Adaptive piezoelectric optics for XUV wavelengths

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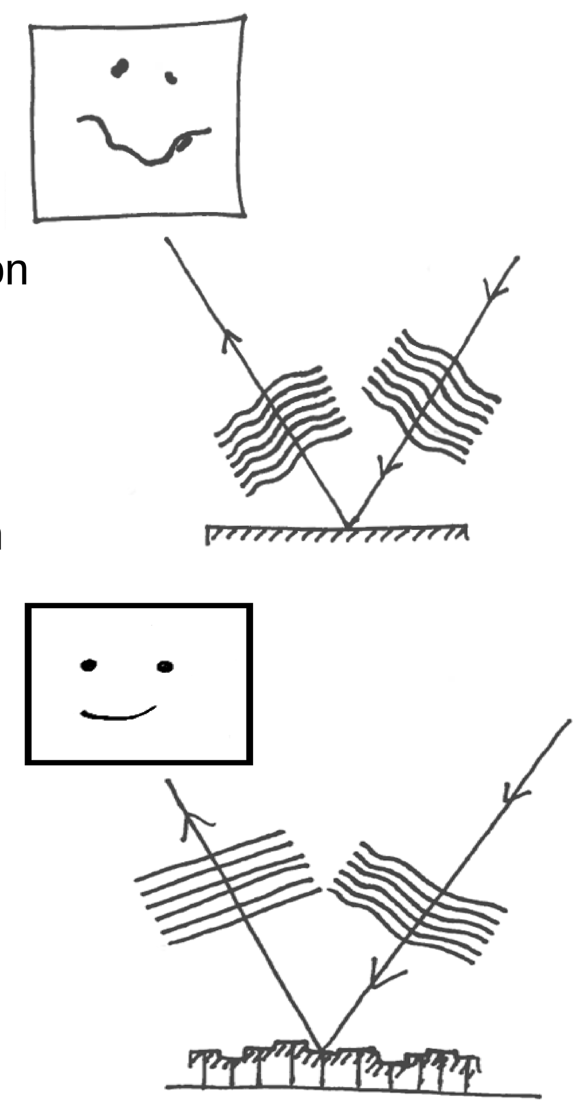
Introduction

- Adaptive optics are needed for many applications in the SXR- (soft X-Ray) and XUV-range (eg. photolithography, microscopy and material analysis by SXR)[1]
- Current solutions have low spatial resolution and low speed
- Our solution: surface modulation based on thin film piezoelectric actuators
- Advantages: Sufficient deformation >15 nm High spatial resolution and fast response

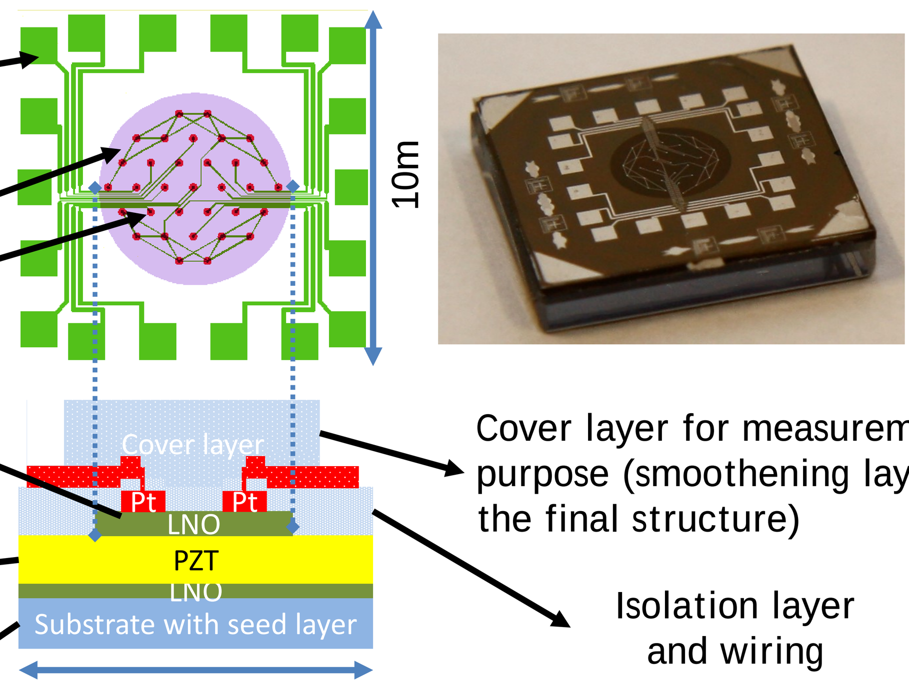
Principle of Wavefront correction



Aim

- Proof of principle of our adaptive scheme on a small scale sample
- Showing gradually varying deformation
- Steering patterns (multiple activated pixel)

