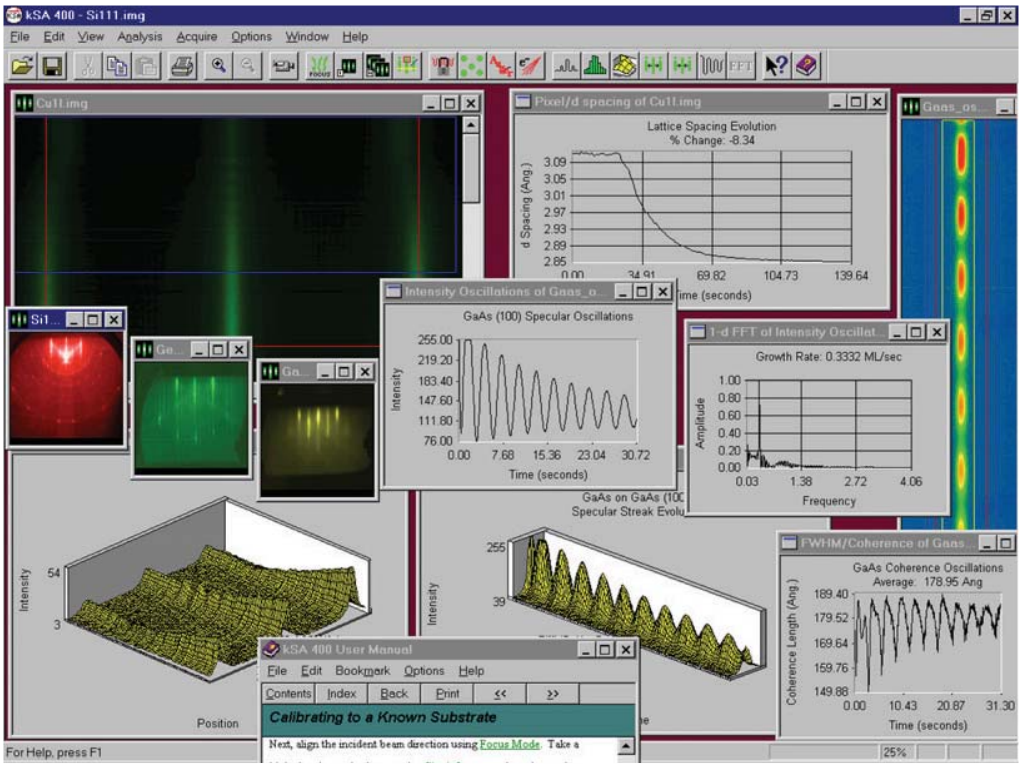
Software

The kSA 400 is the most powerful analytical RHEED software available. k-Space offers three RHEED software packages for a full range of RHEED acquisition and analysis. All are user-friendly, and built in the Windows™XP/7 (32-bit or 64-bit) standard environment, with extensive error-checking and file handling. The tables on the following pages highlight the capabilities of each package.



RHEED Acquisition and Analysis Software Suite

kSA 400

The kSA 400 is the most advanced, full feature RHEED Data Acquisition and Analysis package available. With a long list of capabilities, the kSA 400 offers the most insight from RHEED patterns.

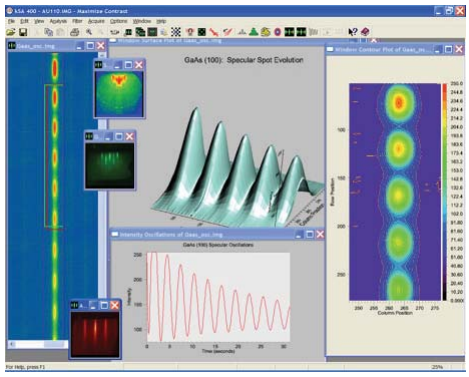
kSA 400 Lite

A RHEED acquisition and analysis package for those requiring only basic image capture and data analysis. The Lite package can be upgraded to the full featured version of kSA 400 at any time.

