XY-positioning and stitching improvements for conventional SEM based lithography solutions by piezoelectric sub-stage assembly

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Introduction

Conventional SEM stages are lacking the precision for certain lithography procedures; while conventional step and repeat of single exposure fields do not require better stage performance, advanced lithography techniques which for example employ the so-called stitching technique, cannot be executed with sufficient success. Typically a repeatability of a few micrometers is insufficient for precise exposure field size calibration as well as for the stitching technique by subsequent exposure of adjacent exposure fields.

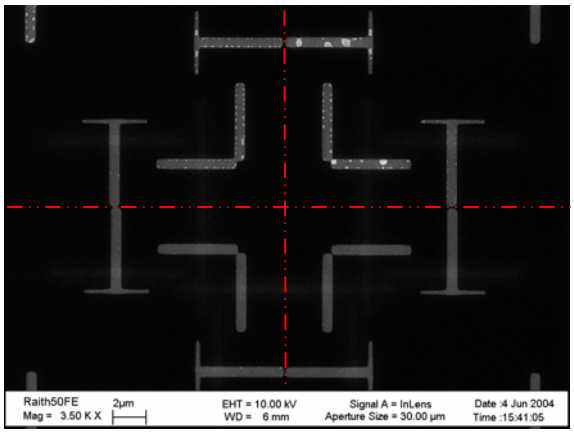

Figure 1: Four exposure fields with stitched patterns demonstrating sub µm stitching accuracy - red dotted line indicates exposure field boundary

Functionality

The two axes piezoelectric sub-stage assembly has been optimised for the use in SEM based EBL applications. It will be installed as a reversible sub-stage assembly on top of the original SEM stage.

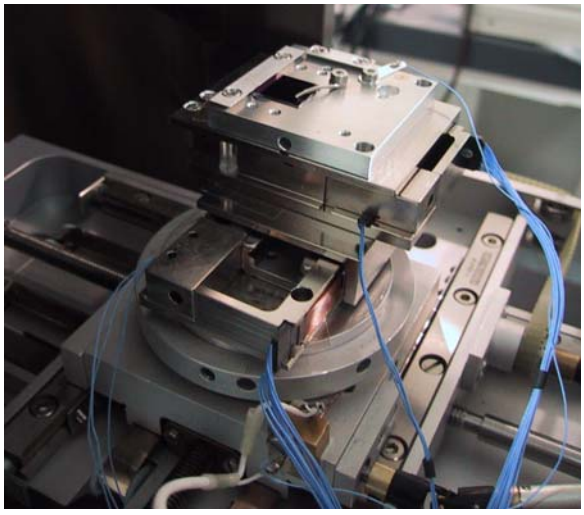

Figure 2: Piezo electric sub-stage assembly in a FE SEM

High precision encoders enable the individual single sub-stage positioning axes to attain a reproducibility of about 100 nm. Two axes repeatability is in the range of a few 100 nm and suitable for Mix & Match tasks. The sub-stage enables stitching with typically sub µm accuracy (mean + 2 σ).

The piezoelectric sub-stage assembly cannot replace a laser interferometer controlled stage if the highest precision is required e.g. for stitching or repeatability. In such a case, the laser interferometer position sensing which is in the Abbé plane, intrinsically provides true two-dimensional position read-out accuracy in contrast to the stacked piezoelectric sub-stage assembly.

The sub-stage assembly is controlled via proprietary Raith software drivers, to ensure an optimum integration level into the ELPHY Lithography Suite.

Typical hardware specification comprises:

- 20 x 20 mm^2 travel range (optional 30 x 30 mm^2) - usable travel range depends on SEM chamber confines, sample size and arrangement of the vacuum feed through)
- High vacuum compatible
- Encoder system, resolution ≤10 nm
- High vacuum feed through and cable set for SEM operation
- Network controller unit (Ethernet communication)
- Power supply
- Rack housing for network controller and power supply
- Universal lithography sample holder
    - Calibration standard CHESSY for field size adjustment
    - Faraday Cup for probe current measurement
    - Typical sample size up to 10 x 10 mm^2

Raith software driver integrated into Raith ELPHY Software Suite:

- Fracturing package for stitching
- Automated and manual stage position control

Remark

The total height of the XY sub-stage arrangement is 39 mm (may vary slightly on the SEM stage adapter). The SEM stage must therefore provide sufficient Z-travel to allow at least 5 mm working distance with the complete sub-stage mounted. If in doubt, please provide photos of your SEM stage sample mount and measure the longest and shortest working distances available.

The sample exchange via a load lock is not available for the sub-stage. Only manual loading via the main vacuum chamber door is possible - please check if the evacuation times are acceptable.

The stage adaptation to any SEM/FIB might require special mechanical efforts. Please provide detailed information about your SEM and ideally images of your chamber, stage and (available!) ports.

Questions

For technical discussion about feasibility or possibility to check the compatibility with your SEM/FIB stage, please consult your Raith partner or Raith directly.

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