Faculty of Electrical Engineering & Computer Science
Master Degree Course Electronics Engineering, MSc EE

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Hochschule Bremen
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Master 2016

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Investigation of Outgassing Behavior of Electron Beam Resists in Extreme Ultraviolet Radiation.

ABSTRACT - Masterthesis

Extreme ultraviolet lithography is the most promising technology to fabricate structures with smaller minimum feature sizes. It is a relatively new form of lithography that uses extreme ultraviolet (EUV) radiation with a wavelength in the range of 10 nm to 18 nm to structure photosensitive materials, so called photoresists (because they have to resist following etch steps). Due to the high photon energies of above 100eV it is possible to expose photoresists that are commonly used for electron beam lithography with EUV radiation. Experiments have to be carried out in vacuum and under cleanroom conditions.

The EUV laboratory exposure tool (EUV-LET) allows to expose these photoresists by proximity and interference lithography. The aim is to achieve periodic structures with minimal feature sizes below 50 nm relevant for several applications like future storage media, nanoantennas etc. Also scientific resist characterization itself is an important task in this field enabling for industrial application of the technique.

Resist outgassing is one of the critical issues in EUV lithography and therefore needs to be monitored, qualified and quantified. Hydrocarbons outgas from electron beam resists when they are placed in vacuum chamber and exposed to EUV radiation. As a result, they can form a carbon layer on the optics nearby and this can lead to a degradation of optical components such as Mo/Si multilayer, spectral filters or transmission gratings. Due to this a detailed research has to be carried out to measure the species and quantities of the outgassing components of the applied resists by a residual gas analysis with the help of a quadrupole mass spectrometer.

The following tasks need to be fulfilled during the master thesis:

- Integration of the quadrupole mass spectrometer (QMG220) into the existing EUV-LET setup (in ISO-class 5 environment).
- Quantification and qualification of outgassing effect for different high resolution electron beam photoresists ZEP520A-7 and CSAR62 (both positive tone resists) and XR1541 (a negative tone resist also known as HSQ):
    - Measurements during exposure series of different resists with the help of Quadera software (software for data acquisition and control of QMG220 mass spectrometer).

  - Data handling and evaluation using Matlab software.
  - Monitoring of pressure inside of vacuum chamber, room temperature and relative humidity by two different devices. The values should be recorded during the residual gas analysis and time matched by a Matlab routine. The data acquisition from the following devices need to be implemented:

    a. Testo 175h1: for temperature and humidity measurement.

    b. TPG 262 and PKR 251: dual-channel measurement and control unit together with compact full range gauge is installed for total pressure measurement at mass spectrometer.

- Systematic analysis of resist surface roughness after each lithographic process step by atomic force microscopy:
  - Silicon substrate surface roughness.
  - Resist before exposure (spin-coated and prebaked).
  - Resist after vacuum treatment (Inside of EUV-LET vacuum chamber but not exposed).
  - Resist after exposure (before and after development).
- Study of outgassing behavior as a function of resist thickness, prebake temperature arid prebake time for positive tone resist ZEP520A-7.
- Absolute calibration of mass spectrometer by calculating the outgas rate of species.
- Creating a graphical user interface (GUI) for recording and reading data values (mass spectra, pressure, ambient temperature and relative humidity) automatically instead of re-writing Matlab code each time, allowing creation of time matched measurements in tabulated and graphical form.
- Systematic analysis of the experimental results and documentation in form of a master thesis.