



## Full Temperature-Dependent Mapping of Curvature, Film Stress, Tilt, and Bow Height



The kSA MOS ThermalScan is a flexible, high-resolution scanning metrology instrument that measures curvature, film stress, bow, and tilt as a function of sample temperature. Based on proven and patented kSA MOS technology, the kSA MOS ThermalScan uses a laser array to map the two-dimensional curvature, wafer bow, and stress of semiconductor wafers, optical mirrors, lenses – practically any polished surface.

<b>Measures:</b>
Curvature
Bow height
Thin film stress
Tilt
Absolute reflectance
Film thickness and spectral reflectance (Optional)

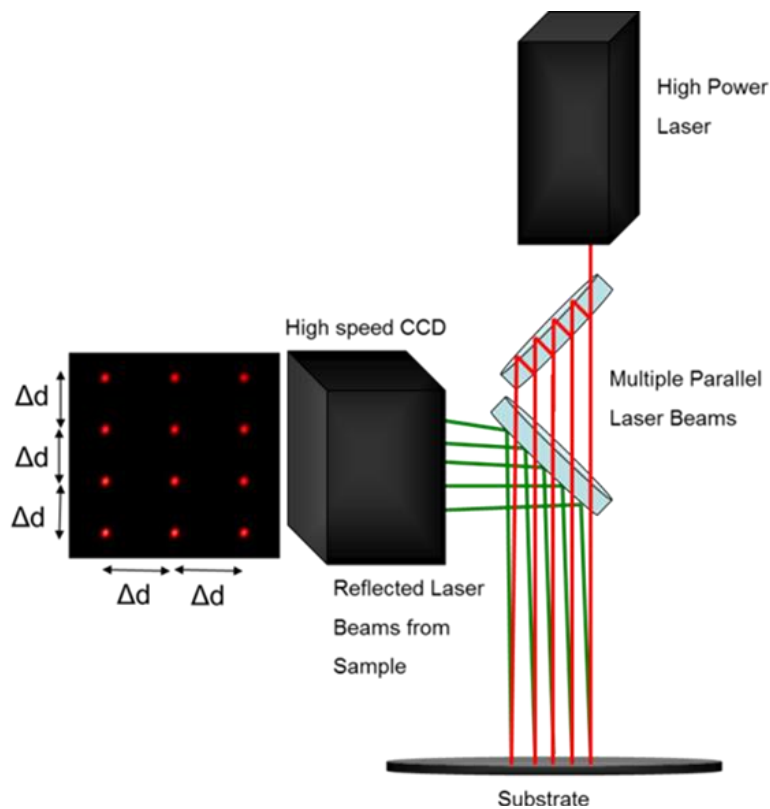
<b>Materials:</b>
Wafers
Optical Mirrors
Lenses
Hard Coatings
Polished Surfaces



## Product Description

Leveraging k-Space's expertise in integrating critical thin film metrology equipment, the kSA MOS Thermal Scan system utilizes the patented MOS (Multi-beam Optical Sensor) measurement technology to provide unparalleled curvature, stress, and bow height accuracy, resolution, and repeatability. The system is configured with a high-performance vacuum process chamber utilizing advanced rapid thermal annealing heaters and quartz sample holder to maintain wafer temperature stability and uniformity across the entire rated temperature range from room temperature to 1000°C. If you need to know changes with temperature below this, an option is available to measure temperatures down to -30°C.

Measurements can be made during introduction of forming or other gas, with two gas introduction lines included in the standard product configuration. Gas control is accomplished with manual set point flow meters, digital readout, and software-controlled solenoid On/Off valves. Patented multiple-spot laser array and auto-intensity feedback control ensures kSA MOS technology is compatible with substrates having a wide variation in surface reflectivity.



