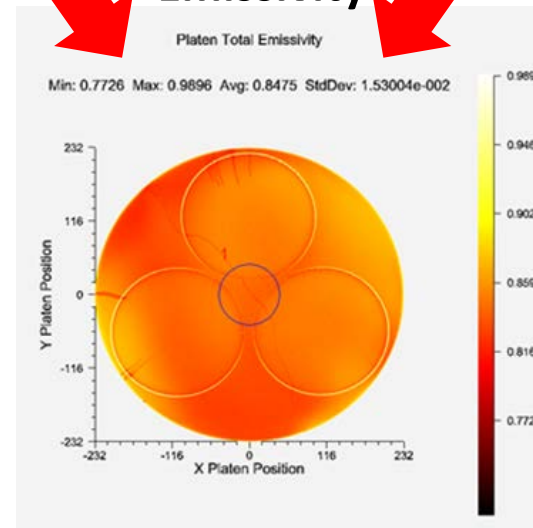
Diffuse Reflectance



Specular Reflectance



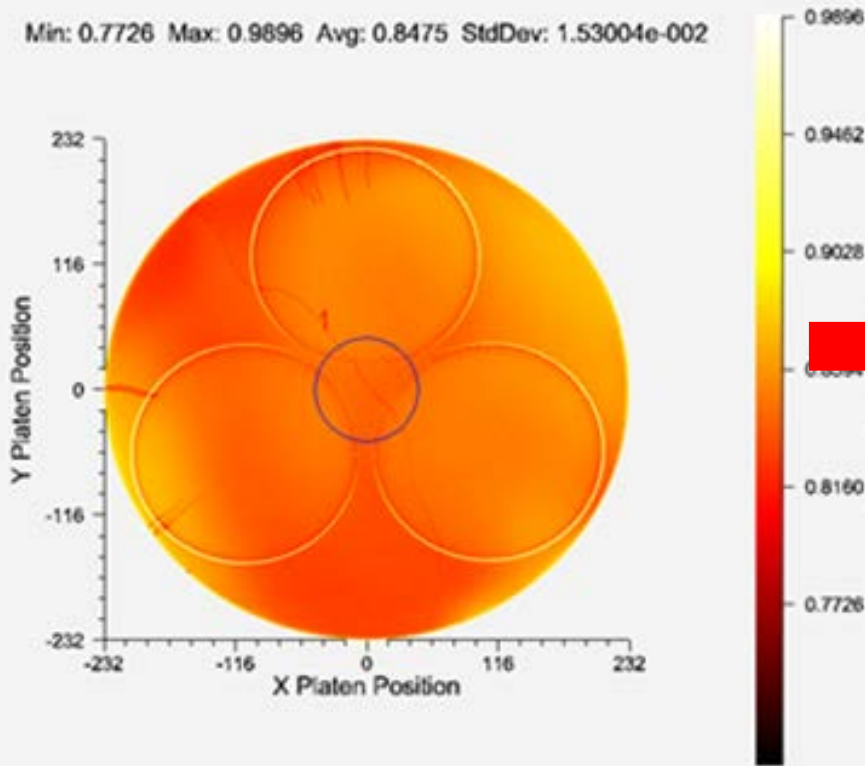
Emissivity



Emissivity

Platen Total Emissivity

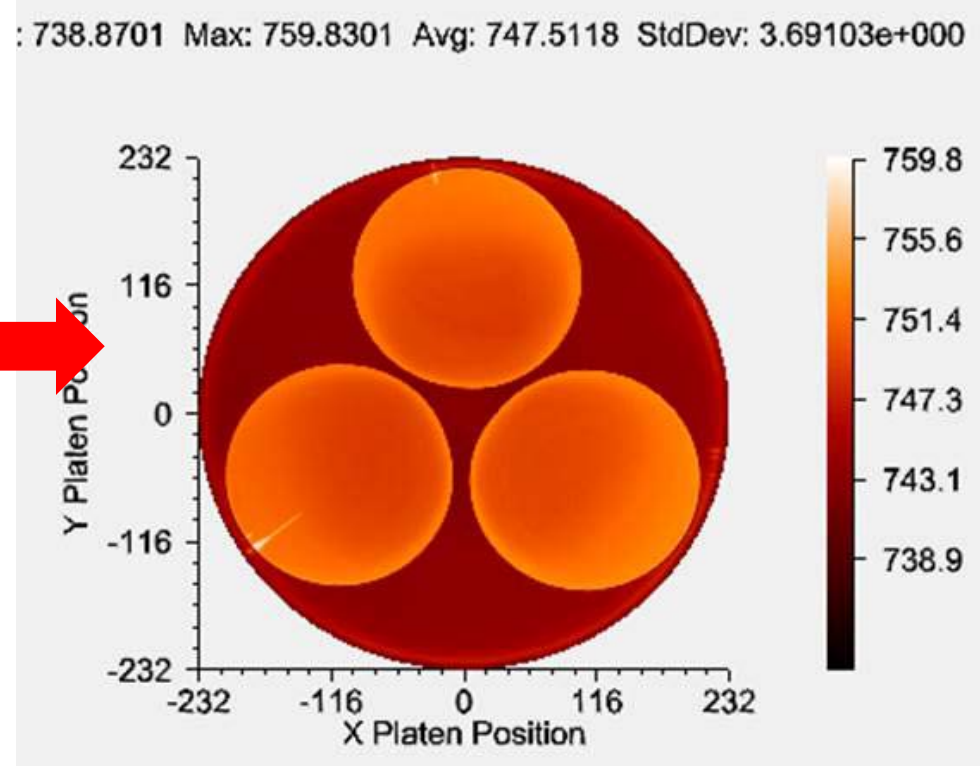
Min: 0.7726 Max: 0.9896 Avg: 0.8475 StdDev: 1.53004e-002



Expected Temperature

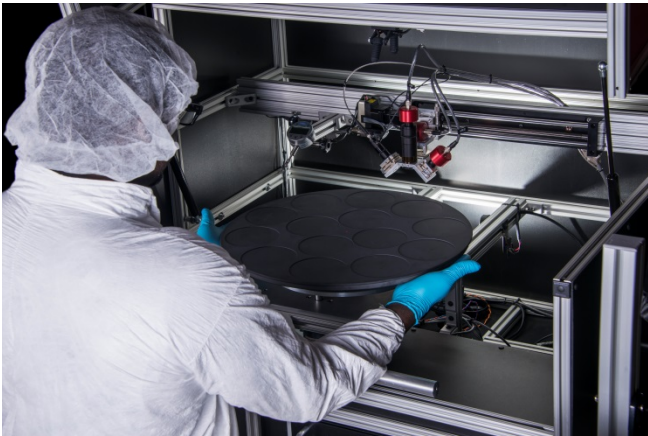
Temperature Degrees Celcius

Min: 738.8701 Max: 759.8301 Avg: 747.5118 StdDev: 3.69103e+000





