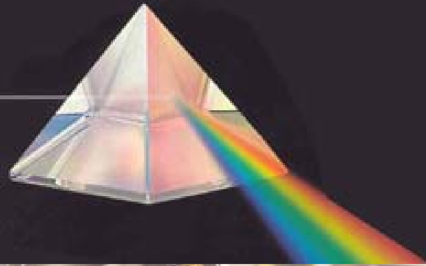
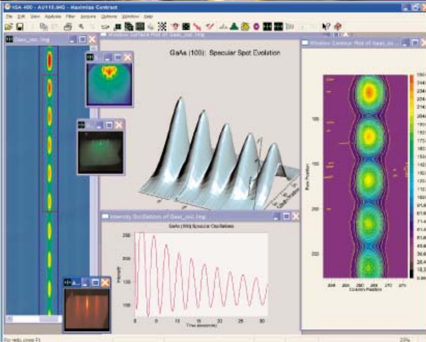
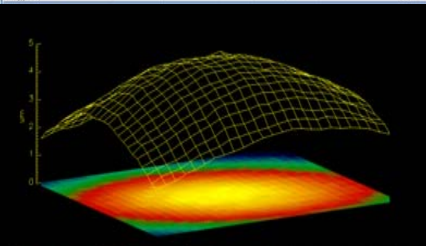
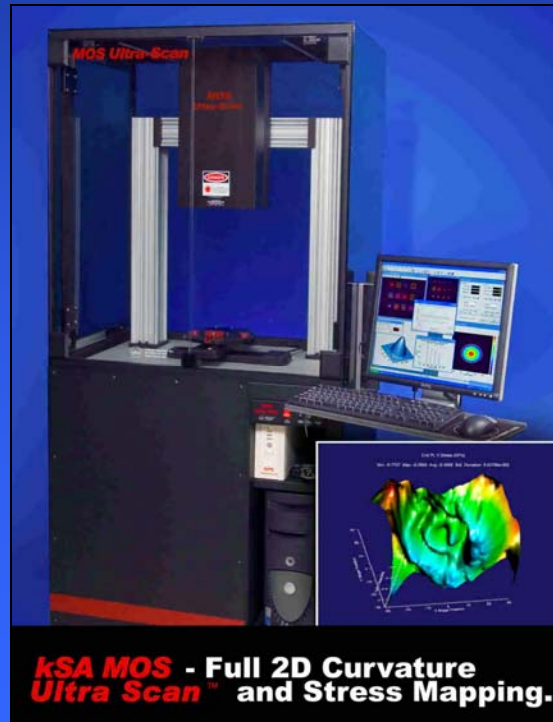
k-Space Associates, Inc







Thin Film Stress and Curvature Mapping

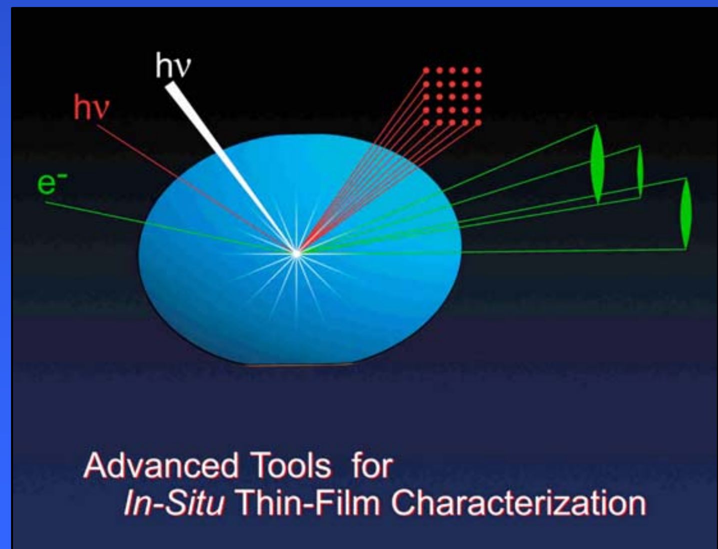


Advanced Tools for Thin Film Characterization

May 2005

Company Overview

- Founded in 1992
  - Headquartered in Ann Arbor, Michigan
  - Advanced *In-situ* 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
  - Strong patent portfolio
- Small, technically focused company that listens closely to customers
  - Cutting-edge products tailored to each application
  - Unparalleled support and response



