Adaptive Optics for EUV wavelength

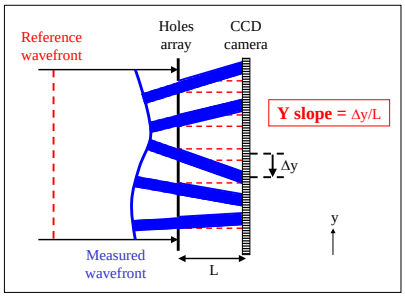
Imagine Optic
18 rue Charles de Gaulle
91400 Orsay - France

S. Bucourt , X. Levecq, M.Idir, P; Mercère, P. Zeitoun, R. Geyl, P. Sauvageot

Hartman Wavefront Sensor principle

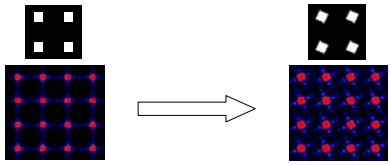
The incoming beam is sampled by a hole array and each beamlet is projected on a CCD camera.

The position of each spot centroid is then compared with a reference position. The shift gives the local wavefront slope, at each measurement point, from which the wavefront is reconstructed.



Rotated square technology®

Specific technology of Imagine Optic, rotated square strongly reduces the overlap of the diffraction lobes between adjacent spots and thus make the determination of the spot centroid even more accurate.

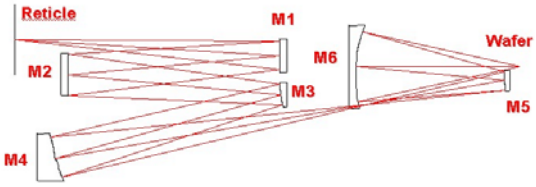


A HASO with rotated square technology offers a better accuracy or a bigger spatial resolution than a standard (Shack-)Hartman sensor !!

More Moore project

EUV lithography at 13.4nm

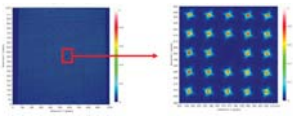
- The reticle is projected on the wafer by an imaging system made of 6 mirrors
- 2 mirrors are active in order to correct all aberrations and achieve nanometric resolution



Two possibilities for nanometric resolution:

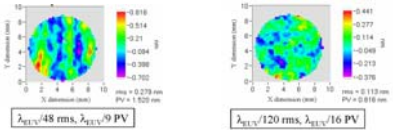
- At-wavelength measurement (13.4nm) with a EUV Hartmann sensor
- Measurement at 405nm with a high-accuracy Shack-Hartmann sensor (cf. poster 2124)

At-wavelength measurement: the Hartman array is associated with a EUV camera for a direct EUV exposure. The whole system is placed in vacuum.



HASO sensor

Camera signal



Absolute measurement

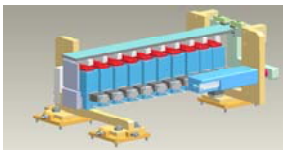
Relative measurement

Repeatability of λ/120 rms at 13.4nm

Achromaticity over 7-25nm wavelength range

In development: MARX project

- Active mirror with 11 actuators (made by ISP System)



Reflective surface in silicon

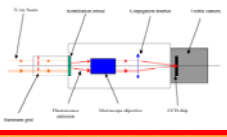
10 actuators for aberration correction

1 actuator for global curvature

Surface figure validated by SH-LTP

Inserted in a closed-loop adaptive optics system with an X-ray wavefront sensor or with genetic algorithm:

- Closed-loop by Imagine Optic: CASAO (done), GENAO (genetic algorithm and software in development)
- Wavefront sensor with indirect detection to avoid CCD damage and shot noise (in development)

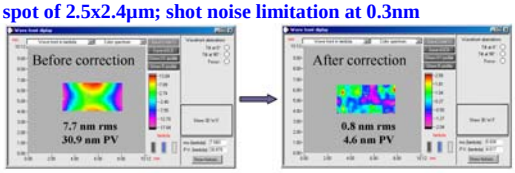


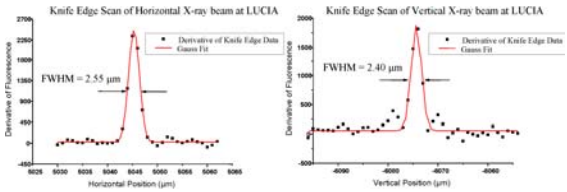
Adaptive Optics at EUV wavelength

Adaptive Optics (AO) systems at 0.34nm

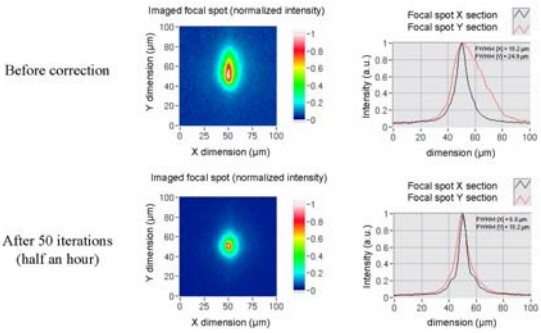
Soleil beamline LUCIA at SLS

- AO system with a deformable mirror and a wavefront sensor in closed loop:
  - minimization of wavefront error
  - Focalisation of the X-ray beam with a KB optics (4 actuators) on a spot of 2.5x2.4µm; shot noise limitation at 0.3nm





- AO system with a deformable mirror and an imaging system:
  - maximization of of the encircled energy with genetic algorithm
  - Focalisation of the X-ray beam with a KB optics (4 actuators) on a spot of 6x10µm (limited by the optical quality of the imaging system)



X-ray beam metrology and X-ray optics alignment by Hartmann wavefront sensing '', P. Mercère and al., Proc. Of SPIE., 5921, 2005

Perspectives

- Pushing the limits of the sensor performances:
  - Calibration
  - Hartmann grid quality
  - shot noise
  - indirect detection with scintillators
- Pushing the limit of AO systems:
  - algorithms and softwares developments
  - imaging system quality

contact@imagine-optic.com