Setup for time-resolved soft X-ray microscopy studies of magnetic nanostructures at PETRA III

Philipp Wessels¹, Moritz Slchie¹, Marek Wieland¹, Johannes Ewald², Gennaro Abbati², Stefan Baumbach², Johannes Overbuschmann², Thomas Nisius², Jens Viehthaus³, Thomas Wilhel², and Markus Drescher¹

¹Institute for Experimental Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany
²Institute for X-Optics, Rhein-Ahr-Campus Remagen, Sodderlaue 2, 53424 Remagen, Germany
³Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany

philipp.wessels@desy.de, http://dynamix.desy.de/

1. Experimental setup

1.1 Transmission X-ray microscope

- Full-field transmission X-ray microscope (TXM) for the soft X-ray beamline P04 at PETRA III.
- Flat-top illumination field of 20 μm diameter generated by grating condenser [1] for Kohler-like illumination.
- Sample plane imaged by micro zone plate with outermost zone width of 50 μm (figure 1).

1.2 Synchronized femtosecond laser system

- Mobile synchronized chirped pulse amplification (CPA) femtosecond Yb:KGW laser system PHAROS.
- Pulse duration of 280 fs and output power of 6 W.
- Laser repetition rate of 130 kHz equal to revolution frequency of the storage ring.
- Electronic phase-locked loop (PLL) synchronization allows to tune the delay \( \Delta t \) between laser and soft X-ray pulses (figure 2).
- Response of laser-excited magnetic samples can be probed by the TXM.

2. Results

2.1 Transmission X-ray microscope

- First full-field TXM images of magnetic nanostructures with \( \approx 700 \times 700 \) magnification recorded (figure 4, 5 and 6).
- Features down to 70 nm are discernible.
- Structure in figure 5 is a speckle pattern originating from the high degree of spatial coherence in the P04 soft X-ray beam.
- By wobbling the beam with the focusing Kirkpatrick-Baez (KB) optics of the beamline, the background can be smoothed (figure 6).

2.2 Laser synchronization

- Synchronization of the laser system has been demonstrated at beamline P11.
- Residual jitter of \( \approx 15 \) ps (likely limited by photodiode) short in comparison to the \( \approx 44 \) ps RMS pulse length of the PETRA III pulses.
- Pump-probe experiments reaching a time resolution limited only by the PETRA III pulse duration become possible.

3. Summary and Outlook

- Spatial resolution \( \approx 70 \) nm with new full-field TXM for beamline P04 at PETRA III.
- Temporal resolution \( \approx 44 \) ps RMS with synchronized femtosecond laser system (jitter \( \approx 15 \) ps).
- Next steps are recording:
  - X-ray magnetic circular dichroism (XMCD) contrast images of nanostructures.
  - Transient magnetic responses excited by pulsed laser.

Acknowledgements

- Dr. Pambos Charalambous (ZonePlates.com) for manufacturing of grating condenser and zone plate.
- Dr. Andreas Vogel and PD Dr. habil. Guido Meier for support during the lithography process.
- Alexander Neumann and Prof. Dr. Hans-Peter Oepen for preparation of the Co/Pt magnetic multilayers.
- The scientific and technical staff of the beamlines P04 and P11 of PETRA III at DESY was always ready to help.
- We gratefully thank the DFG Collaborative Research Centre 668 (SFB 668 - Magnetismus vom Einzelatom zur Nanostruktur) for financial support within the subproject B5 as well as the German Federal Ministry of Education and Research (BMBF - Bundesministerium für Bildung und Forschung) for financial support within the Nanofocus projects (05K5TU4 and 05K5TU1).

References