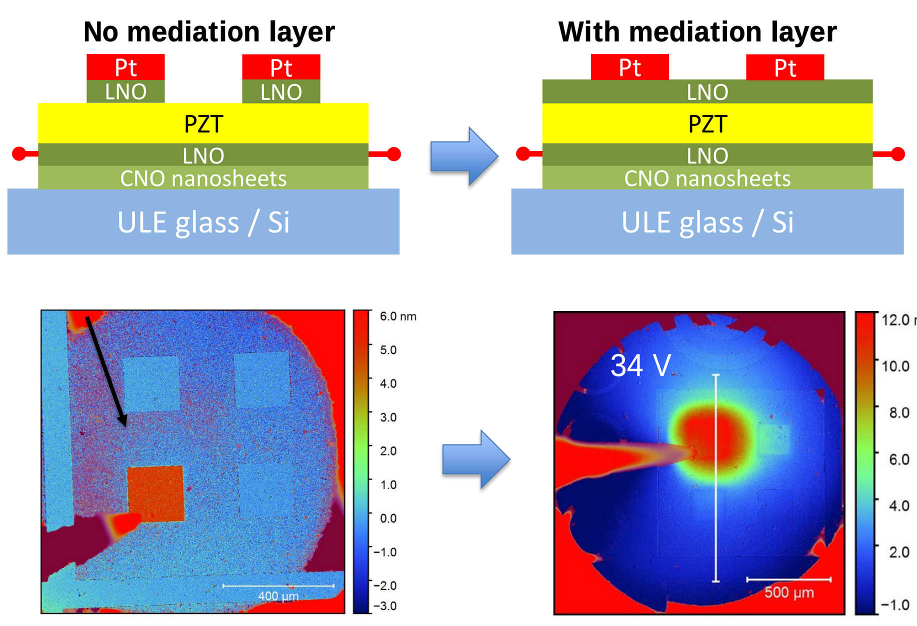
Sample structure and fabrication



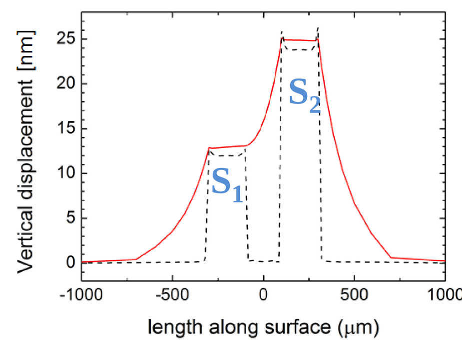
- Functional layers, i.e. LNO top and bottom electrodes and PZT, are fabricated by pulsed laser deposition
- The other layers are deposited and patterned in a cleanroom by lift-off and etching process

Functional layers

Role of the mediation layer

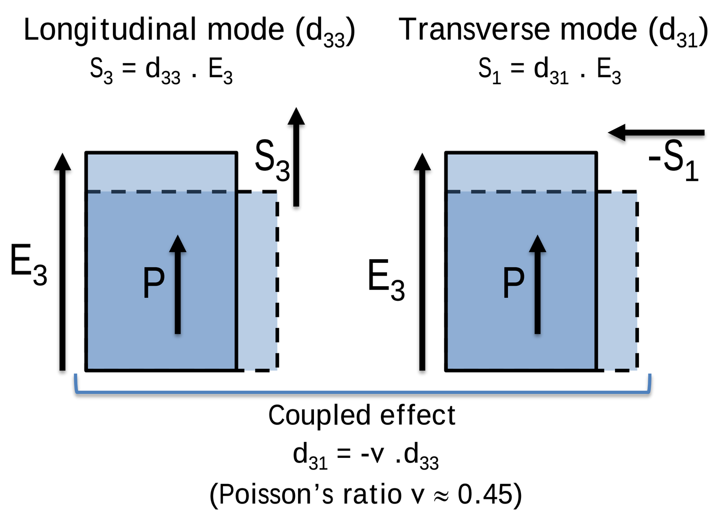


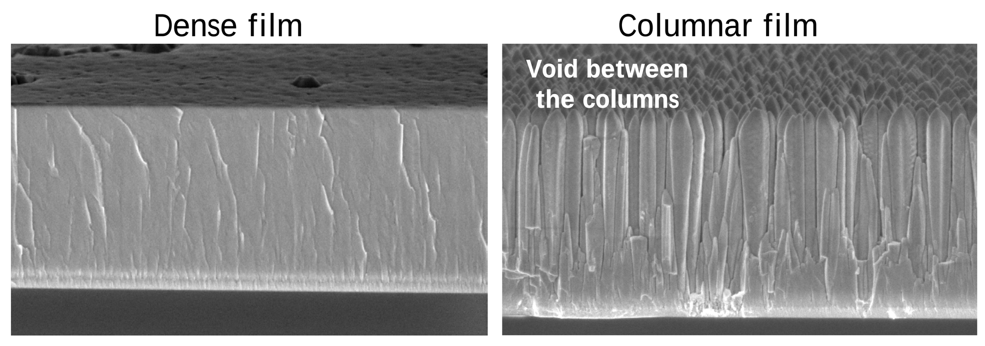
Gradually varying deformation between S_1 and S_2