kSA Emissometer Benefits:



Carrier/Susceptor Manufacturers

XYCARB | CERAMICS

Pure Excellence

MERSEN

SGL GROUP
THE CARBON COMPANY

TOYO TANSO

Reactor Manufacturers

agnitron
technology

AIXTRON

TAIYO NIPPON SANSO

Veeco

APPLIED
MATERIALS®

NUFLARE

Epi Houses

OSRAM

三安光电
Sanan Optoelectronics

LUMILEDS

IQE

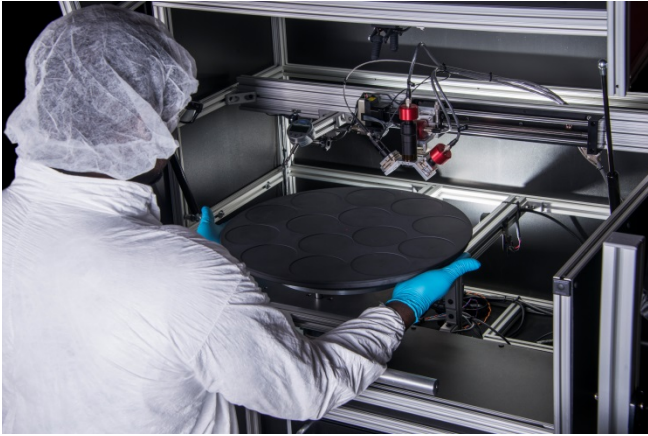
Lextar

CREE

Hermes Epitek



kSA Emissometer Benefits:



