EXTATIC

Extreme-ultraviolet and X-ray Training in Advanced Technologies for Interdisciplinary Cooperation

EXTATIC Project Proposal 2016

Project Title	Extreme ultraviolet based structuring and analysis methods: tackling inverse problem of imaging
Home University	RWTH Aachen, Germany
Home University Supervisor	Prof. Larissa Juschkin
Host University	University of Southampton, UK
Host University Supervisor	Dr. Bill Brocklesby
Third University	
Third Supervisor	
Associated Partner(s)	
Associated Partner Supervisor(s)	
Project Outline (max 250 words)	As the size of functional elements of electronic and photonic devices reduces down to tens or even to single nanometer scale, the precise control over the structure size and shape is needed to fully utilize their potential. Therefore, the employed structuring and analytical methods must create and characterize nano-engineered structures. This project aims at developing of advanced patterning methods and of new highly sensitive characterization techniques capable to provide not only information about single nanostructures, but also about large functional arrays of nano-elements. Special focus will be on methods for solving the following inverse problems: • design of masks for interference/proximity lithography • determination of structural and material parameters from the measured angular distribution of scattered radiation. • Extreme ultraviolet lithography (EUV) is proven to be useful not only for large scale chip manufacturing, but also for large area nanopatterning utilizing diffraction and interference effects. Proper design of laboratory EUV interference/proximity lithography requires simulations of interference/near-field distribution of a radiation field after passing the mask and its propagation to the wafer under careful consideration of optical parameters of the system and source coherence properties. EUV scatterometry allows for characterizing large-area periodic nanostructures non-destructively with high sensitivity due to the short wavelength and elemental contrast at the absorption edges. Due to the penetration depth of up to several tens of nanometers, buried functional layers and also 3D-nanostructures can be investigated. Surface structure determination is possible by solving the inverse scattering problem.
Relevant Reference(s)	T. Weichelt, U. Vogler, L. Stuerzebecher, R. Voelkel, and U. D. Zeitner, "Resolution enhancement for advanced mask aligner lithography using phase-

	shifting photomasks", Opt. Express **22**(13), 16310-16321 (2014) R. Model, A. Rathsfeld, H. Gross, M. Wurm, and B. Bodermann, "A scatterometry inverse problem in optical mask metrology", J. Phys. CS **135**, 012071 (2008) S. Danylyuk, H.-S. Kim, S. Brose, C. Dittberner, P. Loosen, T. Taubner, K. Bergmann, and L. Juschkin, "Diffraction-assisted extreme ultraviolet proximity lithography for fabrication of nanophotonic arrays", J. Vac. Sci. Tech. B **31**(2), 021602 (2013)
Lead University Profile	With 260 institutes in nine faculties, RWTH Aachen University is one of the leading institutions for science and research in Europe and one of eleven German Universities of Excellence. The work carried out in the research centres at RWTH Aachen is strongly oriented towards the current needs of industry which has led to numerous innovations, patents, licenses and the highest amount of third-party funding of all German universities. The chair for Experimental Physics of Extreme Ultraviolet (RWTH-EUV) is a new established group dedicated to the research on EUV sources and their applications. The group is closely linked to the Chair for Technology of Optical Systems (RWTH-TOS), to the Fraunhofer Institute for Laser Technology using the same infrastructure and to the Peter Grünberg Institute PGI-9 "Semiconductor Nanoelectronics" at the Forschungszentrum Jülich. The EUV activities within this collaboration comprise the development of plasma based short wavelength radiation sources and their applications, such as EUV-lithography, EUV and soft x-ray microscopy, defect inspection and surface analysis. This includes tailoring of extreme ultraviolet light sources for specific applications with regard to efficiency, brightness, dynamics, spectral and coherence properties, source metrology, defect inspection, time-resolved microscopy, high performance nanostructuring, surface and thin film analysis by spectrometric reflectometry and scaterometry. A main focus is to transfer some of the techniques known from short-wavelength optics at synchrotrons into the laboratory envisioning new applications and tools for future laboratory devices based on EUV. Such "on-site" tools can finally be accessed by a much broader range of scientific users. Full infrastructure of the Fraunhofer ILT, RWTH-TOS, RWTH-EUV and equipment present at PGI-9 in Jülich will be available in this project. This includes mechanical and electronic workshops, optical simulation tools, several laboratories for structural, optical and surface analysis and lithographic tools. Unique EUV equipment includes broadband EUV reflectometer, EUV transmission/reflection microscope, water window soft-x-ray microscope, coherent diffractive imaging/ptychography set-up, EUV scatterometer, and interference/proximity lithography set-up.