Mediation layer allows gradual deformation between pixels

Columnar PZT film

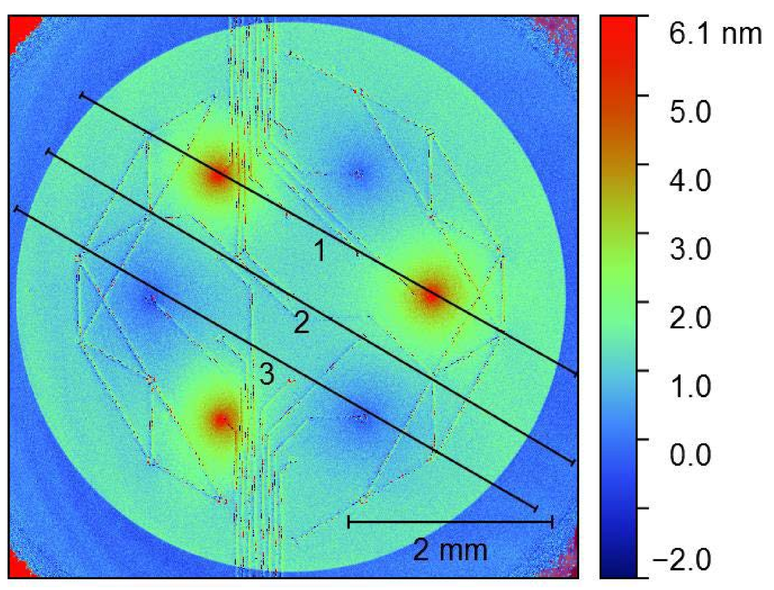


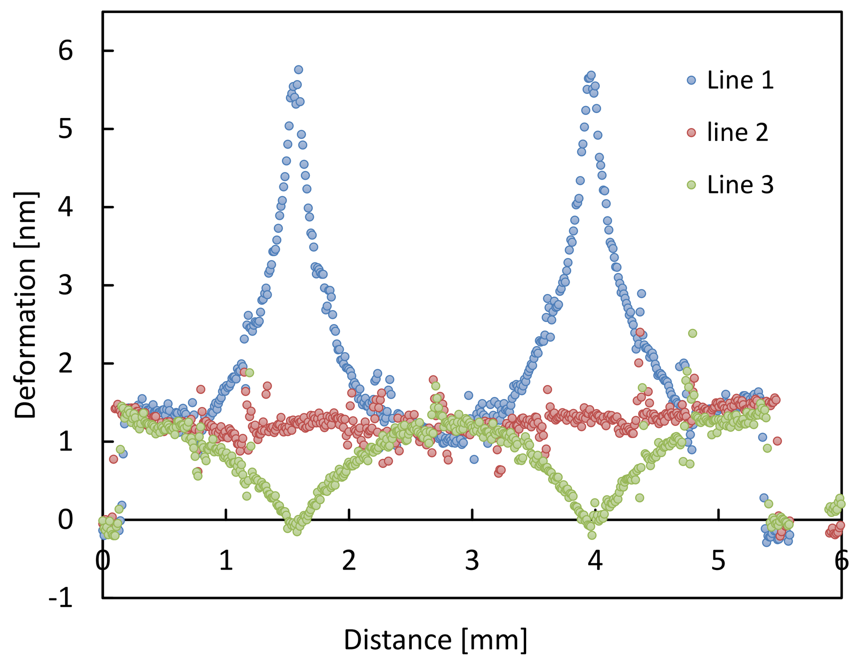


- Dense films are constrained by the substrate to shrink in the in-plane direction
- Out-of-plane displacement is reduced
- Columnar films are clamped less in-plane, higher out-of-plane displacements possible[2]