Reactor Manufacturers

- Incoming quality certification
- Multi-vendor comparisons
- Better end user support

Carrier/Susceptor Manufacturers

- Automated, fast process control
- Out-going quality certification
- Quality control tracking with end user feedback

Epi Houses

- In-coming quality certification
- Multi-vendor comparisons
- Improved yield
- Bake evaluation
- Carrier end of life determination

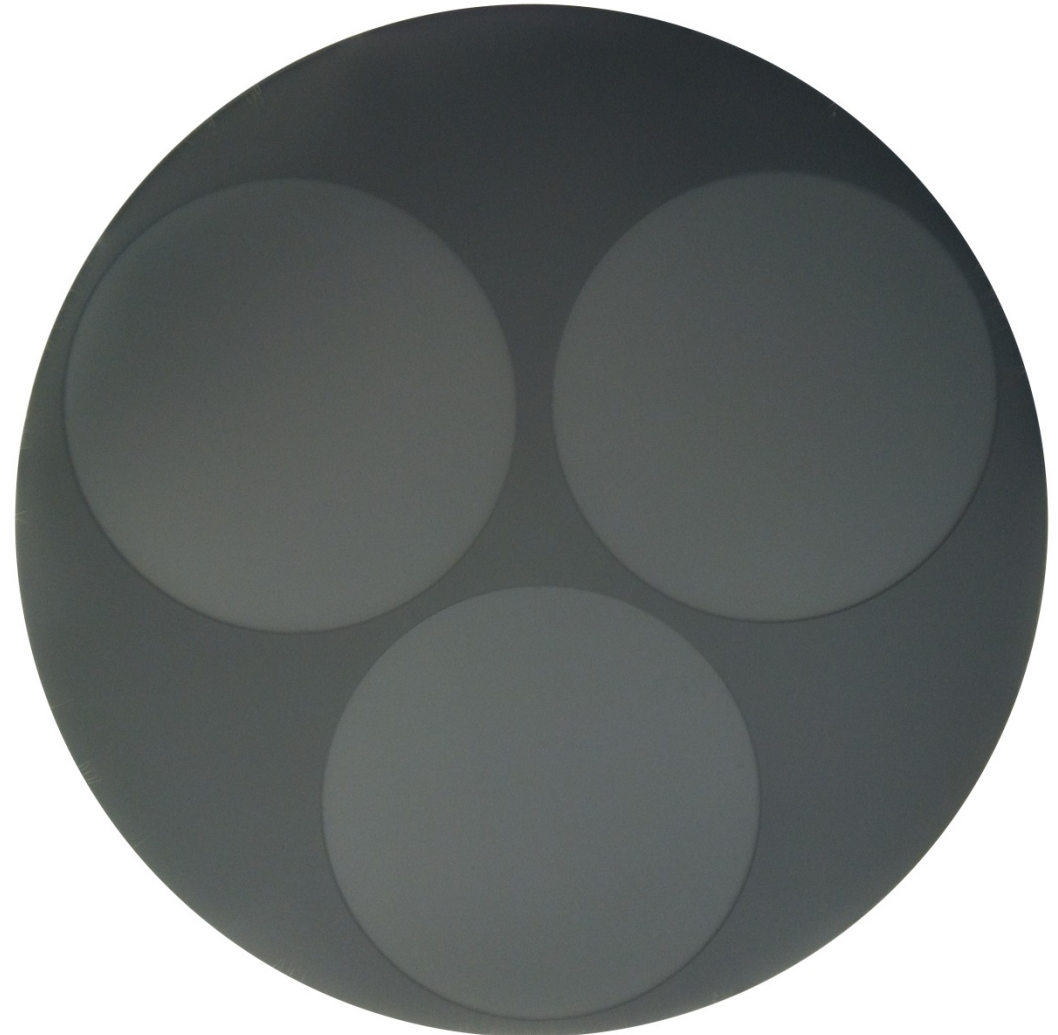


Case 1 – Epi House Post-Bake Carrier Inspection

Microcracks

- Thermal mismatch between SiC and graphite
- High temperature thermal cycles
- Can cause carrier implosion in the reactors
- Can cause carbon out gassing

