The collaboration research for the Dual Graduate School between VNU and JAIST

[Title of collaboration research]:

Nano-characterization and nano-mechanical fabrication of nano-structures using scanning probe microscopy/spectroscopy

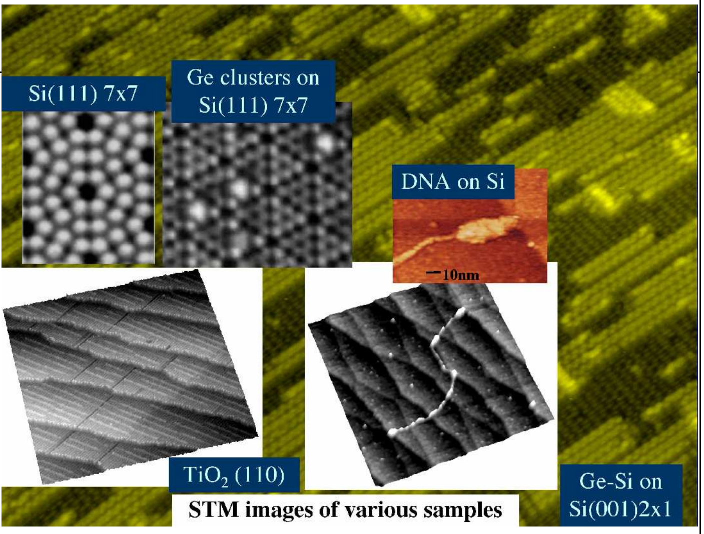
[The members of collaboration research]:

Prof. Masahiko Tomitori

[Reference home-page address]: http://www.jaist.ac.jp/ms/labs/kkk/Tlab/Tlab_home-j.html

[Other references]: Phys. Rev. B 73 (2006) 073307, Appl. Phys. Lett. 86 (2005) 073110, Surf. Sci. Lett. 574 (2005) L17-L22, Phys. Rev. Lett. 93 (2004) 256101

[Contents]



STM images of various samples

When an atomically sharpened tip is brought closer to a sample surface, e.g., ~1 nm, a small electric current starts to pass and the interaction increases between the tip and the sample before they are in contact. These are the so-called quantum tunneling effects; we refer to this current as tunneling current. The tunneling current drastically increases with decreasing separation between the tip and the sample. When we scan the tip over the sample surface while keeping the tunneling current constant, the tip movement depicts the surface topography, because the separation between the tip apex and the sample surface is always constant. This is the basic idea of scanning tunneling microscopy (STM). The obtained resolution is as high as individual atoms can be resolved when the tip apex is atomically sharpened. On one hand, we also obtain atom-resolved images using the interaction force between the tip and the sample, which is kept constant utilizing a tiny cantilever as a force sensor: this is the atomic force microscopy (AFM). Nowadays the microscopies using a scanning sharpened tip, the family of scanning probe microscopies (SPM), are indispensable as tools for nanoscience and nanotechnology.

In this research project, we observe the surface topography of semiconductors, oxides and metals with/without exotic coverage materials on them, including nanoclusters and biomolecules, and take electron spectroscopic data using SPM to understand nanoscale phenomena on these surfaces. We have developed several home-made SPMs operated in ultrahigh vacuum and in environmental controlled atmospheres at JAIST: in particular we have recently developed a nano-mechanical spectroscopic method based on the AFM with a capability of sweeping bias voltage, which reveals the interaction originated from quantum mechanical resonance between the surface electronic states of the tip and the sample: the interaction is enhanced at specified bias voltages. In addition, we have invented the fabrication method of a tiny single crystal nanopillar of Si using the AFM in UHV: we bring a Si AFM tip as a seed onto a heated Si wafer to be in touch under a well-controlled contact force, and slowly pull it from the contact with forming a bridging neck, resulting in nanoscale Si single-crystal growth with a pillar shape at the apex of the Si AFM tip. The nanopillar has exhibited excellent potentials as an SPM tip. Furthermore, we are now developing an SPM combined with an ultrahigh-resolution scanning electron microscope (SEM), which enable us to observe the tip-sample phenomena, including atom/molecule manipulation, from a side view, to control and to measure the bridging nano-structures between the tip and the sample. We open an new era using the developed instruments having our inventive ideas based on basic science.