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kSA 400 RHEED Image Library (RIL)

The kSA 400 RHEED Image Library (RIL) is a compilation of images and movies acquired from our kSA 400 customers, to the tune of ~ 30 gbytes of data. We have asked our customers to document the details of the conditions under which the data was taken, e.g. what the growth conditions are (temperature substrate, etc.), what the crystal orientation is, what the beam energy is, and so on. These details are either in the file name or in the Comments section of the file.

Nearly all the images in the library are of the .img format, so that details on the image (e.g. exposure time, spatial resolution, etc.) are stored within the file and can be read by right clicking on the file and selecting Properties. There are a few images in .bmp or .jpg format, which will then not have the kSA 400 specific details contained within them, but can still be displayed and processed within the kSA 400 software. There are also many, many movie files (.imm format), which can be analyzed or also re-played in Scan Mode to look at dynamic features, for example RHEED oscillations, changes in lattice spacing, and so on. Note that some of the movie files are taken with full substrate rotation and without triggering, so that you see the rotational dependence of the RHEED pattern. This makes some analysis difficult, e.g. pulling out RHEED oscillations, but you can step through the movies to look at specific RHEED patterns along multiple azimuthal directions.

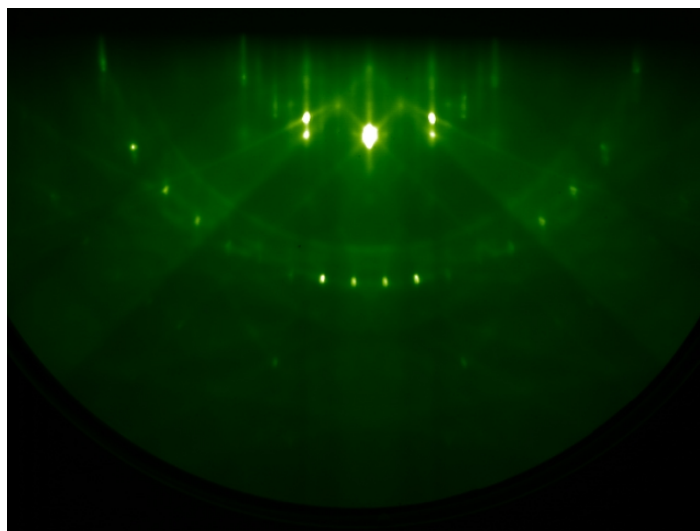


Figure 1: Fe₃O₄-magnetite grown on MgO (001) 30kV along [110].
Courtesy of PNNL.

We envision the use of the RIL to be mainly as a reference library for RHEED. Here are some examples of how we envision the RIL being used:

- You're curious about what the oxide desorption process looks like for a GaAs substrate, so you load a GaAs desorb movie from the RIL and watch the evolution of the RHEED pattern as the oxide desorption occurs.
- You are working with SrTiO₃ substrates, and you'd like to compare your RHEED patterns to those of other researchers in your field checking, for example, the width and length of the diffraction streaks as an indication of surface quality.



- You are teaching a surface science class and are on the topic of RHEED, and you'd like the students to check the ratio of lattice spacings along different crystal directions to verify the bcc structure of a material. You have the students pull up a GaAs movie, identify the major pull crystal directions (rotating substrate movie), and have them check the ratios of pixel spacings.
 - You'd like to see what the growth of Ge quantum dots on Si looks like via RHEED.
 - You'd like to look at GaAs on GaAs RHEED oscillations, and test our growth rate algorithms (we have 3 different algorithms in the kSA 400) on this movie data.

The RIL is organized by substrate material type. Within each substrate material folder, you will see sub-folders organized by overlayer material grown on that particular substrate. The folder structure is conveniently displayed with the latest kSA 400 software (Version 5.2 or later), by selecting View/RHEED Image Library from the main menu. To load an image or movie, simply double click or drag and drop the selected file.