Human Eye (Camera)



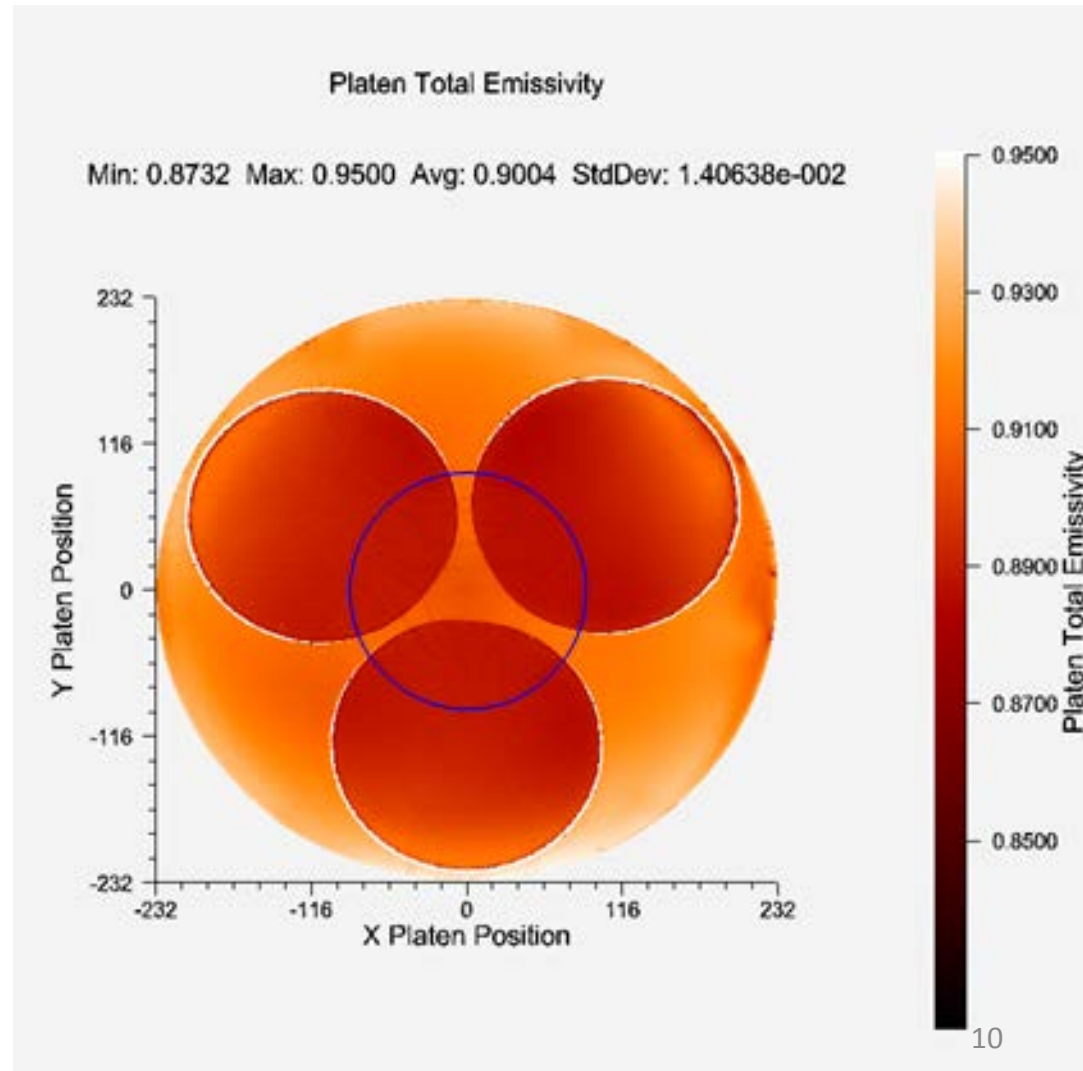


Case 1 – Epi House Post-Bake Carrier Inspection

