Using a SFM/ESEM hybrid for the analysis of vibrating surfaces

H. Sturm[1]

1. BAM – Federal Institute for Materials Research and Testing, BAM VI.25 “Scanning Probe Microscopy and Nanotechnology”, Unter den Eichen 87, 12205 Berlin, Germany

heinz.Sturm@bam.de
Keywords: vibration analysis, cantilever, SFM, ESEM

As often discussed, complementary SEM (Scanning Electron Microscopy) and SFM (Scanning Force Microscopy) analysis have a number of advantages. Both microscope systems support a huge number of techniques, but have also certain limitations. An SEM is capable of scanning large areas at very high speed and samples properties can be analyzed at different depth. An SFM is limited by scan area and speed, but supports techniques to determine mechanical, electrical, thermal and optical properties with highest resolution. The 3D dimensional shape of the topography can be observed directly.

One obvious advantage in a combined system is: different complementary analysis can be made at the same sample position. Time consuming, sometimes impossible position adjustments of a sample in two separate instruments are omitted. Beyond this, there is an additional important aspect of hybrid systems. Both probes, the electron beam and the tip of the SPM, can be used simultaneously and it is worth to look at this opportunity in detail. In a hybrid system these interactions of one probe can be analyzed simultaneously by the other probe. Beside a characterization of such interactions, well-known probe-sample interactions can be deliberately used, allowing analysis of local sample properties, which could not be determined in separate instruments.

For these reasons a universal SFM based hybrid system was developed by I. Joachimsthaler et al. [1] in Wuppertal, Germany. The SPM can easily be implemented, it is mounted onto the specimen holder and no modifications of the SEM are necessary, if feedthroughs for electrical connections are available. At BAM it is used in combination with an ESEM (Environmental Scanning Electron Microscope), which is very interesting due to the fact that both techniques allow investigation of insolating samples not coated with metal.

In this paper investigations on vibrating SFM cantilevers are used to explain a special hybrid technique able to detect vibrations enforced at selected frequencies. The SFM cantilever is excited at its fundamental resonance frequency or at higher normal or torsional modes by the dither piezo of the SFM working at a fixed frequency *f*. The cantilever is imaged in the SEM by scanning the electron beam using a secondary electron (SE) detector. Additionally to the conventional DC-type signal, images of the superimposed AC-modulation as amplitude/phase shift and real part/imaginary part amplitudes can be obtained using a lock-in amplifier synchronized to the excitation frequency *f*. The origin of the measured signals is due to modulation of the SE generation by the vibrating surface. In any case where two adjacent positions of the electron beam show a contrast, i.e. an intensity deviation arises, this intensity is modulated by the vibration of the contrast forming edge, roughly speaking the measured AC-amplitudes reflect the blurring at edges. So the setup discussed here is to a certain extend the inverted setup of Thomas et al. [2], where a modulated electron beam was used to excite the surface of a piezo ceramic, leading to a detection limit of the vibration amplitude of 200 femtometer measured by the SFM.

DOI: 10.3217/978-3-85125-062-6-139,

Images of vibrating SFM cantilevers are presented to demonstrate the technique and to show, that torsional and normal resonances can be distinguished.

The aim of the investigations presented here is to study the dynamic deformation of a polymer surface excited either in normal or lateral direction by a SFM tip in contact under a certain load. Normal vibrations of the contact are used in SFM to study the stiffness of surfaces (e.g. by Force Modulation Microscopy – FMM or Constant Dynamic Indentation Microscopy – CDIM) [3, 4]. Lateral vibrations lead to shear deformation of the surface and reflect the tribological properties (Modulated Lateral Force Microscopy – MLFM) [5–7]. Although the deformation response of the contact is in three dimensions, only the displacement in normal and lateral direction can be addressed using a SFM. On this poster, first results are presented demonstrating a map of deformation of a surface excited by a vibrating SFM tip.

1. I. Joachimsthaler, R. Heiderhoff, L.J. Balk, Measur. Sci. Technol. **14**(1) (2003) p87.
2. Ch. Thomas, R. Heiderhoff, L.J. Balk, Appl. Phys. Lett. **90** (2007) art. no. 144106.
2. M. Munz, H. Sturm, E. Schulz, G. Hinrichsen, Composites A **29A** (1998) p1251.
3. J. Chung, M. Munz, H. Sturm, Surf. Interface Anal. **39** (2007) p624.
4. H. Sturm, Macromol. Symp. **147** (1999) p249.
5. H. Sturm, E. Schulz, M. Munz, Macromol. Symp. **147** (1999) p259.
6. H. Sturm, Proc. Viennano ´07, Vienna, March 2007.

G. Kothleitner, M. Leisch (Eds.): MC2009, Vol. 1: Instrumentation and Methodology,
DOI: 10.3217/978-3-85125-062-6-139, © Verlag der TU Graz 2009