Instrumental Development in Scanning Tunneling Microscopy

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Scanning tunneling microscopy (STM) has been used to map topography of a surface with an atomic resolution. As we all know, it can also measure an electronic or a vibronic structure at a point of interest or map a surface by measuring the dI/dV or d^2I/dV^2signal from the tunneling current at a fixed tip-sample gap. These measurements have been possible as the signal to noise ratio were improved. Improvement of the spatial resolution was also demonstrated by tailoring a probe tip; for example one may attach a CO molecule or a carbon nanotube or magnetic atom(s) to utilize protruded molecular orbital or the spin state. The energy resolution in a spectroscopy measurement can be improved by lowering the operation temperature down to a few milli-Kelvin. However, that was limited by the high electron temperature. Dynamic properties of a surface can be measured by a pump-probe method to monitor dynamics of spin states and charge carriers. However, the time resolution of an STM is intrinsically slower than 10^{-3} sec due to unwanted low-pass filter of an input stray capacitance (1-10 pF) and high feedback gain (10^8 – 10^9) of a preamplifier. A boxcar averaging with electrical or laser pulsing technique was used to overcome the limit. One may have to widen the bandwidth of a preamplifier to measure faster dynamics. Recently, a method for measuring fast dynamical properties was developed by measuring the difference in the signal that a slow preamplifier with a millisecond order bandwidth integrates as varying the time interval between the pump and the probe pulses. In addition to topographic, electronic, vibronic and spin structures measured with STM and STS, photon or magnetic field is applied to the STM junction to probe response to the fields. In this talk, I will review recent progress in STM instrumentation.