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kSA Emissometer



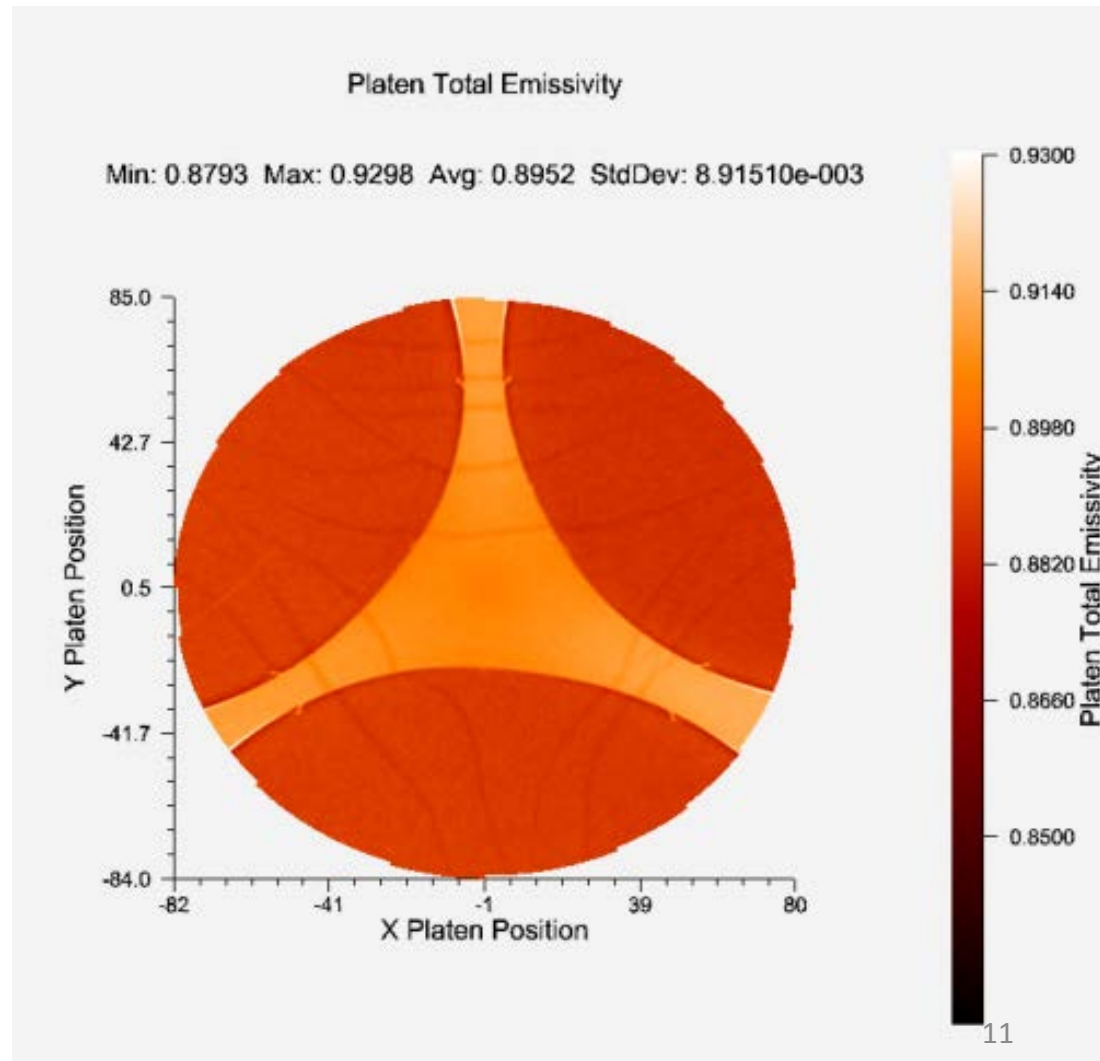


