Abstract

Scanning tunneling microscopes(STM) are instruments capable of extremely high spatial resolution down to sub-angstrom length scales. Their capabilities range from imaging lattice structures, to observing standing wave patterns of surface state electrons in metals, and spatial manipulation of individual atoms. Plainly speaking, they let us 'see' atoms, move them around, and more . Additional capabilities such as spin polarized tunneling microscopy have also been developed for STMs. A prerequisite for high resolution imaging, is an atomically sharp probing tip, preferably with a pz or dz 2 orbital at the apex. However, from the position-momentum uncertainty($\Delta x.\Delta kx \geq 2\pi \bar{h}$), it can be inferred that such a small value for Δx will result in a large error in momentum information(Δk) . Point Contact Spectroscopy is a technique to measure the Fermi surface properties in solids by fabricating nano-metre sized 'ballistic' contacts between conductors, and measuring the current-voltage characteristics. In keeping with the position-momentum uncertainty, the large size of the contacts makes it a very powerful spectroscopic tool that is used to extract momentum and energy resolved spectroscopic information. The IV spectra is used to reveal information regarding the excitation energies of phonons, magnons, quasi-particles in superconductors etc. This technique when applied to nano-constrictions formed between metals and superconductors, can be used to extract the magnitude and momentum space symmetry of the superconducting energy gap by fitting with theoretical formalisms, and this is known as Point Contact Andreev Reflection(PCAR) Spectroscopy. During the course of this thesis, I have developed two major instruments for investigating the physical properties of solids down nano-metre length scales at low-temperatures and high magnetic fields. 1) A scanning tunneling microscope was developed and calibrated. It was also used to image atomic steps in Highly Oriented Pyrolytic Graphite(HOPG), as well as obtain I-V spectra. 2) A low temperature probe for carrying out point contact spectroscopy was also de- veloped in-house, and used with a liquid helium cryostat. Experiments were carried out to study the temperature and magnetic field dependence of $FeTe_{0.6}Se_{0.4}$-Silver point contacts. Andreev reflection spectroscopy was also carried out in Niobium-Gold point contacts.