kSA 400 AOS

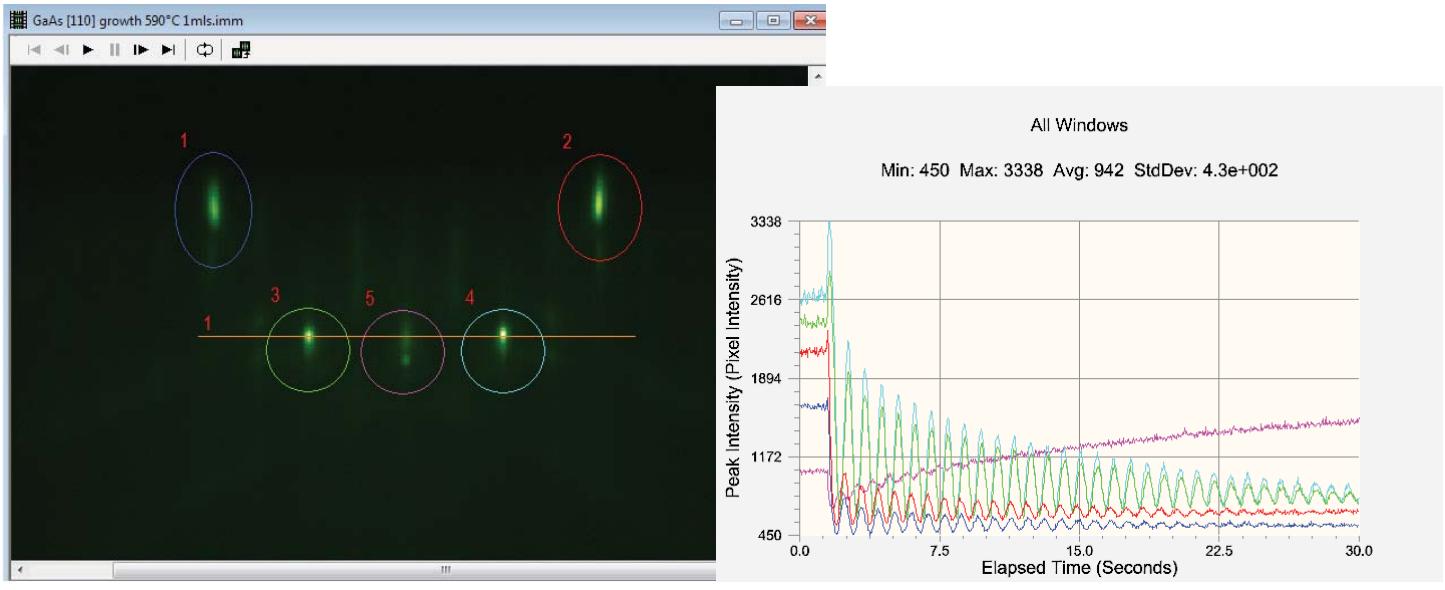
An analysis only version designed for users who want to perform post-acquisition display, processing, and analysis away from the laboratory. The analysis software license is available to users that currently own a full kSA 400 system.

CAPABILITY	kSA 400	kSA 400 Lite	kSA 400 AOS
ACQUISITION			
Camera Control			
Full exposure control	✓	✓	
Soft or hard external triggering	✓	✓	
Gain control	✓	✓	
Programmable 8-bit or 10-bit data output	✓	✓	
Programmable binning for up to 50 fps output	✓	✓	
Data Acquisition Modes			
Single Image Mode: Acquire single images for quantitative static analysis and archiving.	✓	✓	
Multiple Image Mode: Acquire a user selected number of diffraction images sequentially for quantitative analysis and archiving. Acquire in real-time to system RAM up to the limit of physical memory, or store to hard disk.	✓		
Focus Mode: Display real-time line profiles, surface plots, and contour plots on user-defined regions of the diffraction pattern, enabling focusing and alignment without saving.	✓		
Scan Mode: Simultaneously monitor an arbitrary number of lines and windows of the incoming diffraction pattern, yielding time-resolved, simultaneous intensity oscillation (growth rate determination), lattice spacing, and coherence length determination. The lines can be of any length and orientation (within the bounds of the image), and the windows can be rectangles or ellipses of any size.	✓		
Movie Mode: Acquire complete image movies, with the capability to playback, analyze, and run Scan Mode on the movie. With acquired movies, the movie effectively acts as an acquisition source for later analysis.	✓		
Interactive Accumulation Mode: Continuous display of a real-time summed image. Useful for monitoring build-up of system noise, or monitoring pattern shifts with a single image.	✓		
Growth Rate Mode: Acquire intensity data from an unlimited number of user defined windows, which can be rectangles or ellipses.	✓	limited to 1 window	