*Patented kSA MOS 2D laser spot array used for curvature/stress measurements.*



## Equipment Configuration

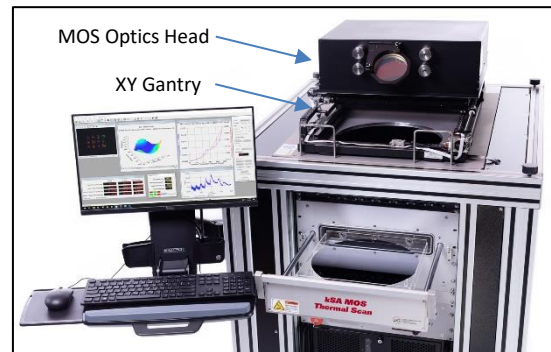
The vacuum heating chamber utilizes patented rapid thermal annealing technology in a completely integrated system with circulated water-cooled chamber, vacuum compatible sample compartment with sample locating features, and integrated thermocouple. The heating is performed with a high uniformity crossed quartz halogen lamp array for maximum temperature uniformity and stability. The system is capable of heating substrates to 1000°C under vacuum or process gas environments. See Model Table for more details.

### General System Specifications

- Maximum substrate size: Holds up to 300mm diameter wafer with provisions for 100mm, 150mm, 200mm and 300mm samples.<sup>1,2</sup> Smaller samples can be held with a graphite susceptor plate (quoted separately). See Model Table for more details.
- Substrate heater temperature range: RT up to 1000°C
- Process gas introduction lines with manual flow adjust, digital readout and software-controlled solenoid on/off valves. Compatible with forming gas, oxide, or inert gas use during heating.

### Vacuum Chamber

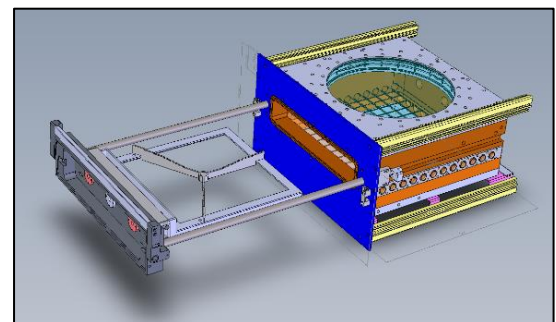
- Water-cooled rapid thermal annealing chamber with O-ring sealed front loading chamber, sample holder, and full upper quartz viewport to facilitate measurement.



Model TS300-HT with wafer loaded in open sample drawer and optics cover off.



Model TS300-HT with wafer sample drawer open showing quartz sample holder.



Rendering of the full oven viewport with the lid off sample holder drawer open.

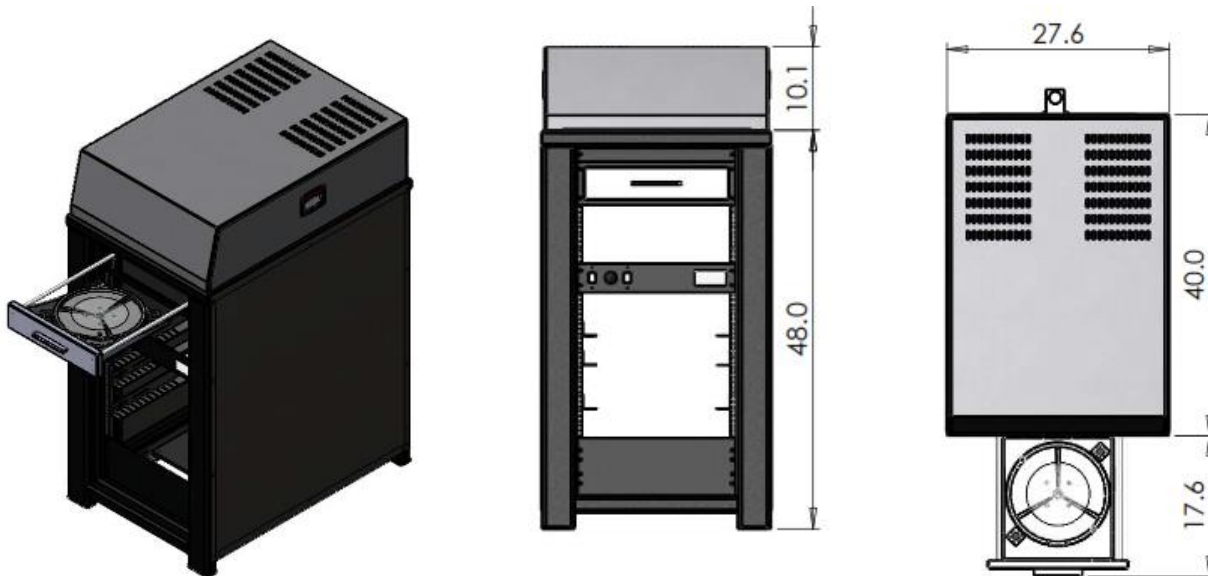
<sup>1</sup> 300mm wafers should only be scanned over the central 200mm to maintain the accuracy specified in this document.

