Analysis and evaluation process for quantification of residual gas deposition by a focused electron beam

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Residual gas contamination in electron microscopy is frequently experienced as severe obstacle. In the vacuum chamber of a scanning electron microscope (SEM) an increasing level of contamination of the in-chamber surfaces can be observed over time, finally resulting in a contamination of the residual gas. Focused electron beam (FEB) induced processes have become increasingly popular in recent years as maskless, direct-write nanofabrication techniques[1,2]. An undesired deposition from residual gas diminishes the purity of the deposited structure[3] and etching processes may even be prevented by a passivating contamination layer. Furthermore, residual gas deposition leads to artifacts in imaging. Therefore, a thorough investigation and methods for removing/avoiding residual gas contamination is of utmost importance.
A process for reproducible evaluation of the amount of residual gas has been developed by depositing material under controlled conditions. In this work we have investigated the deposition rate of the contamination on a silicon surface, its shape and chemical composition. The deposited residuals have been analyzed by AFM and SEM imaging. Mass spectroscopy of the gas phase and X-ray analysis of the deposited material has been performed where the contaminants have been identified as hydrocarbons. The influence of various parameters such as beam current, acceleration voltage, scan speed and evacuation time on the contamination level have been investigated. Based on the experimental data the following mechanism for the deposition from residual gas is proposed: The adsorbed contamination molecules on the sample surface are cracked by secondary effects of the incident electron beam resulting in non-volatile carbon species deposited in the interaction area.
Contaminants were also introduced intentionally by adding gas as precursor for electron beam induced deposition processes. The reusability of the SEM for imaging purposes was evaluated as a function of time. The effectiveness of different methods for removal of contamination will be discussed. The presented work will provide a deeper insight in the fundamentals of residual gas contamination and its removal and avoidance.

[1] Van Dorp, W.F., Hagen, C.W., J. Appl. Phys. 104 (8), 081301 (2008)
[2] Utke, I., Hoffmann, P., Melngailis, J. JVST B 26(4), 1197 (2008)
[3] Joy, D.C. Microscopy and Microanalysis 12 (Supp. 2), 1660 (2006)

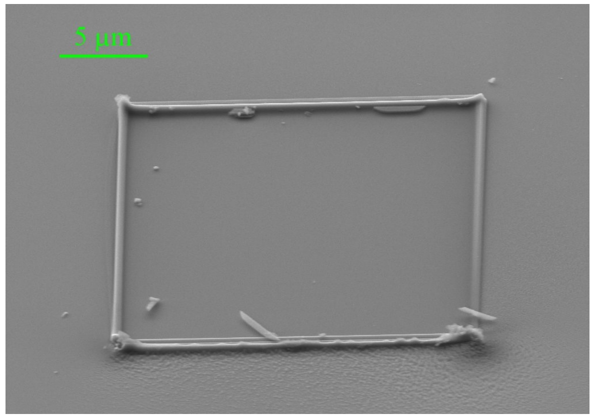

Fig. 1: Tilted SEM image of a residual gas deposition

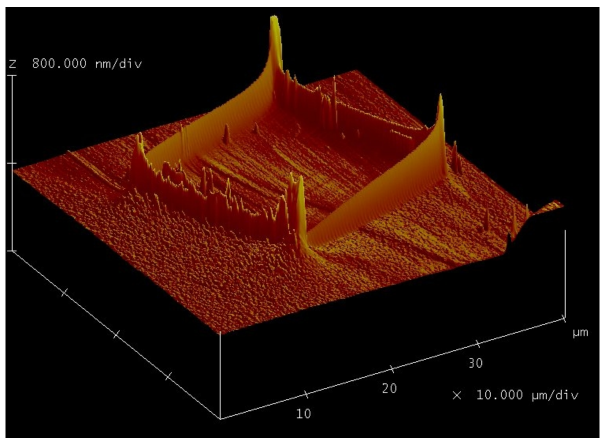

Fig. 2: AFM image of a residual gas deposition

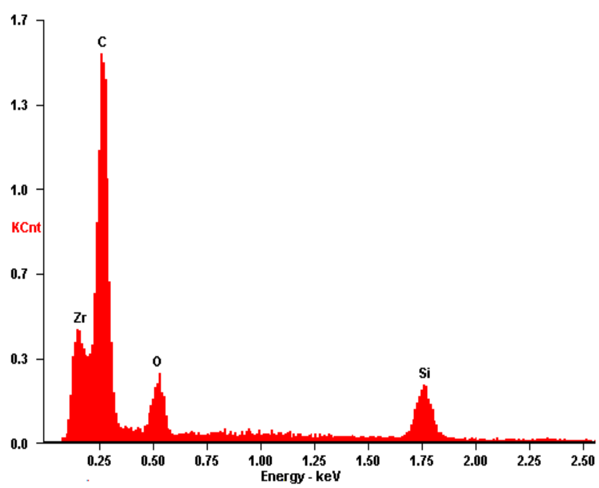

Fig. 3: X-Ray analysis of a residual gas deposition