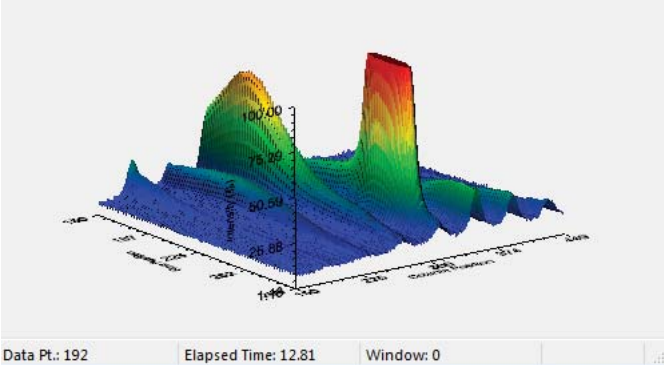
Acquisition Modes

CAPABILITY	kSA 400	kSA 400 Lite	kSA 400 AOS
Acquisition Capabilities			
Tracking: Repositions window center on the brightest portion of the diffraction streak/ spot, or on the centroid position. The position of the peak intensity/centroid intensity is recorded for each incoming image during data acquisition.	✓	✓	
Manual Tracking: Manually move tracking boxes in the event that the spots move out of range, for example due to a phase transition.	✓	✓	
Multi-Threaded Video: Display the on-screen video with interactive camera integration, frame summation, and filtering in real-time or near real-time, while performing other kSA 400 operations.	✓	✓	
Real-Time Zoom: Live video zoom from 25% to 300%.	✓	✓	
External Trigger: Trigger and synchronize data acquisition at the occurrence of specific events, (e.g. at specific rotation angles during substrate rotation.)	✓	✓	
Start / Stop Trigger: Begin and end data acquisition from an external signal input. This is separate from the standard external trigger capability, which uses a trigger signal to grab each frame of the data acquisition.	✓	✓	
Real-Time False Color Palettes: Choose from over 100 colors to apply to the real-time image.	✓	✓	
Enhanced Real-Time Charts: Open, close, smooth, resize or rescale real-time charts during acquisition. Any window analysis parameter can be plotted on the x or y axis.	✓	✓	
Plug-In and Add-On Support: Support for Multiple Data Sets and all Plug-Ins.	✓		



Window Analysis and Charts in Real-Time

CAPABILITY	kSA 400	kSA 400 Lite	kSA 400 AOS
Acquisition Capabilities			
Real-Time Exposure Control & Background Subtraction: Select the camera integration time and turn background subtraction on or off. This is useful, for example, if it is desired to remove the contribution of vacuum chamber light to the diffraction image. For time-resolved acquisition modes, a delay time between image acquisitions, accurate to 0.01 sec, may be selected.	✓	✓	
Real-Time Near Real-Time Surface, Contour and Histogram Charts: Display real-time (or near real-time, depending on CPU speed and size of region of interest) surface, contour, and histogram charts as live video streams in, while acquiring data (scan mode) or displaying data (focus mode).	✓		
Real-Time Growth Rate Determination: Determine real-time growth rate using damped sine wave fitting analysis during acquisition. Compare this with growth rate and thickness analysis using Discrete-Fourier Transform (DFT) analysis and derivative analysis.	✓		
Real-Time Lattice Spacing: Display the surface lattice spacing, or with an uncalibrated RHEED pattern, display the raw pixel spacing, during data acquisition.	✓		
Real-Time FWHM / Coherence Length: Display the evolution of the diffraction streak FWHM/coherence length during data acquisition.	✓		
Easy Chart Rescaling: Position the mouse on the chart for simple x and y rescaling, which automatically applies to any derived charts.	✓		
ANALYSIS			
Image Analysis Capabilities			
Line Profile Analysis: Analyze line profiles at any angle, length or width.	✓	✓	✓
Statistical Analysis: Full statistical analysis of user-definable windows of any size and location on the image source.	✓	✓	✓
Surface Plots	✓		✓
Contour Plots	✓		✓
Triple Region Plot: Overlay surface, contour and image plots.	✓		✓