<sup>2</sup> Non-standard and irregularly shaped wafers can be accommodated with a graphite susceptor (quoted separately).



## Frame Assembly:

- A robust steel frame houses the entire chamber, control electronics, and metrology system.
- The frame has retractable castors so that the system may rest on vibration isolation pads.



Standard kSA MOS Thermal Scan dimensions.

## Substrate Heater and Temperature Control

- Substrates are free standing with an integrated thermocouple.
- Heater is a patented crossed-array quartz halogen lamp design, with bottom heating elements for maximum substrate temperature uniformity and stability.
- Substrate temperature is controlled via a programmable closed-loop temperature control unit and power supply.
- Temperature uniformity: better than  $\pm 2^{\circ}\text{C}$  across central 80% of sample when measured with sample at stable temperature.
- Temperature measurement accuracy is dictated by standard thermocouple accuracy.

## Vacuum/Pumping:

- Vacuum gauging includes one gauge with digital readout and process pressure setpoint relay for safety interlock control.
- Diaphragm backing pump with all pump controllers is required and may be supplied by the customer or by k-Space. System includes related manual isolation and control valves that can be fully integrated to achieve 750 mTorr ( $\sim 1$  mbar) base pressure or better.



## Specifications and Models

### Standard Specifications for All Models

Parameter	All Models
Measurement Range*	1MPa – 7.8 GPa
Temperature Range	See Model Table Below
Temperature Ramp**	6 - 30°C /minute (0.1 – 0.5°C /sec)
Temperature Uniformity	+/-1% on 300mm wafers up to 650°C
Repeatability*	0.32 MPa <sup>2</sup>
Accuracy*	< 1% or 0.32 MPa (whichever is larger)
Minimum Radius	2.0 m (customizable to 1.0 m)
Maximum Radius***	25,000 m
Curvature Repeatability****	$2 \times 10^{-4}$ (1/m)
Bow Height Repeatability	1µm for 10 line scans
Wafer Sizes (mm)	100, 150, 200, and 300 mm (custom sizes available with separately quoted graphite holder)
Minimum Scan Step	0.001 mm
3D Analysis Software	Standard

\* Assumes 725 µm Si substrate thickness, 180 GPa biaxial modulus for Si Substrate, and 1µm fil thickness. 300mm wafers should only be scanned over the central 200mm to maintain the accuracy specified in this document.

\*\* Cooling rate will be slower and is dependent on process conditions of chamber pressure and gas flow rate.

\*\*\* Based on 1-sigma curvature repeatability of line scans and area scans. System dependent. Please ask your k-Space representative for data for your scenario.

\*\*\*\* Measured at room temperature

### Models and Features

Feature	Model TS100	Model TS300-MT	Model TS300-HT
Scan/Wafer Size	Up to 100 mm	Up to 300 mm	Up to 300 mm
Maximum Temperature	Up to 1000°C	Up to 600°C	Up to 1000°C
With Cooling Option	Down to -30°C	Down to -30°C	Down to -30°C
Scan Type	Center Point Only	Area	Line Scan Only
Second Lid for Scan Type Option	-	-	Add a second lid for Area Scan to 600°C; Line Scan to 1000°C



## Options

There are several options available to measure your wafer under the conditions that you need. Please ask your k-Space representative for more details on these options.

- **Cooling to -30°C**  
With the cooling option, cooling is performed through a Brooks Polycold gas chiller to measure the sample at below zero conditions. Without the cooling option, the standard minimum temperature is room temperature.
- **Higher Curvature Measurement**  
For high curvature samples, we offer an upgrade that increases the size of the optics to allow measurement of up to 2mm bow height on 300mm samples.<sup>2</sup> The size of the optics housing and the overall width of the tool also increase by a small amount. The minimum radius and maximum bow height are sample diameter dependent. Contact your k-Space representative for more details.
- **Different Sample Sizes**  
For non-standard samples, we can provide a graphite holder option. Contact your k-Space representative for more details.
- **Area and Linear Scans**  
For the Model TS300-HT, a second lid can be added to provide area scan capability up to 600°C.
- **Other**  
Other customizations are available to meet your needs. Ask your k-Space representative about how we can design a customized tool for what you need to measure.

