# UHV-TEM combined with STM for Nanoscale Material Analysis

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UHV electron microscopy has been used for surface structure studies in the last decade. After the development of atom-resolving STM in 1982, several attempts have been done to built a miniaturized STM in the conventional electron microscope. We developed STM combined UHV electron microscopes; the one allows us to give reflection image and STM image of the Si(111)7x7 surface, and the other, transmission image and STM of the gold surface.

The STM combined UHV electron microscope, then, is applied for the study of electronic conductance of the quantum point contact(QPC). Gold QPC was made by dipping/retracting a gold STM tip into/out a gold sample, the process being observed in TEM images while the current passing through the QPC was measured simultaneously. The gold nanowire formed at the QPC was seen to change the diameter in steps of the atomic sheet, where the current changed in steps. The current steps proved that the conductance of the gold nanowire changes in steps in the unit of $2e2/h$, where $e$ is the electron charge and $h$, Planck constant.

The structure of such thin gold nanowires were studied more in detail by synthesizing long and thin nanowires with electron beam thinning method. The long gold nanowires were found to have specific structures different from the face centered cubic structure. They had helical multi-shell(HMS) structure like carbon nanotubes. Instead honeycomb network of the carbon nanotues, the gold nanotubes had a triangular network. The gold tubes such as (4,2), (5,2), (6,3), (7,3), (11,5), (13,6) ,(14,7), (15,7) make co-axial tubes to make up the HMS.

The STM combined UHV electron microscopy presents a new research technique on nano-materials sciences and technology. The UHV condition is inevitably needed for nano-materials research, since a little carbon contamination could change the physical and/or chemical nature of the nano-scale samples. Without UHV condition, no chemical analysis of any nano-materials could become possible for the next generation FE-TEM, which is UHV-FE-TEM with an angstrom-probe generated by Cs corrector.