SMILE
SEM Image Lines Estimator

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Chapter 1

SMILE image analysis in three steps

SMILE can be run as a standalone application for macOS or Windows, or as MATLAB application running **SMILE.mlapp** from the MATLAB App Designer.

1.1 Step 1: Loading the images

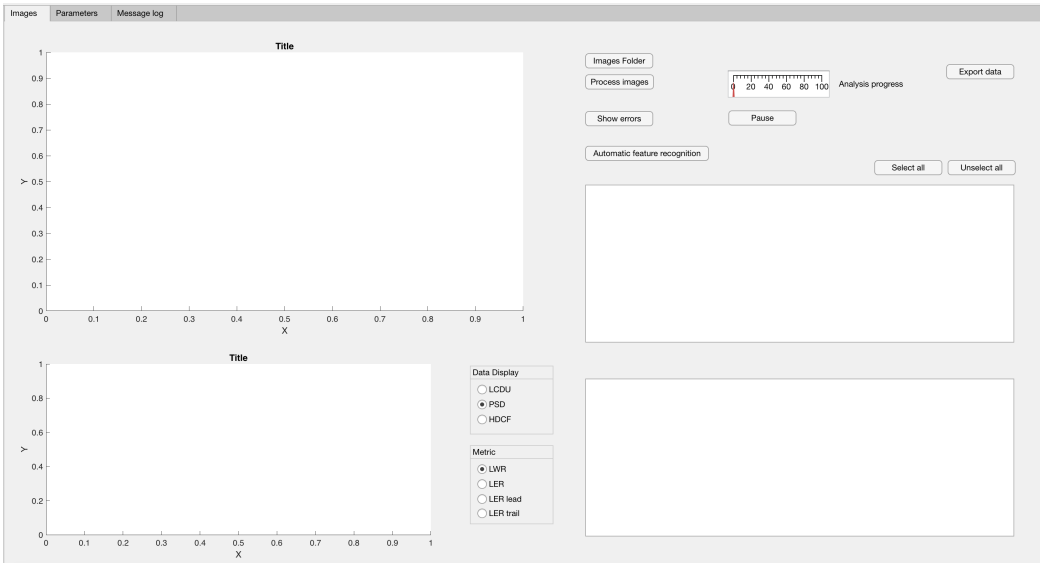

Figure 1.1: SMILE user interface: "*Images*" tab.

The first step is to click on the **Images Folder** button and select the

folder containing the SEM images to analyze. The images must be in TIF or JPG format. The program will try to load all the images in the folder and it will display the first unprocessed image in the top left box. The units displayed are pixels. The tables on the right will be populated with a list of the file names. By selecting a different row in the table, the corresponding image will be visualized. See figure 1.1. SMILE relies on a pre-trained neural network to distinguish images with Line/Space and Contacts arrays. The top table will be populated with the former and the bottom one with the latter. It is also possible to turn off the automatic image classification by toggling the button **Automatic feature recognition** in the *images* panel (Figure 1.2). In this case, when the **Images Folder** button is pressed, all the images are loaded as lines and spaces. The user can select each row and move images with contact arrays to the bottom table by pressing the "t" key.

In general, to change the image type from contacts to lines and vice versa, it is sufficient to select the relative row in the data table and press the "t" key.

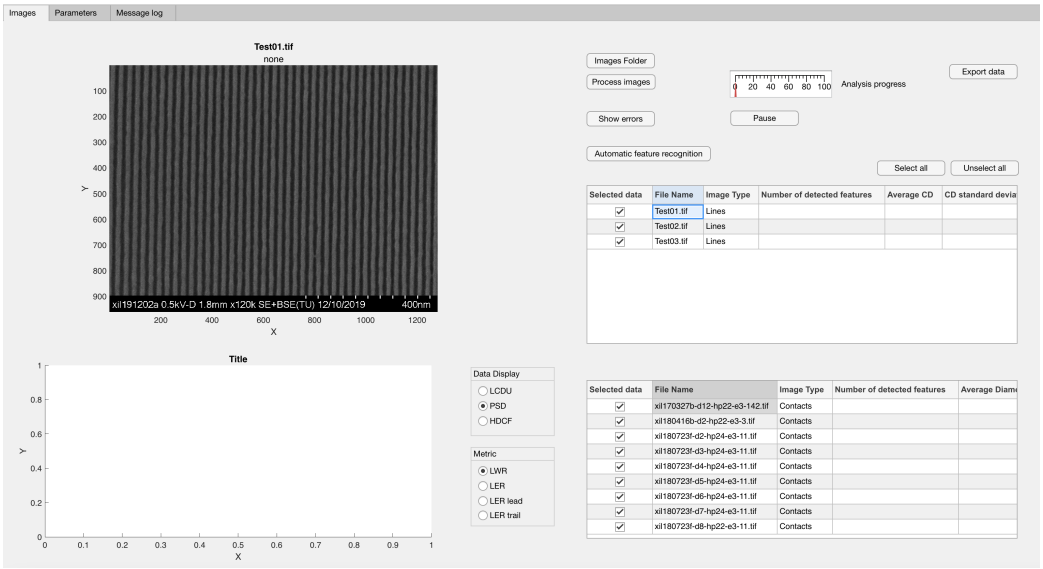

Figure 1.2: SMILE user interface: "*Images*" tab. After selecting the image folder, SMILE will populate the tables and display the first unprocessed image.