Note that all movie files (.imm) can be loaded into the Scan Mode acquisition and replayed or reanalyzed to see the evolution of the RHEED pattern, including growth rate, FWHM, lattice spacing, and so on. As an example, load the file GaAs [110] growth 590°C 1mils.imm. By putting analysis windows over the main diffraction streaks/spots, and putting a line analysis region across the main diffraction streaks horizontally and acquiring from this file in Scan Mode, you will see the following evolution of the 590°C GaAs homoepitaxial growth:

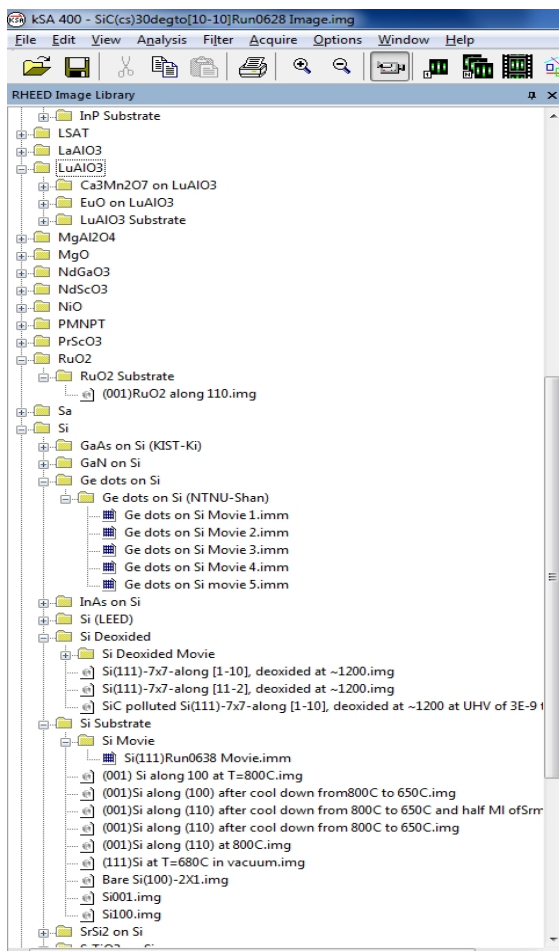


Figure 2: Partial folder list of kSA 400 RIL.



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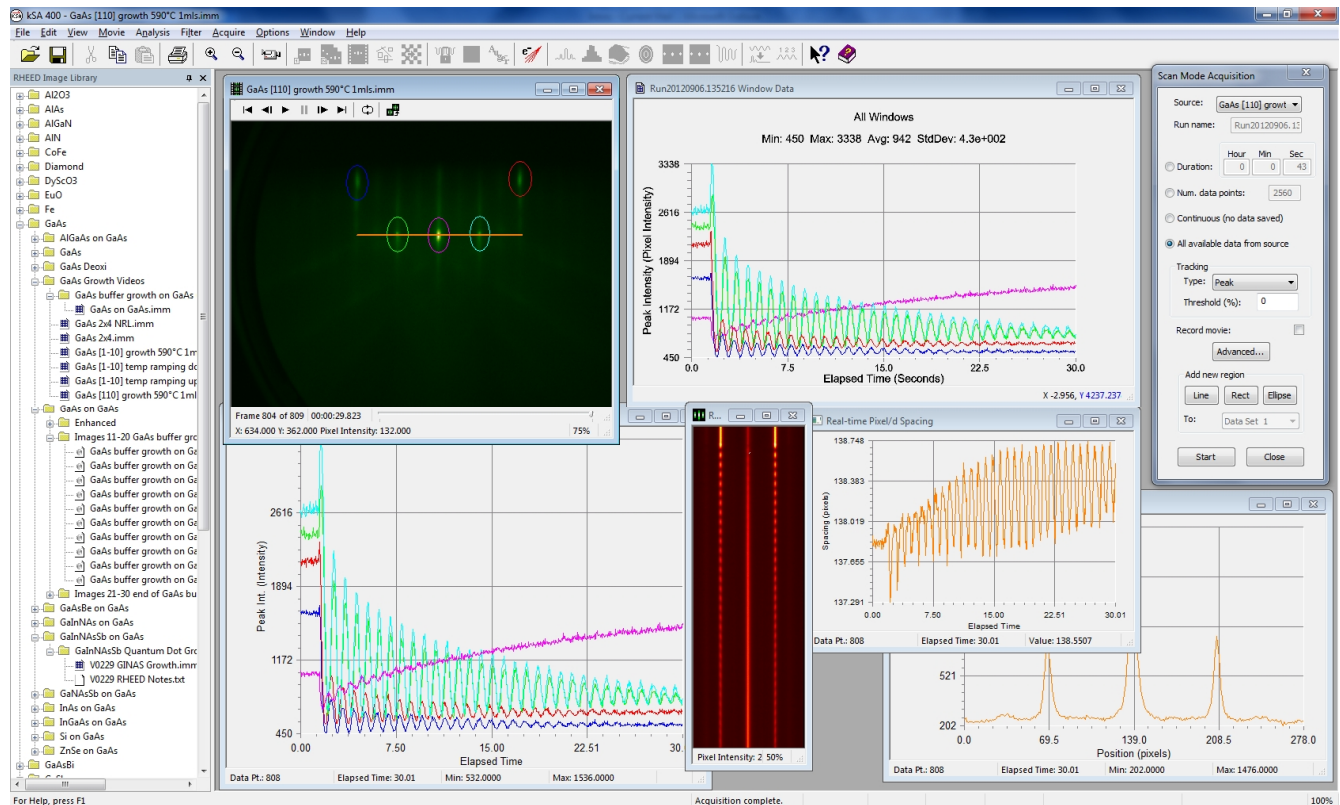


