Towards High-Frequency Electrical Specimen Stimulation for Time-Resolved Electron Microscopy

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Electron microscopic measurements of static specimen provide information down to nature's smallest building blocks. The extension to fast dynamic processes has been gaining increasing interest lately and is driving the development of new methods for the realization of time-resolved measurements in the electron microscope. Furthermore, it is contributing to the development of interesting stimulation mechanisms in the sample.

In the case of transmission electron microscopy (TEM), the ultrafast transmission electron microscopy (UTEM) as a pump-probe technique stands out due to its high time resolution in the sub-ps range and reasonable signal to noise ratio [1]. Here, because of the high trigger frequencies (HF) the sample is excited optically. Another interesting approach would be an electrical stimulation of the specimen. However, are commercially available in situ TEM systems capable of high frequency electrical specimen stimulation?

To find the underlying cause, a special HF-setup was developed for the FEI Titan 80-300 Berlin Holography Special TEM. This setup lays the foundation for a focussed ion beam (FIB) aided testing process of the HF-capabilities of commonly available in situ TEM systems (primarily for heating and electrical biasing). Figure 1 gives schematic overview of the process and the workflow.

With the FEI Helios NanoLab 600 FIB, special geometries are repeatedly milled in MEMS chips, which allow measurements of the influence of impedance mismatching, cable bushings, or coupling effects via time-resolved electron holography [2]. In this context, the high-frequency properties of the MEMS chips themselves are also investigated by means of a systematic geometric change with the FIB between individual measurements in the TEM.

Figure 2 shows reconstructed amplitude and phase of an electron holographic measurement of high frequency electrical stimulation of a specially designed electrode geometry on a MEMS chip at 10 MHz. The amplitude variation and plateau like phases are typical for double exposure holography [3], as here both levels of the applied voltage contribute to equal amounts allowing the study of limitations and physical boundaries of such in situ TEM systems related to their HF-triggering capability.

References:

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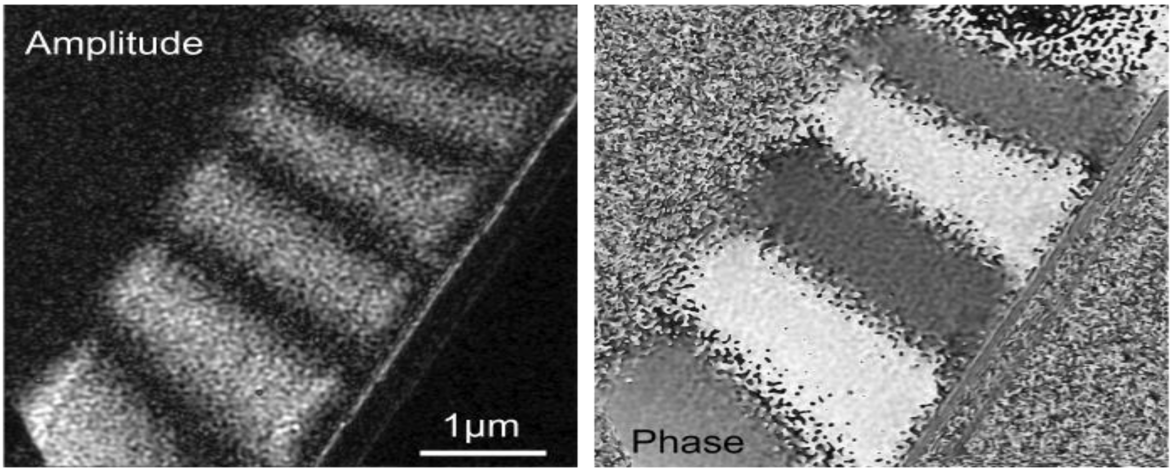

Figure 1: Schematics overview of the electrical wiring for the HF-measurement inside the TEM and the overall workflow between FIB and TEM.

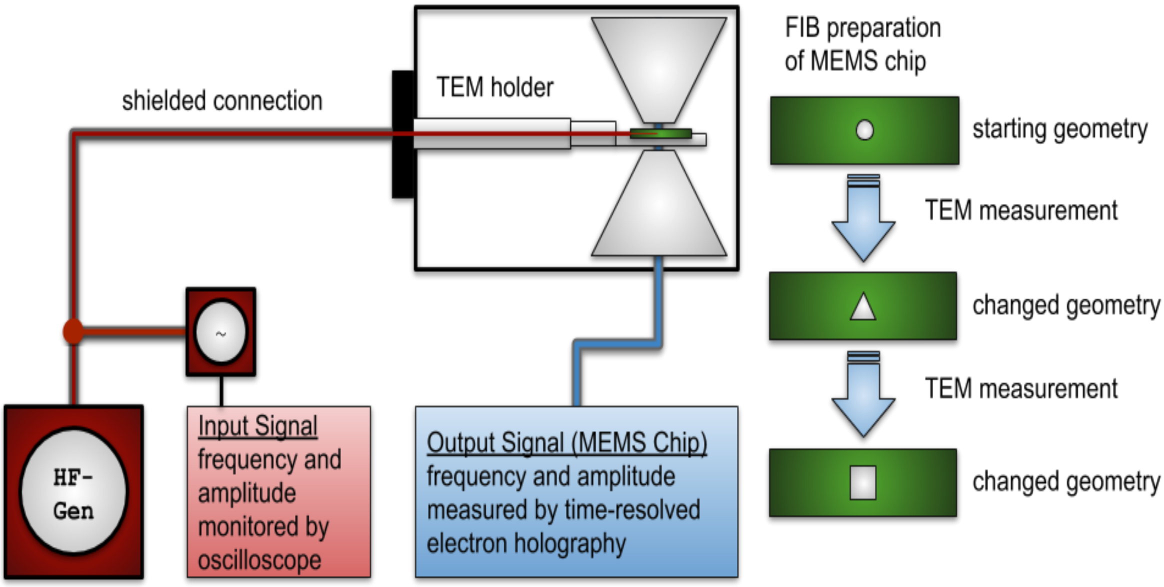

Figure 2: Reconstructed amplitude and phase of a specially designed electrode geometry on a MEMS triggered by a 1 Vpp sine wave signal at 10 MHz.