Development of head-scanning atomic force microscope in scanning electron microscope

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A beam bounce type head-scanning atomic force microscope (HSAFM) is developed that enables a large sample to be imaged. The beam bounce type is the most popular technique to detect the tip-sample interaction by measuring the deflection angle of a laser beam which reflects on an AFM cantilever. It uses both contact and non-contact modes to image and measure material properties. Previously, most of atomic force microscopes installed in a scanning electron microscope (AFMinSEM) scanned a small sample, or some scanned an AFM tip using a tuning fork for the detection of tip-sample interaction. But, the tuning fork type AFM can't be used to measure material properties using contact mode.

The HSAFM head frame was made to be compact and light by removing unnecessary parts from an aluminum block only to have structures to mount necessary components of a beam bounce type AFM head including a laser part, a focusing lens, two mirrors, a tip mount and a positioning sensitive photo diode (PSPD) and to be scanned without mechanical bending or vibration. The machined one-body structure of the head frame was used as part of two small mirror mounts and an optical fiber collimator. A through- hole from the collimator to the mirror was used to mount a small lens mount inside. The distance from the tip to the top of the mirror is only 5.5 mm and the working distance of a microscope to be combined with the HSAFM like a SEM or an optical microscope can be small enough to give a high resolution image of the combined microscope. The HSAFM is installed in a SEM of Quanta 650 FEG from FEI. The head of HSAFM is made so small and light that a good image can be acquired at a line scan rate of 1.8 Hz without loss of image sharpness, that is faster than general sample scanning AFMs, while scanning 7 μm x 7 μm area of tens to hundreds of nanometer high gold prisms on silicon. Also a general 3-axis nanostage with capacitive sensors makes calibrated topographical imaging possible.

The HSAFM will allow people not only to image the sample topography but also to measure material properties using all of the material property getting modes of the beam bounce type AFM like conductive AFM mode. Hopefully, the HSAFM may be applied to the imaging of a large sample like a semiconductor wafer in SEM or may be combined to a focused ion beam system (FIB) to image a nanofabricated sample by the FIB.

Figure 1: The design of HASFM head frame

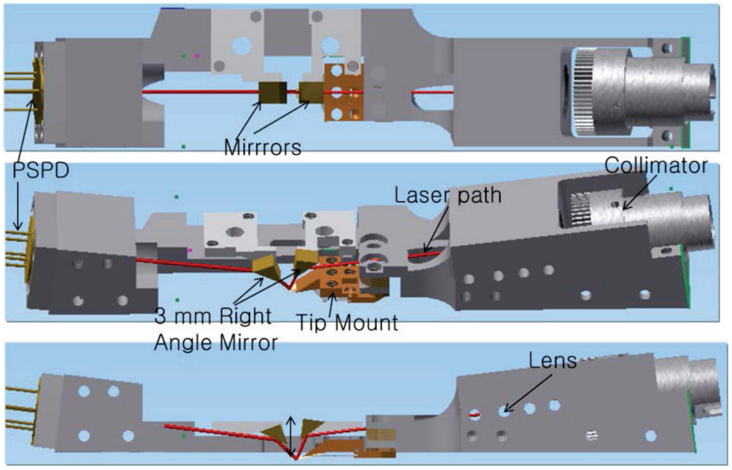


Figure 2: The design of the head: The size of the head is 103 x 22 x 15 mm^3.

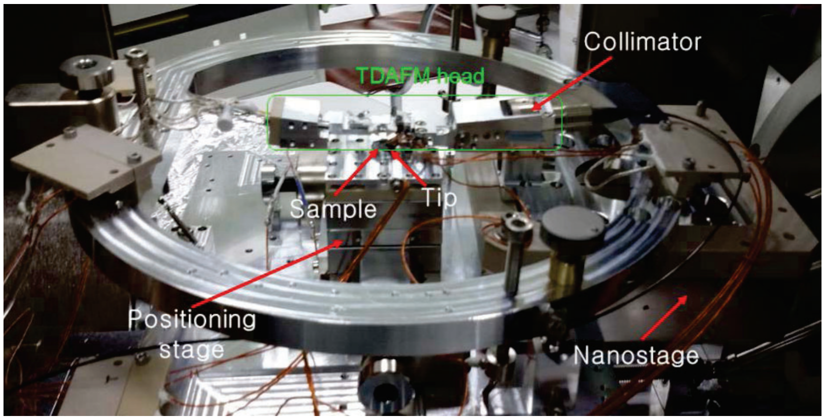
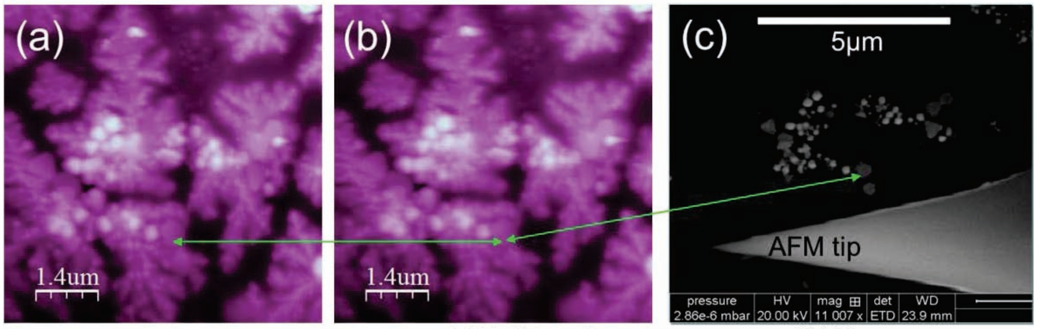


Figure 3: The picture of the HASFM in a SEM



scan rate 1 Hz / 7μm x 7μm

scan rate 1.8 Hz / 7μm x 7μm

SEM image

Figure 4: The images of gold prisms: (a), (b)- AFM images, (c) SEM image.