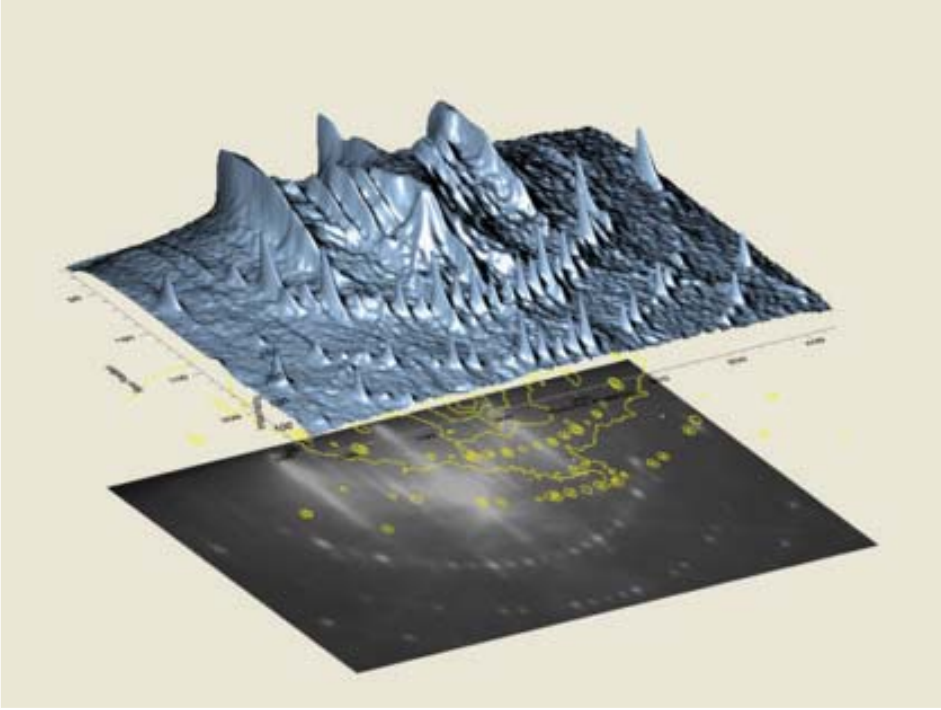


Surface Plot

CAPABILITY	kSA 400	kSA 400 Lite	kSA 400 AOS
ANALYSIS			
Data Analysis Capabilities			
Data Calculations: Data calculated from each window includes: peak intensity, minimum intensity, summed intensity, average intensity, centroid intensity, elapsed time, data point, peak row, peak column, centroid row, centroid column, standard deviation of intensity	✓	✓	✓
3 Growth Rate Analysis Methods: Determine growth rate during or after acquisition, using damped sine wave fitting analysis. Compare this with growth rate and thickness analysis using Discrete-Fourier Transform (DFT) analysis and derivative analysis. Output includes growth rate, total thickness, and error in rate determination. All three methods allow for user configurable fitting parameters.	✓	✓	✓
Line Profile Fitting: Accurate determination of streak spacing/in-plane lattice spacing.	✓		✓
FWHM / In-Plane Coherence: Determine FWHM / in-plane coherence length with accuracy.	✓		✓
Time-Resolved Analysis: Monitor in-plane lattice spacing and coherence length to determine strain profiles and domain profiles.	✓		✓
Multiple RHEED Oscillation Monitoring: Monitor an unlimited number of diffraction features to determine growth rate from multiple diffraction ?, as well as phase differences between the various diffraction ?.	✓		✓
In-Plane Spacing, Coherence Length and Intensity Oscillations: Determine all three properties through simultaneous monitoring during growth and conduct post-growth analysis from .kdt data files.	✓		✓
Image Processing Filters: Filter live video, single images, scan mode images, or movies, including 2D FFT, 2-image manipulation (subtraction, addition, etc.,) edge detection, median filtering, band pass filtering, contrast maximization and much more.	✓		✓
Data Processing Filters: Apply data processing and fitting filters to any 2D data, such as linescans, lattice spacing, intensity profiles, etc. Filters include bandpass, derivative, polynomial fit, Gaussian fit, cubic spline fit, Savitzky - Golay digital filter, and much more.	✓		✓