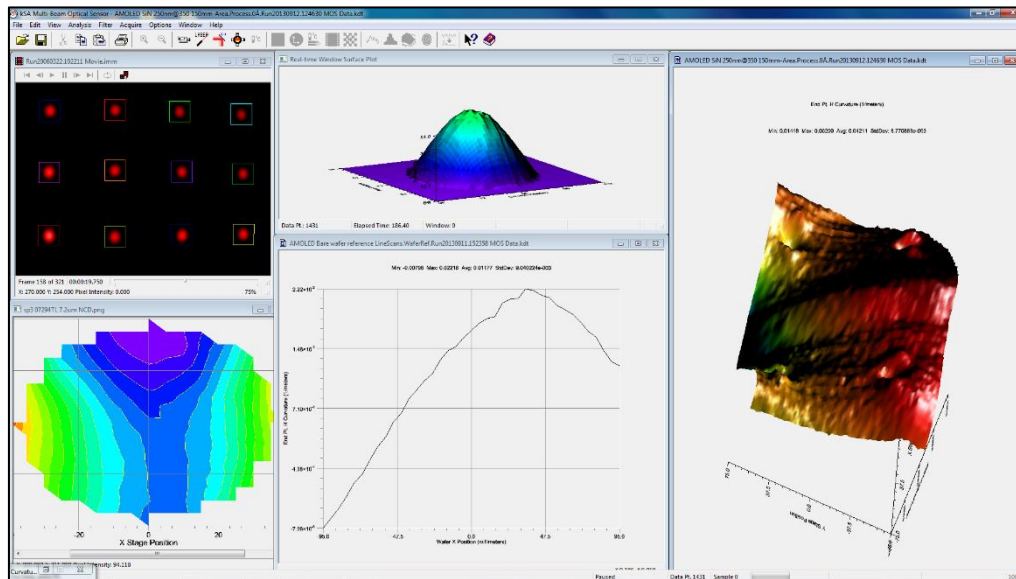


*Custom kSA MOS ThermalScan for small samples and direct vacuum hot plate heating.*

<sup>2</sup> 300mm wafers should only be scanned over the central 200mm to maintain the accuracy specified in this document.



## kSA MOS ThermalScan Computer Hardware and Software



- Complete kSA Multi-beam Optical Sensor (MOS) ThermalScan System for measuring wafer curvature, wafer bow, and thin-film stress.
- Configurable scan resolution parameters.
- Integrated scanning stage to allow for line scans and full 2D area scans of up to 300mm samples through optical viewport at stabilized temperatures, and center point during ramping of temperature. Model dependent.
- Patented, Automated Mirror Tracking with Servo Control and auto-intensity laser control ensures kSA MOS signal continuity during thermal expansion effects, surface reflectivity changes, and large variation in curvature/tilt during thermal cycling.
- Thirty (30) 2-D curvature/stress measurements per second (maximum rate) when acquiring data at center point of wafer. Slower data rates are fully programmable.
- Thermal scan software to provide fully automated multi-segment ramp/soak recipe control for annealing studies. Curvature and stress can be monitored and plotted as a function of temperature and time. Up to 100 cycles.
- Complete data storage, including full digital movies of the laser array that can be re-analyzed or incorporated into presentations.
- Complete publication quality graphics and color display.
- Export of all data to Windows Excel format or ascii text file.
- Offline analysis available with supplied Analysis Only software license.



## Computer Specifications (Minimum):

- Model: 4U Rack Mount Server Case
- Operating System: Windows 10
- Optical Drive: None (optional)
- Processor: Intel i5 Quad Core Series Processor
- Graphics: Sapphire Radeon HD 6450 1GB DDR3
- Hard Drive: 1TB 7200rpm 6.0Gb/s
- Memory: 8GB (2x4 GB) DDR3 1600 SDRAM
- 22" LCD flat panel display on frame-mounted arm with keyboard and mouse platform

## Warranty

All kSA systems and integrated components are warranted against defective materials and workmanship for a period of ONE YEAR from the date of delivery to the original purchaser.