Product Overview

- Analytical RHEED and Surface Imaging
- Thin Film Stress and Curvature
- Optical Temperature Measurement
- Deposition Monitoring
- Supporting Accessories

kSA 400

kSA MOS

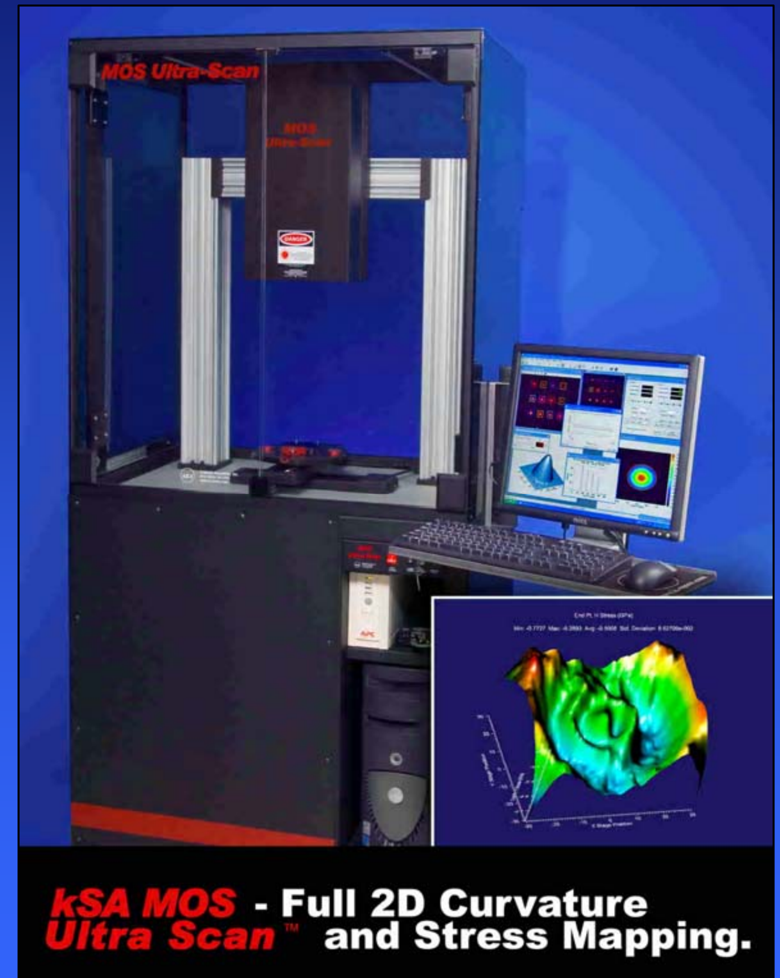
kSA BandiT

kSA RateRat Pro

Accessories

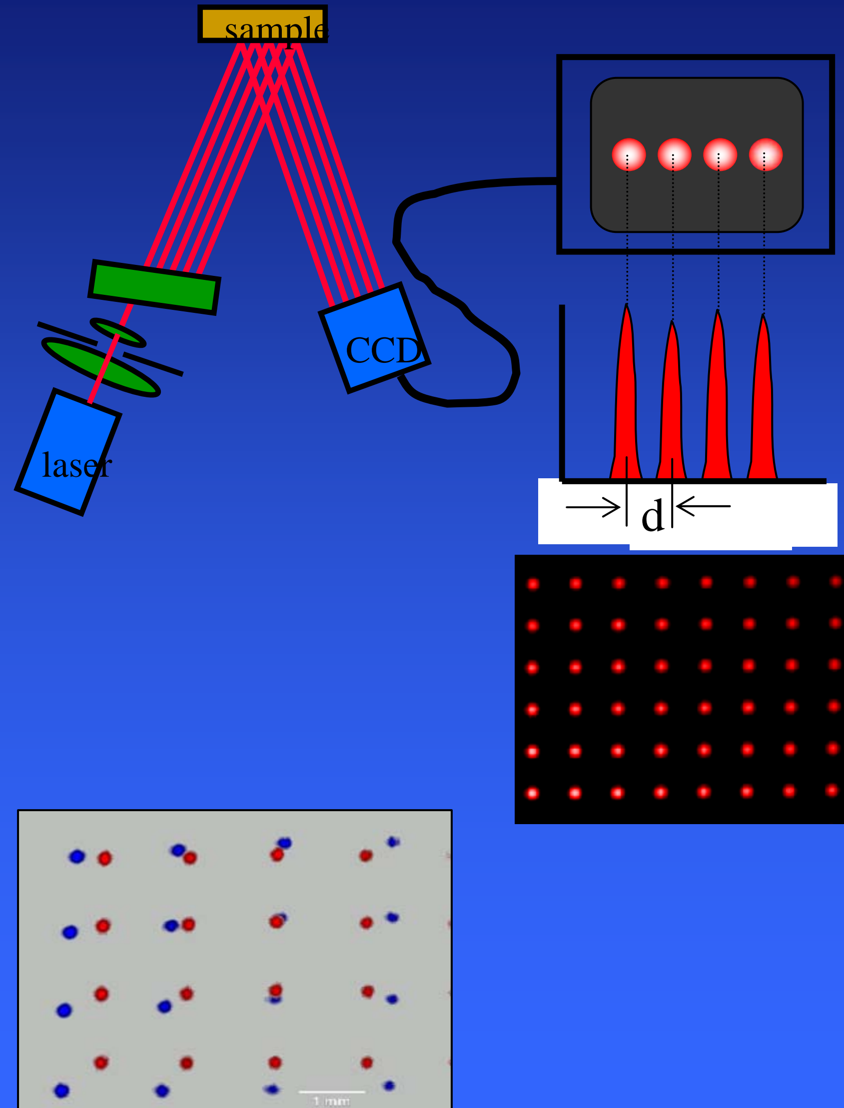
New! – kSA MOS Ultra-Scan

- Flexible, high-resolution, scanning curvature and tilt measurement system
- Based on proven technology of in-situ Multi-Beam Optical System (MOS)
- Maps two-dimensional curvature of semiconductor wafers, optical mirrors, lenses, or any polished surface.
