Correlative AFM-SEM Platform Enabling Unique Characterization of Samples

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Simultaneous acquisition of complimentary data of a sample provides highly valuable information. This could be achieved by integrating different analytical methods into one instrument. Scanning electron microscopes (SEMs) are powerful research tools that reveal surface details at nanoscale resolution. Atomic force microscopes (AFMs) can extract important mechanical, electrical, and magnetic information by localized nanoscale probing of the surface. Combining these two technologies into one instrument presents a unique opportunity to gather novel insights into the micro- and nano-world.

In this work, we present AFSEM (see Figure 1), an AFM designed for integration into an SEM or focused ion beam SEM (Dual Beam). AFSEM has a small size that is highly integrable with most SEMs/FIBs without impeding their normal operation. It is a fully functional and a highly modular AFM that provides all standard and most advanced imaging modes. We also have developed an interface unit to drive our AFSEM. The interface unit is operated by the Open Hardware Controller, a project that is maintained by École Polytechnique Fédéral de Lausanne (EPFL). The AFSEM interface unit contains HV amplifiers for the AFM piezo stage and stick–slip piezo motor driver for the coarse positioner stage. In addition, it provides access to all important signals such as position sensors, all cantilever related signals, as well as LV and HV piezo signals. AFSEM interface unit opens a world of possibilities to implement novel ideas, thanks to auxiliary analog IOs and easy to program open-source LabView-based environment. We will present a few case studies to highlight the application of AFSEM for characterization of different materials and devices.

Finally, we will present our tilt rotation stage that can also be integrated inside an SEM (see Figure 2). This stage can be incorporated to position hard-to-reach areas of a sample under an AFM tip. It has a rotation range of 360° and a tilting range of -90° to 90°. This enables imaging of a sample from all sides. Both tilt and rotation axes are equipped with encoders that enable precise closed-loop positioning control. We also have designed and implemented an FPGA-based controller to operate the tilt-rotation stage.

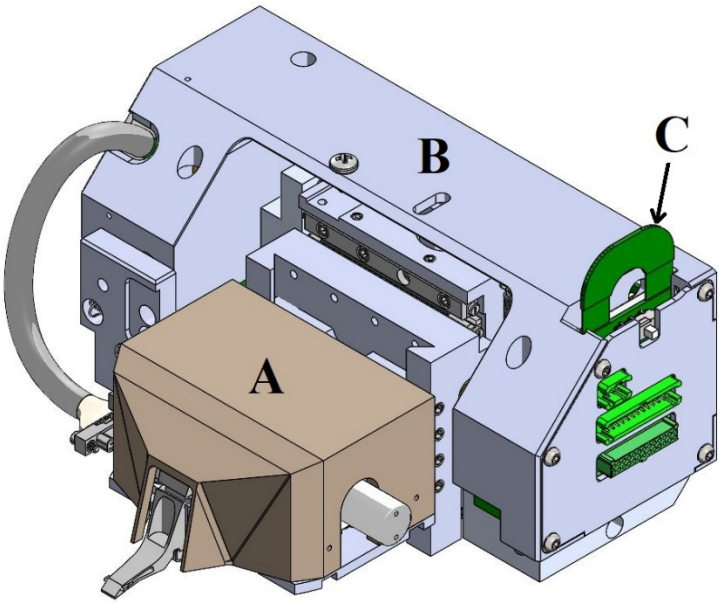

Figure 1: Functional elements of the AFSEM. (A) AFM stage, (B) coarse positioner, and (C) measurement module.

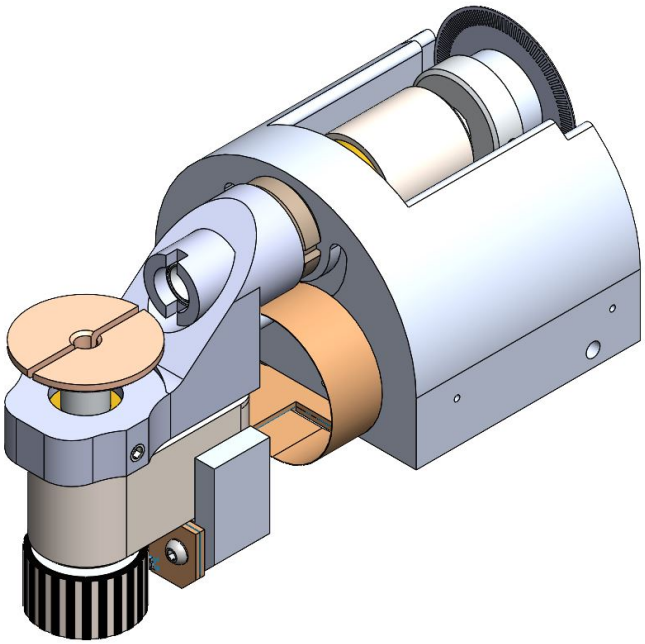

Figure 2: The tilt rotation stage enables imaging of a non-flat sample.