COMPUTER-CONTROLLED SCANNING TUNNELING MICROSCOPE

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Scanning tunneling microscope (STM) developed in recent years is a new instrument for the observation of surface structure of various materials. It is based on the tunneling between an atomically sharp tip and the sample narrowly separated by a few angstroms (usually less than 10 Å). The topographic images of the sample surface can be obtained by detecting and monitoring the changes in the tunneling current with the distance between the tip and the sample surface.

Fig. 1 shows a computer-controlled STM developed at the Institute of Chemistry, Academia Sinica, Beijing in April, 1988. The experimental results have proved that a resolution of 0.1 Å in the vertical dimension and that of 1 Å in the horizontal dimension have been achieved for this instrument. Compared with others in the laboratories abroad, the performance comes up to the top level.

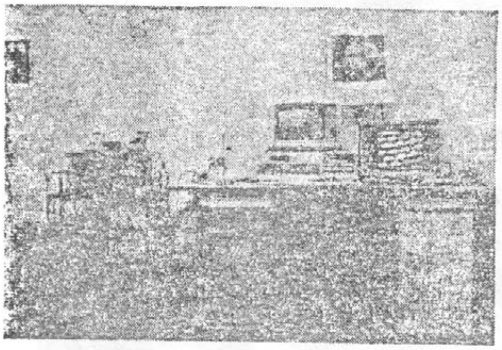
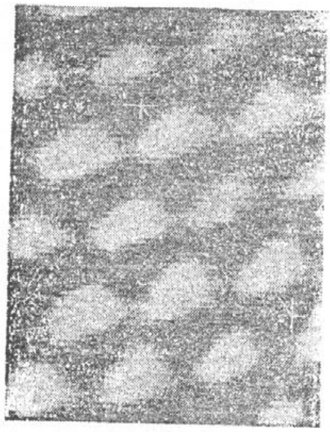


Fig. 1. Computer-controlled STM.

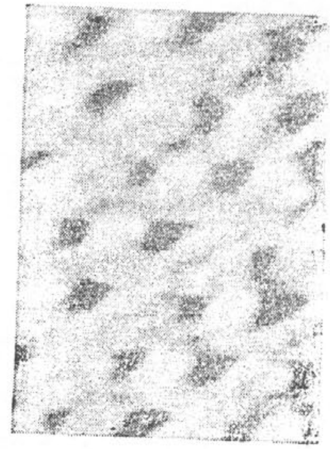
Our implementation of a computer-controlled STM consists of a computer, a high resolution display monitor, electronics control unit and the core STM. The high resolution D/A and A/D converter cards are used for IBM PC/AT computer to drive the microscope tip scanning over the sample in three dimensions and to record the topographic information. A high resolution graphics controller card is used for real-time display of the STM images on the high resolution terminal either as a grey scale image or as a line-scan. Some image analysis and display tools are included for a posterior image processing such as planar background subtraction, smoothing, cross sectional cut, data statistics, Fourier transformation, calculations of X, Y, Z coordinates at any point and the distance between two cursors anywhere.

Our laboratory has investigated graphite, molybdenum disulfide and organic conductor $(BEDT\text{-}TTF)_2Ag(SCN)_2$ by using this STM. The obtained images clearly reveal the atom arrangement on the surface (Fig. 2). The STM image of $(BEDT\text{-}TTF)_2Ag(SCN)_2$ shows the individual donor and acceptor molecule arrangement on the single crystal surface. Recently, we have obtained some new images of phosphatidylcholine membranes, Bi-Sr-Ca-Cu-O superconductors and conducting polymers.

STM emerges as a powerful tool not only for the visualization of localized surface structures on an atomic scale but also for studying the electronic structure of the surfaces such as energy gaps, charge-density waves in combination with scanning tunneling spectroscopy. In addition, STM can be performed in vacuum, under ambient conditions, at low temperature, and even in isolating liquids as well as in electrolytes. New horizon has been widened through STM for applications to biological



(a)



(b)

Fig. 2. STM grey scale images of graphite (a) and $(BEDT\text{-}TTF)_2Ag(SCN)_2$ (b).

materials, superconductors, L-B films and for electrochemical reactions on electrode surfaces. The modified STM is capable of doing lithography on substrate of submicrometer scale. Recently, scientists have produced the resistive patterns with linewidths of about 100 Å on the workpiece.

With the invention of STM, a new window is opened to a fascinating view on the atomistic world of real surface. It has been proved by scientists in foreign countries that this technique is revolutionizing surface science and the way of studying surface phenomena. We believe that this technology has immense implications and extensive applications for surface science, material science, life science and microelectronics.

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