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Model based drift compensation after sample load

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Abstract
For electron microscopes, throughput is an important aspect. A common problem for electron microscopes is the sample drift compared to the electron beam after loading the sample into the microscope. Sample drift has a big impact on the throughput of the electron microscope. When sample drift is too high, the user must wait until drift is low enough before they can start their measurement. A method to prevent the sample drift is by compensating for it with a highly accurate sample manipulation stage. This has been investigated and first tests showed that this method could decrease the waiting time before measuring from 22 minutes to below 10 minutes.

Thermal, Lumped mass model, drift compensation

1. Problem statement

A common problem for electron microscopes is the sample drift compared to the electron beam after loading the sample into the microscope. Figure 1 shows an example of the impact of drift on the microscope performance.

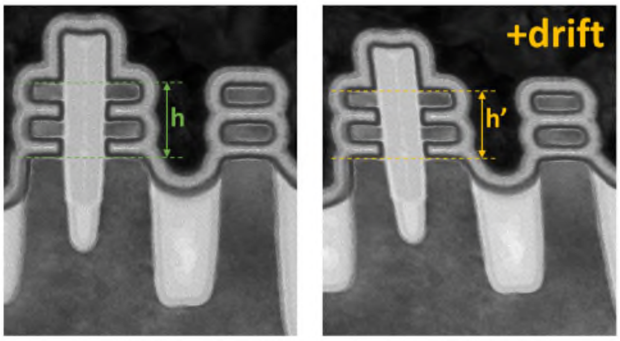

Figure 1. *Example of the impact of drift on the microscope performance. On the left the image without drift is shown and on the right with drift.*

Drift impacts the performance of the microscope in the following ways:

- Automation processes suffer from features drifting out of the field of view.
- Contrast in TEM images deteriorate.
- STEM images are distorted, leading to metrology errors which is shown in Figure 1.

2. Root cause

It is required that drift meets the relatively low drift requirement to ensure high quality images, and throughput of the microscope. Thermal effects are a large contributor to drift, which will only slowly decay over time. Causes of thermal drift are:

- Heat loads switching on or off.
- Temperature differences after sample holder insert.

3. *Modelling method*

Using thermal lumped element modelling, a model has been made existing out of more than 400 elements. With this, the sample drift as a result of a change in the thermal balance during sample insertion, can be investigated and predicted. To improve the drift predictions, a Kalman filter is used which uses real-time temperature inputs. This model with Kalman filter is running on the actual microscope. Figure 2 shows the impact of adding a Kalman filter to the thermal model. Without the Kalman filter, the model can only predict the general trend, while with the Kalman filter, the model can predict the temperature much closer to the measured temperature.

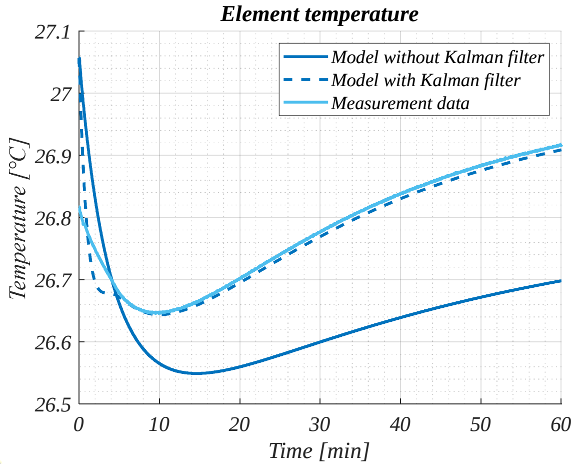

Figure 2. *Effect of using a Kalman filter*

Using the drift predictions, the stage can move the sample in the opposite direction of the predicted drift which leads to theoretically, a sample standing still with respect to the electron beam.

4. *Results*

A proof of concept of using model-based predictions to compensate for sample drift has been made, and the results are shown in Figure 3. Here, the "measured drift" is the drift measured on the microscope with model-based drift compensation active. The “reconstructed drift” is the drift that would have occurred when model-based drift compensation would have been off. The dashed red line is the drift requirement to make high quality images.

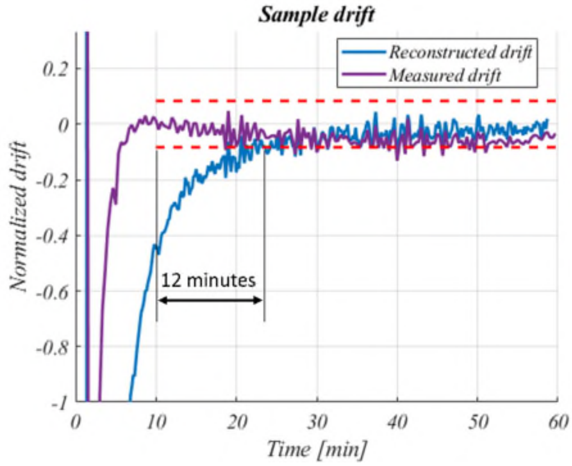

Figure 2. *Drift results proof of concept executed on a TEM.*

As can be seen in Figure 3, for this measurement, model-based drift compensation decreases the waiting time from 22 minutes to less than 10 minutes. Because of this, for this measurement, the requirement is met.