- Up to 300mm x,y scanning range with 4 um resolution
- Scans are fully programmable for selected area, line scan, or full area map.
- Quantitative film stress analysis map:
  - First scanning the bare substrate and then re-scanning the sample post-process



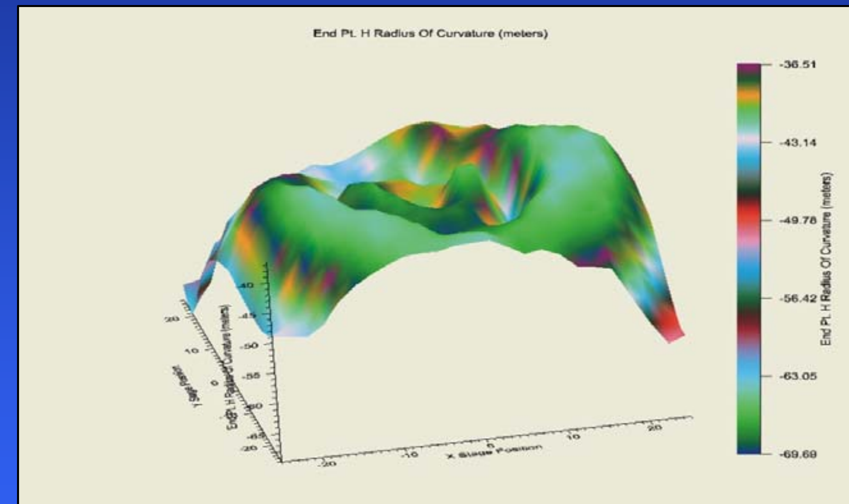
kSA MOS-based Technology

- Multi-beam Optical Sensor (MOS)
  - How it works:
    - 2D-array of parallel beams reflects from the sample
    - Beam position is measured with a CCD camera
    - Frame grabber digitizes the image, MOS software calculates the beam spacing
  - Change in beam spacings determines curvature, stress profile