## Installation and Training

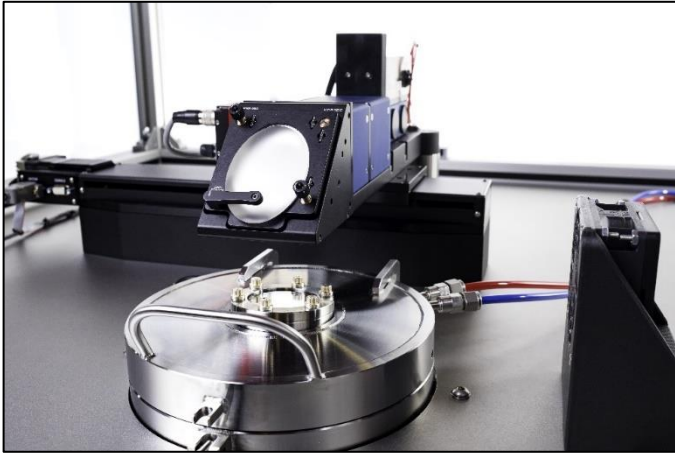
A minimum of five days of installation is required. Additional support for tool training suggested. Any customer defined tool acceptance criteria will need to be approved by k-Space prior to tool purchase and additional service for acceptance testing is required.

## Customer Facility Requirements

- Cooling Water: Approximately 15 L/min, pressure differential 2-3 bar, stable incoming temperature 15°C-18°C, Two ½" Swagelok fittings provided for both the inlet and outlet connections
- Vacuum Connection: KF25 flange provided, requires 2.8 m<sup>3</sup>/h
- Exhaust Connection: KF40 flange provided, requires 60 m<sup>3</sup>/h
- Process Gas connections: Two ¼" Swagelok connections provided for room temperature Nitrogen or Argon process gas connections
- Power: RTP furnace power supply requires 3 x 230 V (3 Phases with neutral & ground) in star connection (400V phase to phase). A 5-wire, 3- phase UPS may be used to provide backup power to entire system (including RTP furnace) if supplied by the customer.
- All safety considerations will be provided by k-Space in the kSA MOS Thermal Scan User Manual.
- k-Space uses all CE marked components.



