Wafer stage assembly for Ion Projection Lithography

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In the framework of the Ion Projection Lithography (IPL) project a resolution and position repeatability of written patterns better than 36 nm (stitching error) is required. This resolution exceeds that of the best present optical lithography systems approximately by a factor of six. Though the exact position of the written pattern is controlled electronically during exposure via a pattern lock system a submicrometer stability of the wafer position is required.
Furthermore the horizontal orientation of the ion-optical axis implies a vertical orientation of the wafer stage, which results in additional challenges to the mechanical design. Because of the high dynamics of the stepping motion a resonance frequency in excess of 200 Hz is required for the wafer stage assembly.
In the framework of the IPL project, the IOF, as a subcontractor of Leica Microsystems Lithography GmbH Jena, is responsible for the development of a wafer stage assembly which has to comply with the above-mentioned stability requirements.
All major components of the wafer stage assembly are made from glass ceramics. The advantages of the chosen material are

- mirrors for interferometric position control may be incorporated directly into the stage body
- high specific stiffness and low specific weight allow for high dynamics and low power consumption of the drives
- high stability, no creep
- non-magnetic.

The wafer stage assembly consists of a lightweight glass ceramic metrology unit, which carries the interferometer mirrors and an exchangeable electrostatic chuck. A small, pneumatically activated chuck for wafer handling is integrated into the center of the main chuck.

The interferometer mirrors are orthogonal to each other with a precision of 2 seconds of arc while the pyramidal error is below 15 seconds of arc. The remaining deformation of the metrology unit under gravity load amounts to 40 nm which is close to the theoretical limit of 30 nm which is set by the material properties when an ideal mount is assumed.
The whole assembly of metrology unit and chuck is mounted cinematically to a moveable frame via 6 solid-state hinges, which bind each degree of freedom separately. This way strains in the mounting frame are completely decoupled from the wafer stage assembly.
The frame is clamped via piezo actuators to an vertically oriented 800 mm long, hollow, Si/SiC ceramics beam with a bending stiffness of 115 N/µm which is moved in the horizontal direction for stepping from one exposure area to the next one. For vertical motion the clamping is released and the wafer stage is lifted along the beam to the next exposure area.

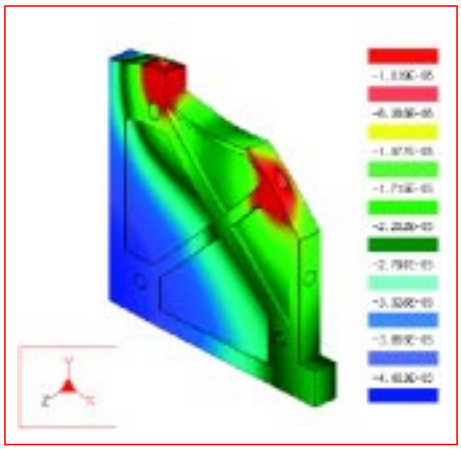

Fig. 1:
Finite element investigation of the deformations of the metrology unit

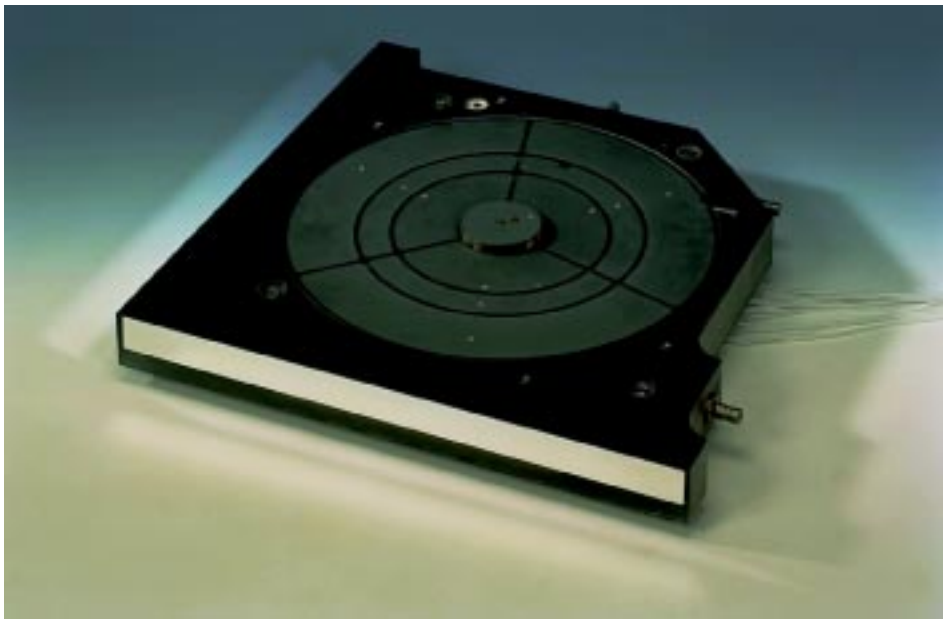

Fig. 2:
Assembled wafer-metrology unit with handling chuck activated

Fig. 3:
Mount frame for the metrology unit attached to the ceramics beam.
The whole wafer stage assembly is integrated into the IPL machine. In its working position the ceramics beam is connected with two linear magnetic drives which move the whole wafer stage assembly during stepping.

Acknowledgement

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References

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