Measurements using while light interferometry

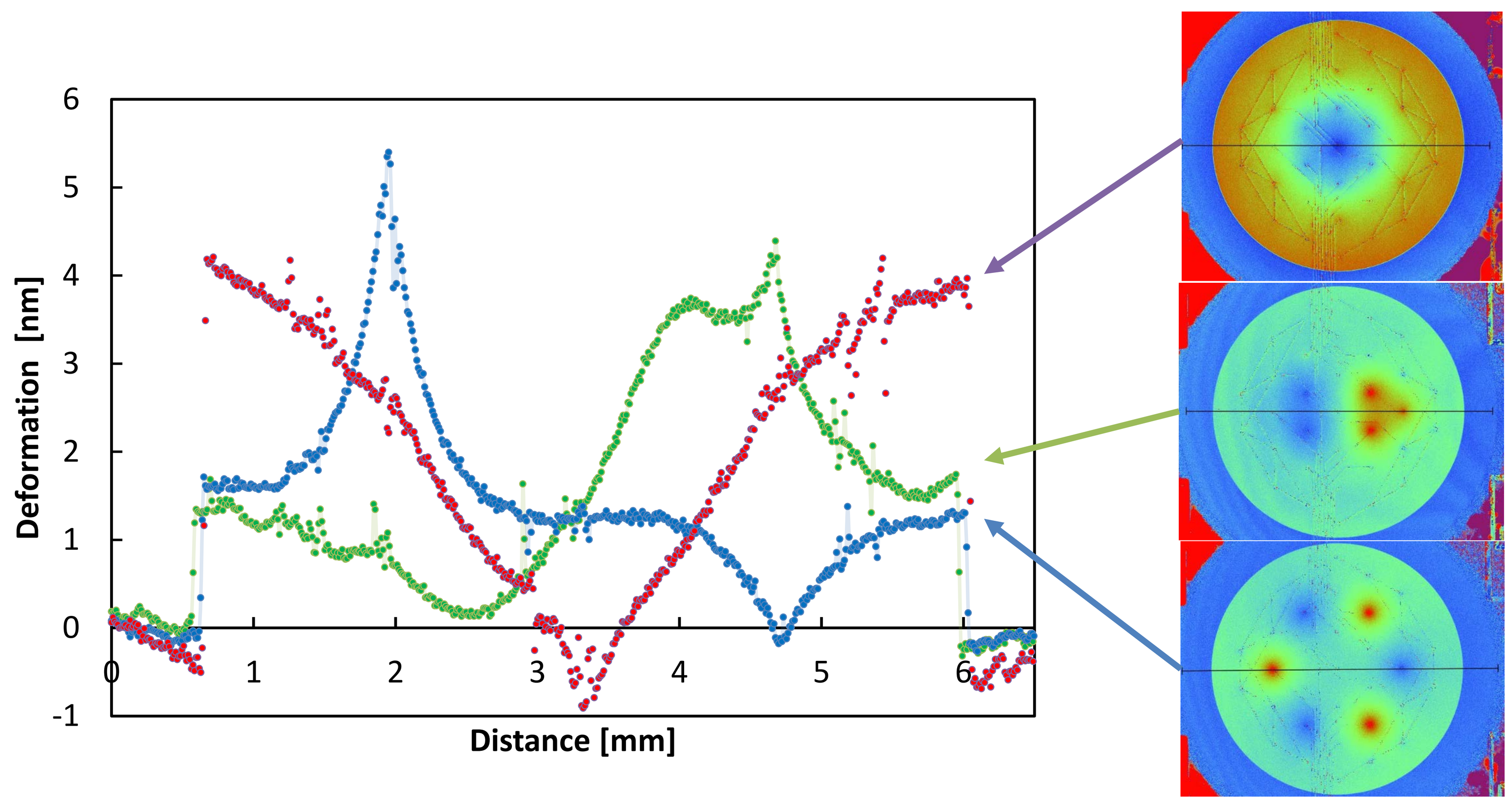
Cross-sections through a steered pattern





- Pixels can be independently actuated to steer desired surface patterns
- Extensions of up to 5 nm are measured
- Displacement between the pixels is gradual, allowing smoother corrections with reduced number of pixels

Cross-section of steered patterns



- Imprint of the wires is observable, can be prevented with the smoothing layer to be deposited in the future
- Even with only 16 powered pixels, many patterns can be steered

Conclusion

- We have developed a functional model of an adaptive optical component for XUV applications
- Enhanced piezoelectric response has been observed with columnar piezoelectric film
- Extension is sufficient for XUV applications
- Mediation layer approach enables gradual surface deformations
- **Future steps:**
- Reaching sub-nanometer smooth surface by a "smoothening" layer
- Completion with the multilayer mirror deposition

Acknowledgments

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1. M. Bayraktar, A. Chopra, G. Rijnders, K.-J. Boller, and F. Bijkerk, "*Wavefront correction in the extreme ultraviolet wavelength range using piezoelectric thin films*" Opt. Exp., 22, 30623 (2014).
2. A. Chopra, M. Bayraktar, M. Nijland, J.E. ten Elshof, F. Bijkerk, and G. Rijnders, "*Tuning of large piezoelectric response in nanosheet-buffered lead zirconate titanate films on glass substrates*" Sci. Rep., 7, 251 (2017).

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