1.2 Step 2: Setting the parameters

The second step is setting the parameters for the analysis. This is done in the "*Parameters*" tab as shown in figure 1.3. The parameters can be set manually, or imported from a predefined parameter file using the **Load parameters** button. Usually, the first parameter to set is the region of interest. This is done by clicking the **Set ROI** button and dragging a rectangle on the image displayed over the area that needs to be analyzed (Figure). Another important parameter to set is the pixel size. The pixel size can be retrieved automatically for images collected at PSI. To do this, the SEM model drop down menu should be set to "Hitachi" or "Zeiss", depending on the model used. If the SEM model is set to "Generic", the software will read the value (expressed in nanometers) in the **Pixel size** text box.

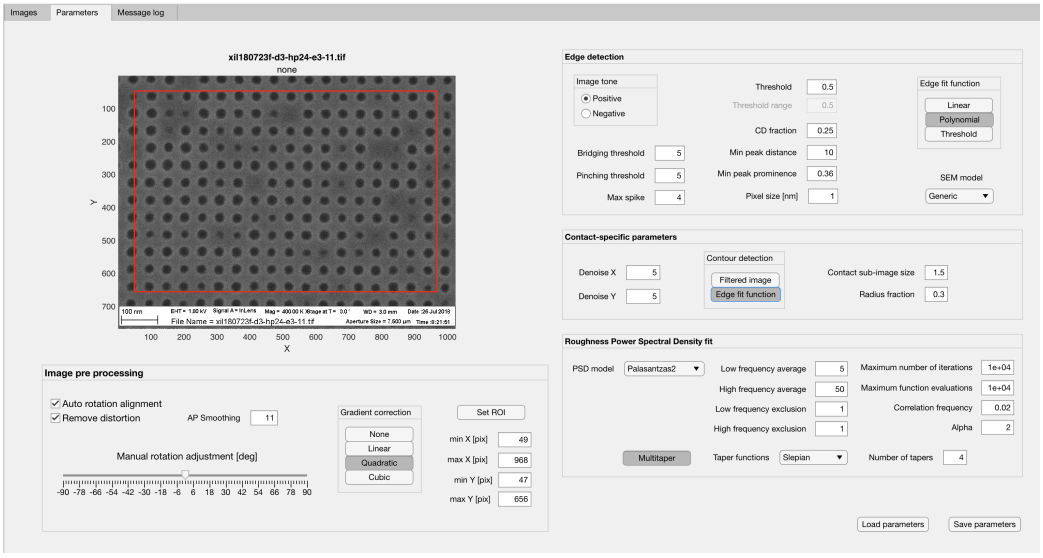

Figure 1.3: SMILE user interface: "*Parameters*" tab.

1.3 Step 3: Run the analysis

The third step is the image analysis which is performed from the "*Images*" tab pressing the **Process images** button. As the images are analyzed, the software fills the data table with the measured values and displays the detected contours of the image features as shown in figure 1.4.

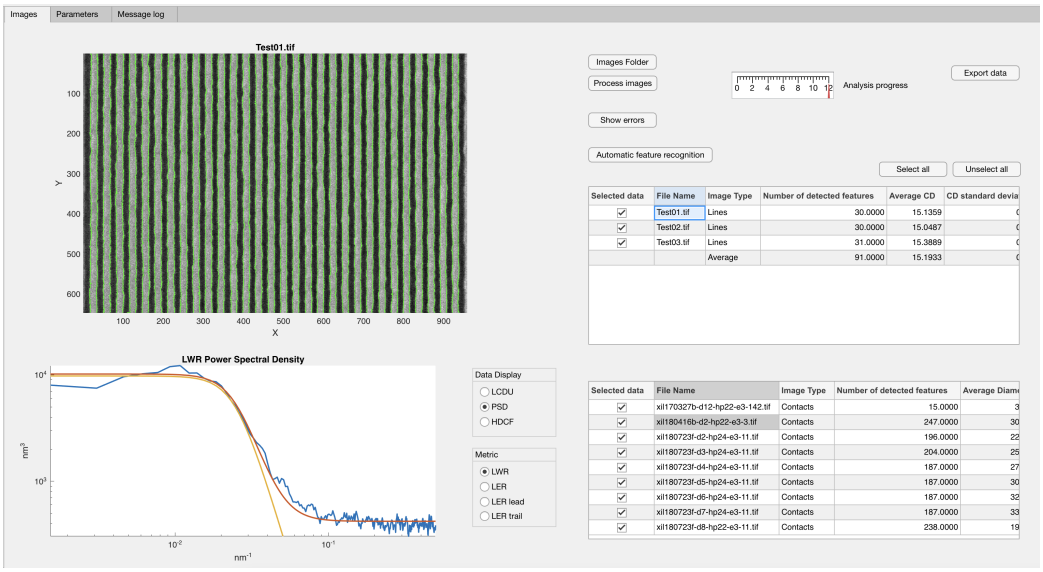

Figure 1.4: SMILE user interface: "*Images*" tab. After processing the images the detected contours of the image features are overlayed to the original image. Press the **Show Errors/Hide Errors** button to display or hide edge detection failures or bridging/pinching defects.

Bibliography

[1] G. Palasantzas, "Roughness spectrum and surface width of self-affine fractal surfaces via the k-correlation model," *Phys. Rev. B*, vol. 48, pp. 14472–14478, Nov 1993.

[2] I. Mochi, M. Vockenhuber, T. Allenet, and Y. Ekinci, "Open-source software for SEM metrology," in *Photomask Technology 2020* (M. E. Preil, ed.), vol. 11518, pp. 58 – 67, International Society for Optics and Photonics, SPIE, 2020.