UE5010300

SCANNING TUNNELLING MICROSCOPES

EXPERIMENT PROCEDURE

- **Display individual atoms on the surface of a graphite sample, analyse the lattice structure and how the atomic bonds are related.**
- **Display the surface of a gold sample and measure steps in the atomic structure.**

OBJECTIVE

Viewing the atomic structure on the surface of graphite and gold

SUMMARY

A scanning tunnelling microscope is used for microscopic investigation of electrically conducting materials with resolution down to atomic level. The scanning probe is a sharp needle which scans the surface of the sample from a distance of only a few atomic diameters. The tunnelling current between the probe and the sample is measured and kept constant by varying the distance of the probe from the sample. The altered variables are mapped to an image of the sample's surface which shows the electrical conductivity superimposed on the topography of the sample.

REQUIRED APPARATUS

Quantity	Product	Number
1	Scanning Tunnelling Microscope	**1012782**

Additionally recommended:

1	$TaSe_2$-Sample	**1012875**

GENERAL PRINCIPLES

A scanning tunnel microscope is equipped with a very sharp probe, which is moved close enough to the surface of a conducting material, so that application of a bias potential between the probe and the sample results in a current due to quantum tunnelling. Minimal changes in the distance between the probe and the sample of as little as 0.01 nm lead to measurable changes in the tunnelling current, since the probability of tunnelling is related exponentially to the separating distance. This allows the atomic structure of surfaces to be scanned by moving the probe of the surface row by row and modifying the distance in such a way that the tunnelling current remains constant. The movements made are plotted in real time during the scan to create an image which can be viewed on a computer. The image shows the electrical conductivity of the of the sample surface superimposed on its topography.

In this experiment, the first task is to make a probe out of platinum-iridium alloy. The aim, if possible, is to create a tip so sharp that it is only one atom across. In order to prepare the graphite surface, it is cleaned by pulling off an adhesive strip. For other samples, it is sufficient to check that they are free of grease.

Obtaining a good image with resolution down to atomic level requires a sharp tip, a smooth sample surface and care in carrying out the experiment. Each time one of the measurement parameters changes, the probe should always be scanned over the sample multiple times before the final image is obtained. Only after that is it sensible to change any measurement parameter anew.

EVALUATION

In the image of graphite's hexagonal structure there are alternating carbon atoms which are shown as light or dark: The lighter ones are atoms with no immediate neighbours and the others have an immediate neighbour in the layer of atoms beneath. The former atoms appear lighter because they have a greater electron density. In order to measure distances and angles between atoms identified in this way, you can use the software's measurement tools.

When investigating the surface of gold, it is possible to identify steps in the atomic structure comprised of single atoms, the height of which can be measured.

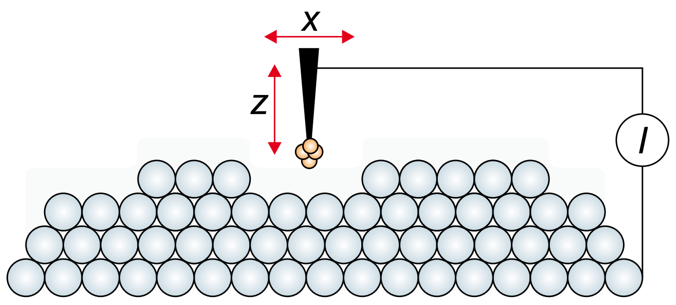

Fig. 1: Schematic diagram of tunnelling current.

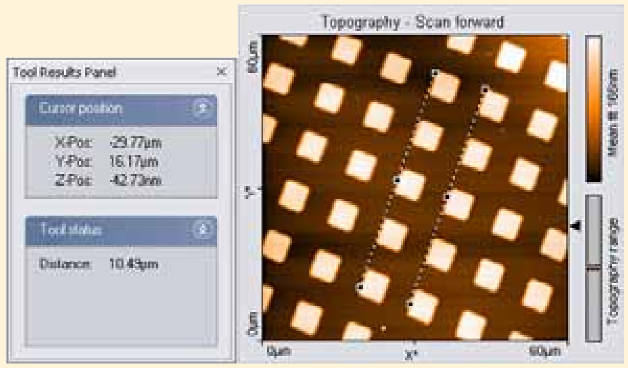

Fig. 2: Determining separation of atoms.

Display of a gold surface.

Display of the surface of TaS_2 with standing waves in the charge density.

Display of the hexagonal structure of a graphite surface.