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# SPM Integration Into SEM/FIB/SAM Systems
# New Opportunities . . . . . or Only Integration Problems?

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In order to meet the growing analytical needs of modern nanoscale research and technology, analytical system designers must continually investigate new system concepts. One of the obvious development routes is to integrate increasing numbers of analytical techniques into a single system. The system to be considered here is a combination of Scanning Probe Microscopy (SPM) - in particular the two different modes of Atom Force Microscopy (AFM) - with Scanning Tunnelling Microscopy(STM).

AFM and STM have unequalled lateral and depth resolution down to the molecular and even the atomic scale. Significant also, is the electronic information content in the image signal, derived from the interaction mechanism between the tip- and sample-atoms, which they provide. The current state of the art, in AFM mode, is the ability to chemically identify a single surface atom [1] and even to gain insight into electronic bond-structure [2].

AFM and STM, provide complementary information and are therefore natural partners in a unified system approach. Modern AFM sensors such as the Kolibri, Fig. 1 [3] and the QPlus, Fig. 2 [2] permit the parallel recording of up to four signals, such as STM current, AFM frequency shift, damping and topography, all with atomic resolution. It is clear that the combination of these information sources leads to a deeper insight into the functionality of the nanostructure, far beyond the simple morphological picture.

However a weakness which STM and AFM have in common is a restricted field of view. This could be overcome by the integration of an SEM/FIB capability with its associated electron-optical columns.

In this talk we will present some recent results achieved with an AFM/STM sensor system integrated into different SEM/FIB/SAM system platforms. Fig. 3 demonstrates the complementary nature of SEM and AFM image information.

The scientific and technical challenges of the integration work will be discussed and an outline presented of the limitations we are currently facing, together with some conceptual ideas as to how these might be overcome.

The second part of the talk will deal with the question of whether further integration of surface-sensitive analysis methods within a UHV environment is really needed. We strongly believe that it is, since the driving force to bring nanoanalytical tools into UHV arises from the fact that the properties of 3-dimensional nanoscale systems are excessively influenced by extraneous surface atoms/molecules which are more easily controlled under UHV conditions.

Finally, the consequences of such UHV integration will be described and discussed.

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References:

[1] Yoshiaki Sugimoto et al, "Chemical identification of individual surface atoms by atomic force microscopy", Nature **446** (2007), p. 64.
[2] J. Welker, F. J. Giessibl, "Revealing the Angular Symmetry of Chemical Bonds by Atomic Force Microscopy", Science **336** (2012), p. 444.
[3] Kolibri brochure. SPECS Surface Nano Analysis GmbH Berlin
[4] F. J. Giessibl, "AFM's path to atomic resolution", Materials Today **8** (2005), p. 32.

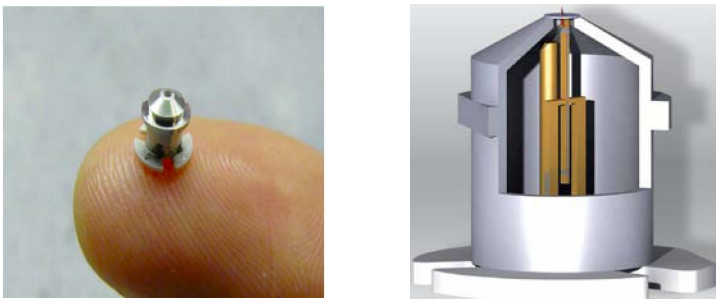

**Figure 1.** Kolibri AFM /STM sensor head, dimensions: about 3mm diameter and 4.8mm long

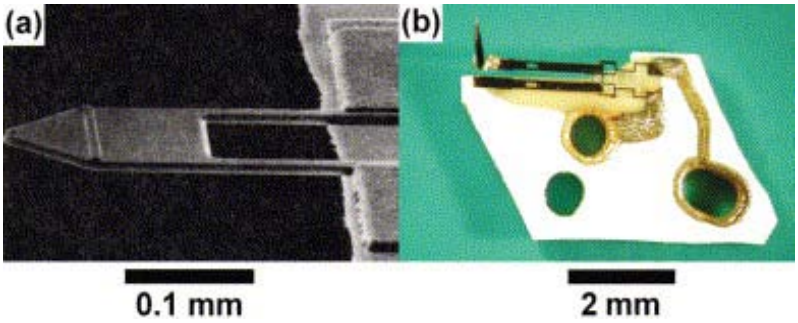


**Figure 2.** QPlus sensor (Fig 4 in [4])

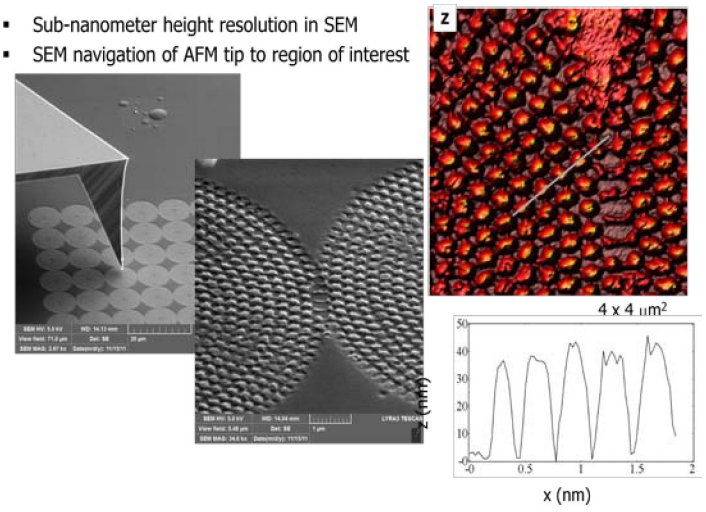


**Figure 3.** From left to right: Two SEM images showing nano-lithographic patterning of a surface and an AFM image (upper) and 1-D profile (lower) of the same surface. Performed using a CURLEW sensor in a LYRA machine from TESCAN a.s. Brno, Czech Republic.

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