Figure 3: Reprocessing of RIL data file (GaAs [110] growth 590°C 1mls.imm) using Scan Mode Acquisition mode in the kSA 400. Very clean RHEED oscillations from all streaks except the specular streak are seen in this GaAs homoepitaxial growth.

Note the Scan Mode image that is generated (orange or blackbody palette image shown above). This image, which is generated by stacking the extracted line profile vertically in time, clearly shows the evolution of the RHEED intensity oscillations as well as the surface quality, as dictated by the width of the diffraction streaks. In plotting this image using the Surface Plot analysis capability of the kSA 400, we see the following:

We want to make the RIL as useful as possible for you, our customer. We look forward to your feedback on this feature so that we can improve the RIL wherever possible. We also want to continue to expand the RIL: if you'd like to contribute some

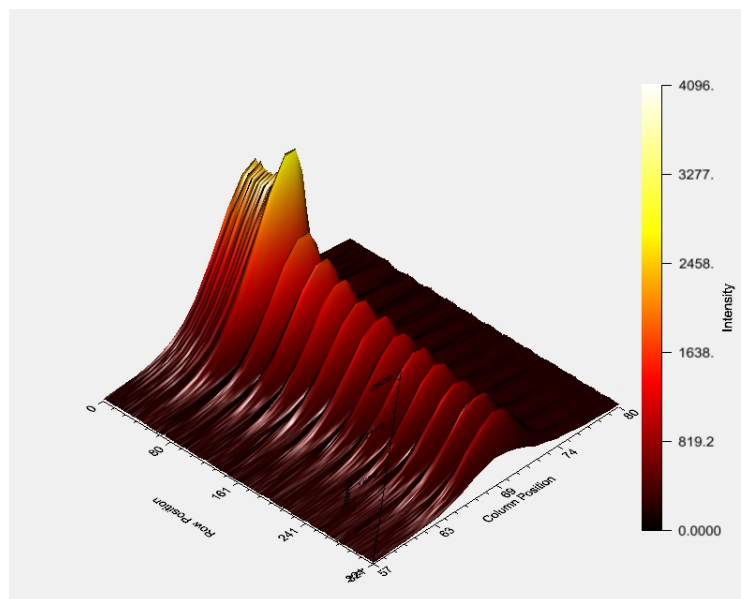


Figure 4: Surface Plot of portion of Scan Mode image generated from RIL movie analyzed in Figure 3.



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images or movie files, please email us at requestinfo@k-space.com, subject line RHEED Image Library, and we'll send you details on how to send us your files.