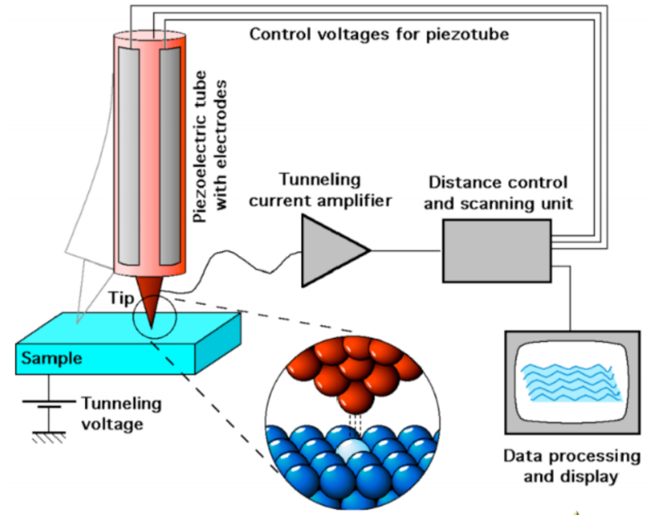
Physics Lab
ETH zürich

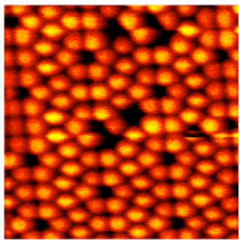
D PHYS

Scanning Tunneling Microscope

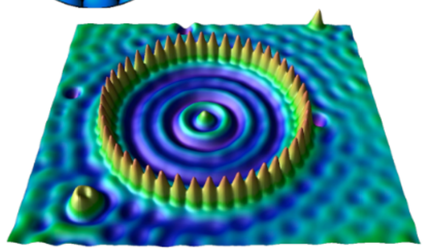
Abstract

The scanning tunneling microscope (STM) is the ancestor of all scanning probe microscopes. It was invented in 1981 by Gerd Binnig and Heinrich Rohrer at IBM Zurich. Five years later they were awarded the Nobel prize in physics for its invention. The STM uses a sharpened, conducting tip. A bias voltage is applied between the tip and the sample. When the tip is brought to a very close distance to the sample (1 nm or less), electrons tunnel through the gap between the tip and the sample. The resulting tunneling current varies with tip-to-sample separation, and it is the signal used to create an STM image. For tunneling to take place, both the sample and the tip must be conductors.
The setup in use consists of the commercially available STM EasyScan 2 with the corresponding electronic control box. The STM is connected to a PC equipped with the control and imaging software. We use PtIr tips fabricated by the students during the experiment. It is possible to measure the surface of graphite and gold (111). For the case of graphite it is possible to achieve atomic resolution.



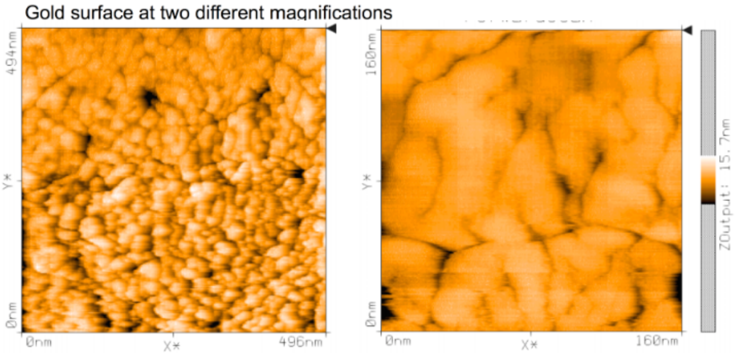


Si 7x7 surface imaged with a commercial STM

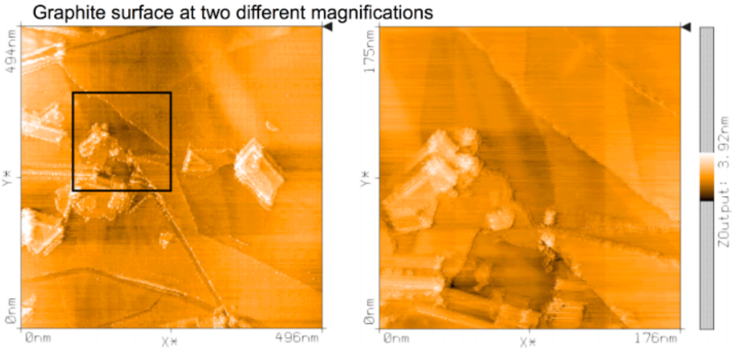


A quantum corral fabricated and measured with an STM at IBM Zurich

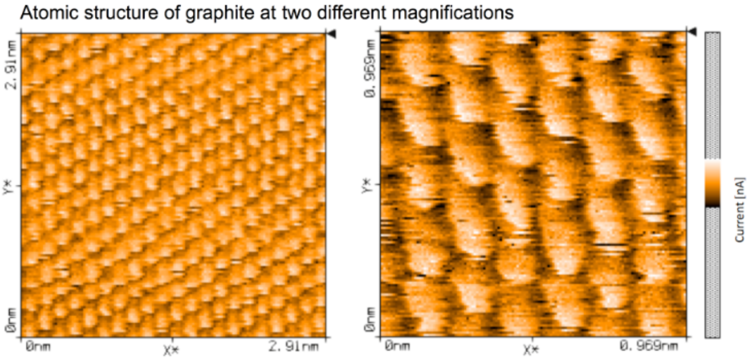
Gold surface at two different magnifications



Graphite surface at two different magnifications



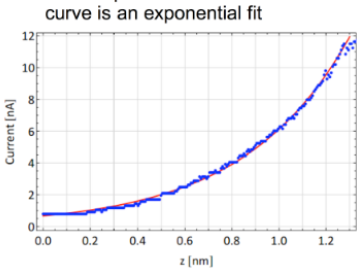
Atomic structure of graphite at two different magnifications



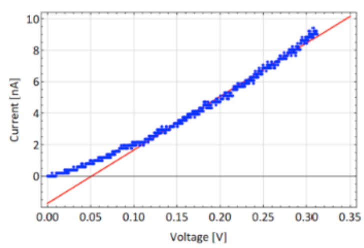
Results

The students learn how to produce an STM tip and start a standard measurement. With the setup in use it is possible to scan from a range of 500 x 500 nm down to 2 x 2 nm, where atomic resolution is achieved.
In order to improve the picture quality it is possible to optimize the scanning speed, the current set-point, the bias voltage and the parameters of the PI controller. Once atomic resolution is reached on graphite, the students can use the imaging software to measure the lattice constant of graphite and compare it with the value found in literature.
In spectroscopy mode the STM measures the tunneling current at a fixed surface point varying the separation z or the voltage V. Keeping the same bias voltage and changing the tip-surface distance results in an exponential dependence of the current. Keeping the same distance and changing the bias voltage results in a linear dependence of the current.

Tunneling current in function of the tip height. The distance decreases in the positive direction. The red curve is an exponential fit



Tunneling current in function of the tip voltage. The red curve is a linear fit



Poster made by: R. Pisoni 12.03.2019