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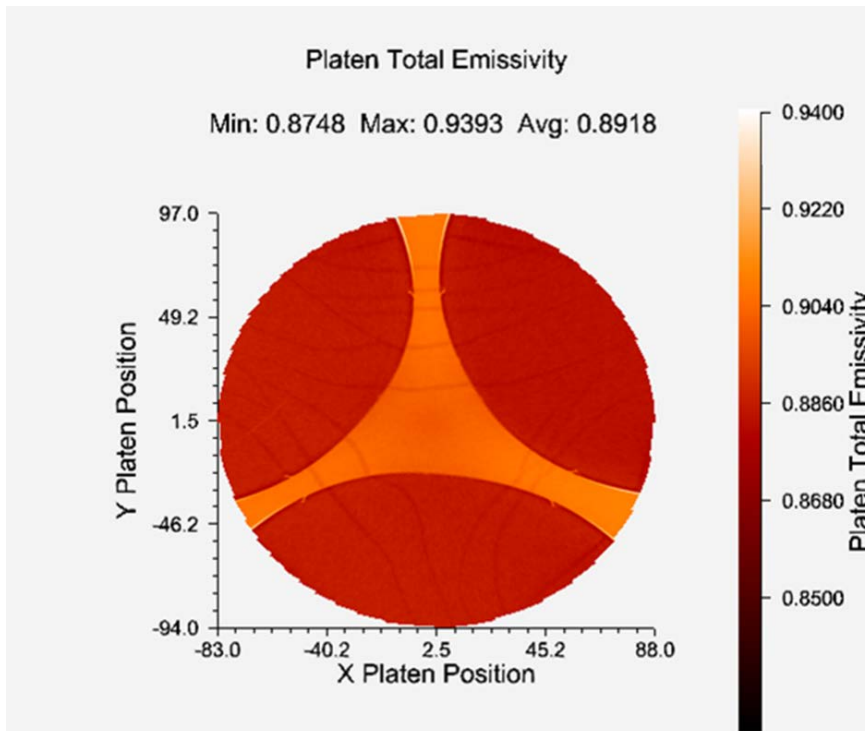
kSA Emisometer - Zoom



