12

Scanning Tunnelling Microscopy

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12.1. Introduction

Since its introduction by Binnig et al.,\(^1\) the Scanning Tunnelling Microscope (STM) has engendered much excitement among surface scientists, not only for the atomically resolved surface topography it can achieve, but also for the range of surface spectroscopy possible. In this chapter we discuss scanning tunnelling microscopy in the context of the study of thin films (for example, an organic adsorbate on a metal substrate), highlighting the strengths and weaknesses of the technique. Greater detail may be found in the literature; in particular, the review by Hansma and Tersoff\(^2\) provides a wide survey of the field. For more general reviews of tunnelling and tunnelling spectroscopy the reader is directed to the books by Wolf\(^3\) and Hansma.\(^4\)

12.2. Outline of Scanning Tunnelling Microscopy

The phenomenon of tunnelling, in which a particle may traverse a region through which, classically, it is forbidden to pass, has been of great interest since the early days of quantum mechanics. Tunnelling of electrons through solid-state barriers was first demonstrated convincingly about 30 years ago in semiconductor junctions by Esaki\(^5\) and in metal-insulator-superconductor junctions by

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Giaever.\(^{(6)}\) Apart from field emission, however, vacuum tunnelling of electrons was generally neglected until the advent of the STM. Some of the ideas of scanning tunnelling microscopy were found in the topographer of Young \textit{et al.},\(^{(7)}\) but the much greater tip-sample distances used in this device (of order 70 Å rather than 10 Å) prevented attainment of atomic resolution.

In principle, the microscope is very simple (see the block diagram in Figure 12.1 and an example of a commercial UHV STM in Figure 12.2). A sharp metal tip (usually tungsten or platinum-iridium) is brought close to the (conducting) surface of interest, say within 10 Å, and a tunnel current established by application of a suitable bias. A feedback loop adjusts the vertical (Z) position of the tip.