kSA MOS Ultra-Scan: Standard Specifications

- Scan Range:
  - Standard system is supplied with a wafer chuck capable of handling up to 200mm wafers
- Scan Speed:
  - Max 20mm/sec (x,y)
- Scan Resolution:
  - User programmable up to 2 um
  - Higher resolution stages available
- Average Radius of Curvature Resolution:
  - (100km radius) 1-sigma
- Average Tilt:
  - < 5e-6 (radians) 1-sigma
- Scan Geometry:
  - Programmable multi-point line scan, or full area scan
- Options available for enhanced performance

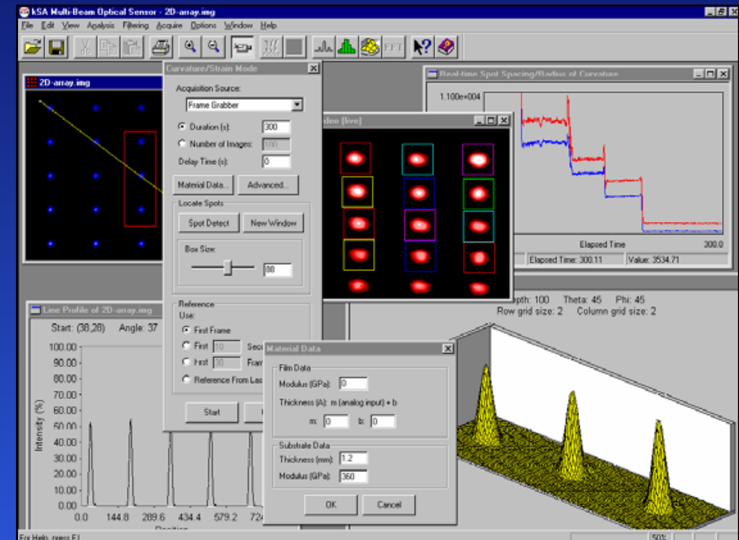


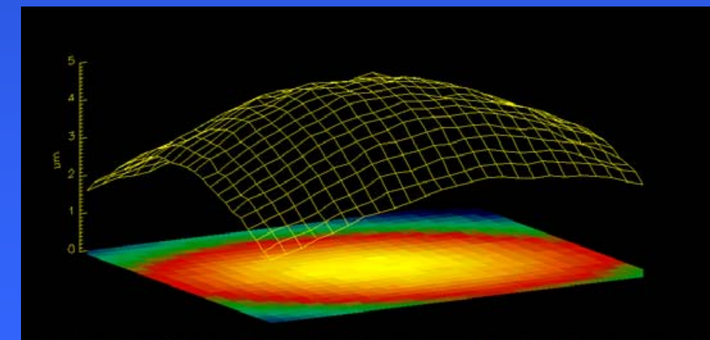
kSA MOS Ultra-Scan Hardware Features

- Pair of etalons to generate a 2-D array of parallel laser beams from a single beam laser source
  - Simplified optics and alignment system
- Optics are rigidly mounted to reduce vibrational noise
- Fiber coupled, Peltier cooled laser diode package with integrated current controller and temperature controller
- Linear, low-noise diode laser controller operates in constant current mode with output power stability of 0.2% typical (24 hours)
- Automated mirror tracking with servo control
  - A dual-axis, servo-controlled, optical flat mirror is used for tracking the reflected laser array as the wafer is scanned
- Linear XY-stage and 5-phase stepper controller
- Robust steel and aluminum frame enclosure
  - Vibration dampening integrated to enclosure for improved resolution
  - Scanning stage and sample area are enclosed with tinted plexiglass for optical/thermal noise isolation
  - Enclosure doors are interlocked for laser safety
- DELL™ Pentium computer system and control boards