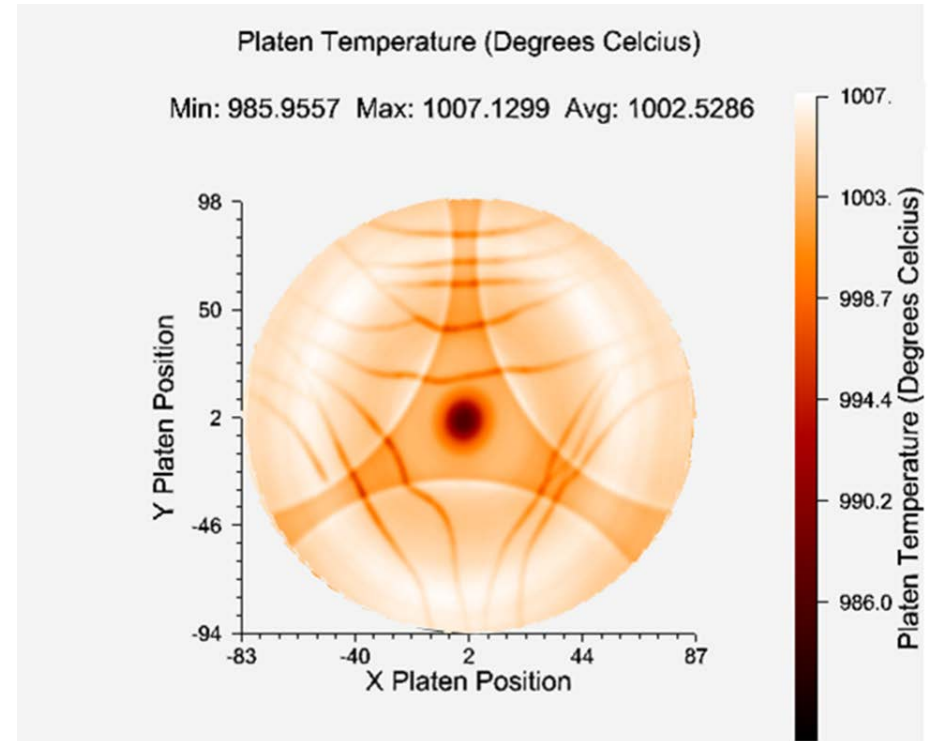


Case 1 - Temperature and Emissivity Comparison

kSA Emissometer (ex-situ)

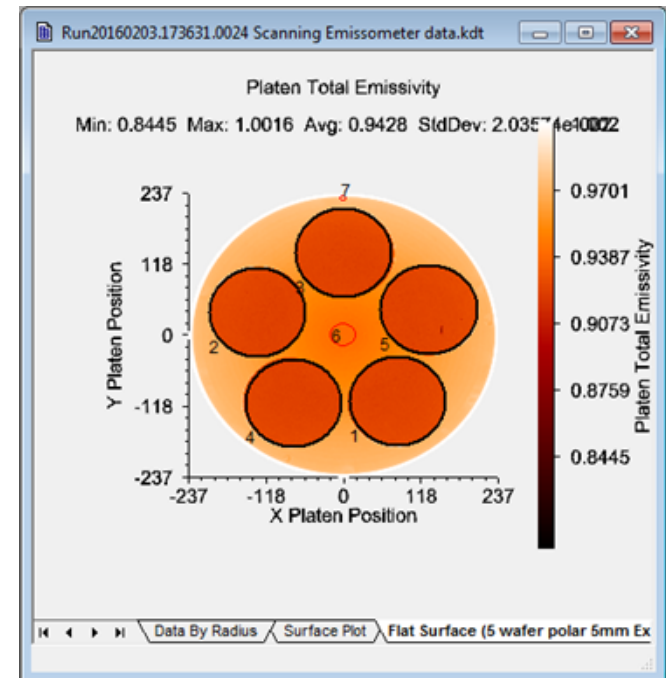


kSA ScanningPyro (in-situ)



All Users Benefit:

- Quality Certificate
 - Overall carrier statistics
 - Individual and cumulative pocket statistics
 - Web statistics
- Multi-vendor comparisons
- More data for QC systems



Template Analysis of Run20160203.173631.0024 Scanning Emissometer data.kdt

Platen Report - 5 wafer polar 5mm Exclusion

Platen Total Emissivity

Total Pocket Statistics				Individual Pocket Statistics				Pocket
Min: 0.8445	Max: 0.9339	Avg: 0.9242	StdDev: 1.67107e-003	Min: 0.9098	Max: 0.9296	Avg: 0.9242	StdDev: 1.43089e-003	1
				Min: 0.8445	Max: 0.9339	Avg: 0.9241	StdDev: 1.51662e-003	2
				Min: 0.9145	Max: 0.9319	Avg: 0.9246	StdDev: 1.75584e-003	3
				Min: 0.9112	Max: 0.9291	Avg: 0.9239	StdDev: 1.34337e-003	4
				Min: 0.8568	Max: 0.9310	Avg: 0.9244	StdDev: 2.10008e-003	5
Bare Platen Statistics								
Min: 0.9211	Max: 1.0016	Avg: 0.9602	StdDev: 1.61703e-002					



Will kSA Emissometer benefit your process?

- Do you want to:
 - Provide better Carrier Quality Reports to your customers?
 - Use quantitative data to help adjust temperature set points?
 - Use an automated approach to wafer carrier inspection to eliminate human error?
- Not sure?
 - Contact k-Space about a kSA Emissometer demonstration on your wafer carriers.



Thank You!