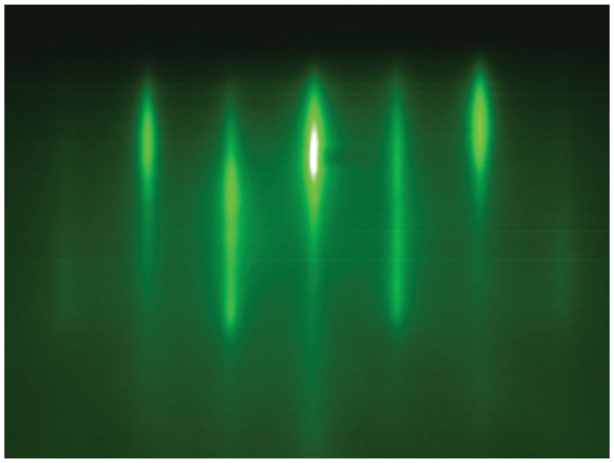
Scan Mode Image

CAPABILITY	kSA 400	kSA 400 Lite	kSA 400 AOS
Data Analysis Capabilities			
Advanced Plotting Capabilities: Plot static diffraction images and evolving line scan, column scan, or dual scan images to view evolution of growth in 3D. Interactive 3D graphing enables rotation and perspective, the ability to plot individual data point markers with varying symbols, contour plotting, and a data editor that allows direct editing of data associated with a graph. Data visualization features include 3D rendering, triple region plots, multiple data set display, interactive mouse rotation, and full plot customization. Edit colors and transport graphics directly to Windows™ clipboard, exported to Windows™ Metafile, or .tif format.	✓		✓
EXPORT			
Compress and Convert Image Files: Compress images on-the-fly or post acquisition including files taken with previous versions of the kSA 400 software. The "Zlib" routine is lossless, and typically compresses RHEED images by a factor of 2 or more. Convert to .wmf, .bmp, .eps, .tif, .gif, or .png graphics file formats.	✓	✓	✓
Compress and Convert Movie Files: Compress movies on-the-fly or post acquisition including files taken with previous versions of the kSA 400 software. The "Zlib" routine is lossless, and typically compresses RHEED images by a factor of 2 or more. Convert any kSA .imm movie file to AVI movie format (.avi).	✓		✓
Export Data Sets: Display and export charts in Excel (.xls) spreadsheet form.	✓	✓	✓
Custom Export: Define which parameters to export and save in a template file.	✓	✓	✓



Powerful Plotting Tools

CAPABILITY	kSA 400	kSA 400 Lite	kSA 400 AOS
DATA STORAGE AND COMMUNICATIONS			
Analog and Digital I/O Support: Complete analog and digital I/O support for most data acquisition boards from Measurement Computing Data Translation and National Instruments. Simultaneously monitor voltages from external sources (such as temperature probes) during image acquisition, or map image acquisition parameters (such as growth rate or lattice spacing) to analog or digital output channels. Support for PCI and USB-based data acquisition boards.	✓		✓
TCP / IP Support: The kSA 400 supports full TCP / IP communication. Transfer data and control acquisition via the kSA TCP/IP interface.	✓		✓
Networking Capability: Network capable software license for multiple users for data analysis and archiving, with the exception of data acquisition from a live video source.	✓		✓
Log Files: A continuously updated log file records all events, including acquisition times, error messages, processing messages, hardware communication, etc. The log file can be viewed to determine actions and to troubleshoot.	✓	✓	✓
Preferences and Configuration Files: Save all user interface and processing settings to a unique file for multiple users and/or disaster recovery.	✓		✓
User Programmable: Write image processing filters, data processing filters, analysis routines, and real-time charts using IDL™ (the Interactive Data Language). Edit these C-like procedures with a standard text editor, which are compiled at launch of the system. Successfully compiled procedures become part of the kSA 400 application.	✓		✓
Double Precision Data Storage: Store all calculated parameters with double precision instead of single precision float for utmost accuracy. All generated data files (with the exception of image files) store values as double precision float as well.	✓	✓	✓
RHEED Image Library: Compare important RHEED information with real-world examples of RHEED images and movies supplied by other kSA 400 users.	✓		



Sample Image from RHEED Image Library