kSA MOS Ultra-Scan Software Features

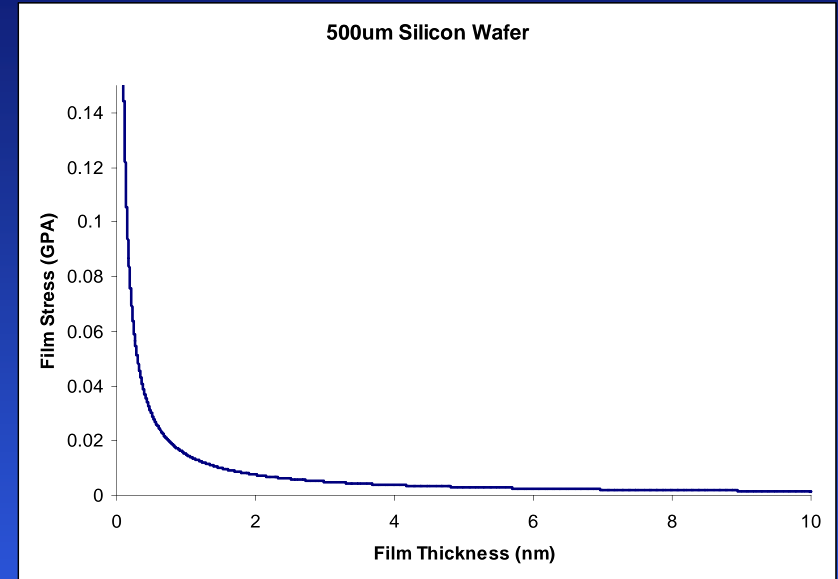
- Superior Analysis Capabilities:
  - Full surface and polar plots of curvature, tilt, and stress
  - Standard line profile, statistical analysis, and contour plotting
- Data acquisition and analysis control:
  - Automatic laser spot detection
  - Automatic laser power control; no saturation of detector as surface reflectivity changes
  - Real-time plotting of curvature, radius of curvature, stress-thickness product, stress, and tilt
- Data acquisition modes:
  - Focus mode: Laser alignment and optics focusing by simultaneously monitoring image and line profile of the laser spot array
  - Scan Mode: An arbitrary number of laser spots are tracked simultaneously, yielding two-dimensional curvature, radius of curvature, tilt, and stress

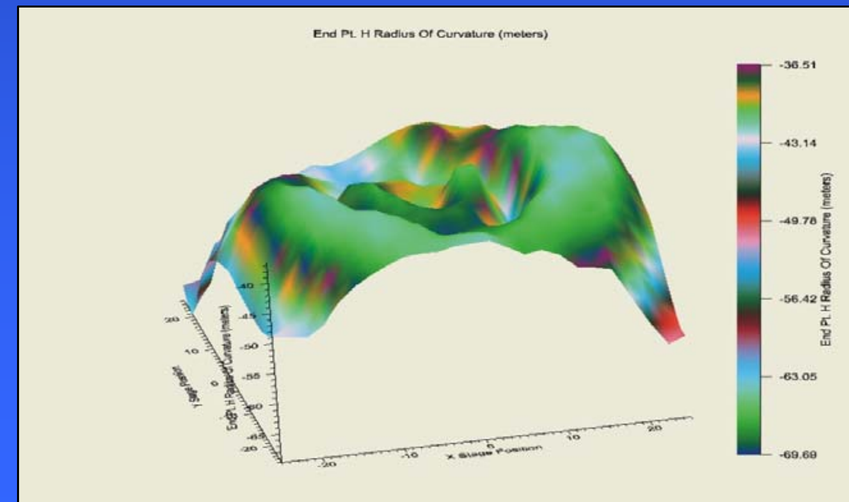




kSA MOS Ultra-Scan Application Data: Silicon

- 100km radius of curvature resolution
  - 150mm wafer corresponds to a bow height change of 0.375um
- 3-D surface plot showing end point horizontal radius of curvature from a silicon wafer





kSA MOS Ultra Scan vs. Competition

- Other curvature/bow/stress systems only use <u>single line or point</u> scan
- Ultra-Scan's patented 2D array ensures:
  - Lower noise susceptibility
  - True physical property directly measured
  - Higher resolution (>10x better than competitors)