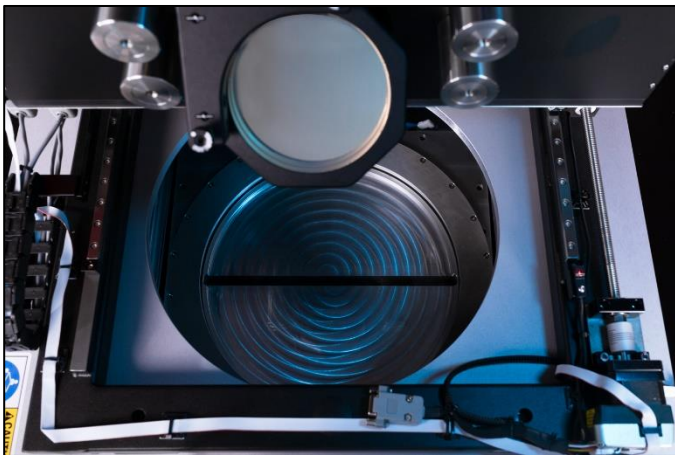
# kSA MOS ThermalScan



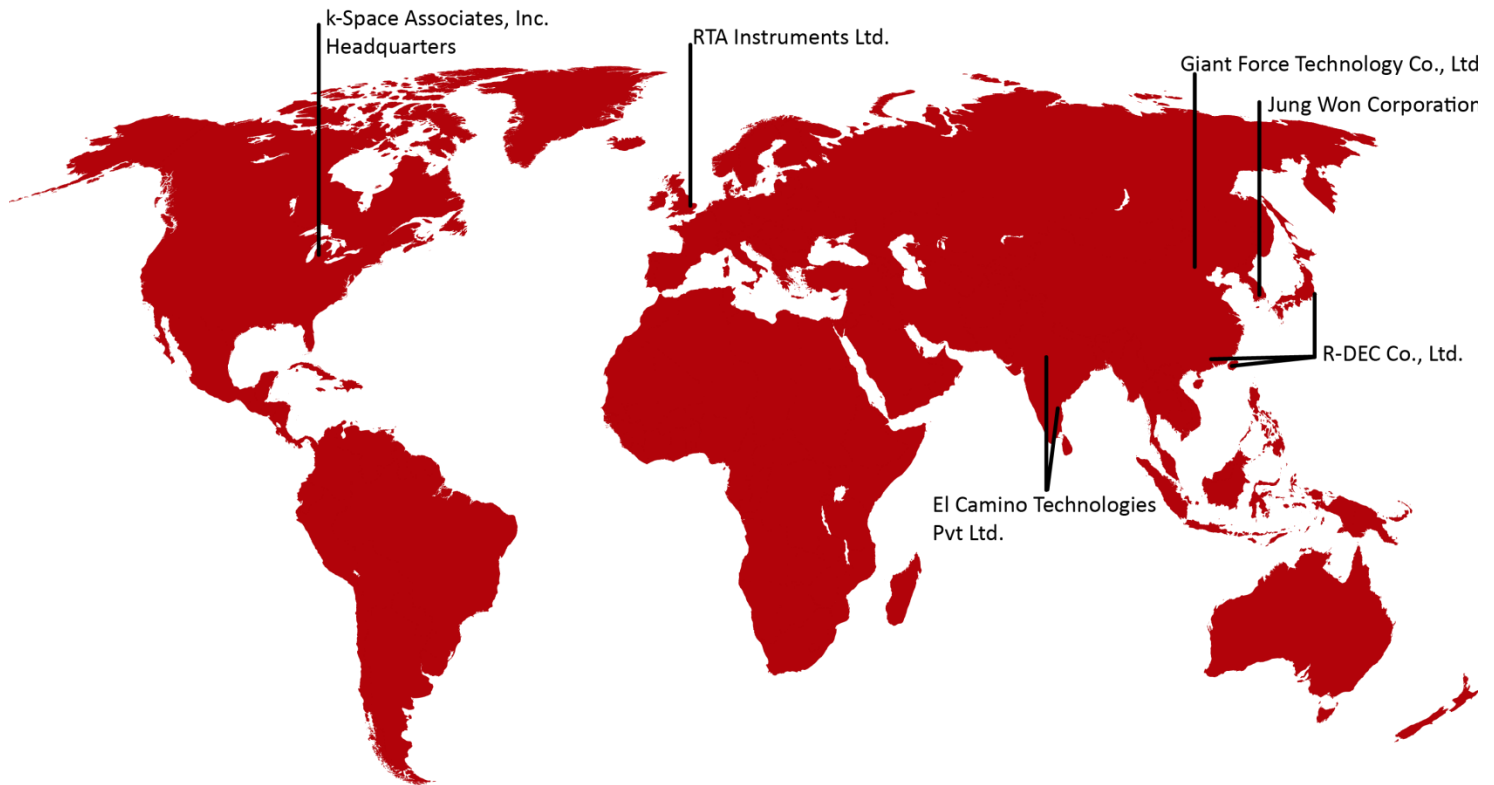
*Optics head and chamber lid for a custom center point  
kSA MOS ThermalScan TS100 model.*



*Sample loading of 300 mm wafer for a kSA MOS ThermalScan  
Model TS300-HT.*



*Slit style viewport for a kSA MOS ThermalScan  
Model TS300-HT.*



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### HEADQUARTERS

**k-Space Associates, Inc.**  
Michigan, USA  
[www.k-space.com](http://www.k-space.com)  
[requestinfo@k-space.com](mailto:requestinfo@k-space.com)

**El Camino Technologies Pvt Ltd.**  
India  
[www.elcamino.in](http://www.elcamino.in)  
[chetnamohan@gmail.com](mailto:chetnamohan@gmail.com)

**Jung Won Corporation**  
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[www.jwc.co.kr](http://www.jwc.co.kr)  
[salesinfo@jwc.co.kr](mailto:salesinfo@jwc.co.kr)

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*Specifications are subject to change without notice. Design varies based on model and options chosen. While due caution has been exercised in the production of this document, possible errors and omissions may occur.*

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