Contribution ID: **113** Type: **Poster**

P22 - Identification and reduction of acoustic-noise influence on focused ion beam (FIB)

Friday, 11 July 2014 13:00 (1 hour)

The use of focused ion beam (FIB) for research or processing of nanostructures requires very accurate beam positioning. However, numerous reasons for beam-position fluctuations exist. When FIB is used for specimen imaging, then these beam fluctuations cause the image jitter, blur or specimen-edge deformation. Similarly, beam fluctuations decrease the spatial resolution of FIB-based technological processes of milling or deposition. The sources of fluctuations are electromagnetic interference (EMI), floor vibrations and airborne acoustic noise.

Our work concerns acoustic noise impact on focused ion beam fluctuations. The measurements were carried out on Helios NanoLab 600 DualBeam system with ion and electron beam columns. Reference specimens were imaged by electron or ion beam while acoustic waves of different frequency, magnitude and direction were intentionally generated nearby the system.

It was found that while EMI-related distortions are caused by a wide and continuous spectrum of frequencies, for acoustic noise the strong deformations of image occur only at several resonant frequencies (mainly in the range 100-400 Hz). Comparison of results obtained for either electron or ion beam allowed to attribute different resonant peaks to various FIB-system components (ion column, electron column, specimen stage). Spectral analysis showed that resonant components of the acoustic noise surrounding the system cause beam-position fluctuations in the range of several nanometers, highly unfavorable for nanotechnological works on FIB. The noise is generated mainly by various parts of the system itself.

A method was also developed to identify whether the observed beam-position fluctuations originate from acoustic noise or from electromagnetic interference. It was possible because electromagnetic field impacts charged particles along their entire path while the acoustic vibrations act only on the mechanic elements of the system. Therefore the electromagnetic fluctuations are dependent on the particle velocity (i.e. the beam energy) while the acoustic fluctuations are independent of it.

It was found that distortions (of FIB image and of patterns performed by FIB technological processing) caused by ion-beam position fluctuations due to acoustic noise can be reduced. The reduction can be achieved by selection of appropriate parameters of FIB process e.g. working distance and scanning parameters (like scan rate and scan direction).

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Session Classification: Poster Session with Cheese and Wine