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Organising Atoms, Clusters and Proteins on Surfaces

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This talk will discuss new developments in the creation of nanoscale surface features and their applications in biomedicine. Electron-surface interactions and plasma methods play a crucial role in both the production and analysis of these "atomic architectures." At the extreme limit, electron injection from the tip of a scanning tunnelling microscope (STM) enables bond-selective manipulation of individual polyatomic molecules [1]. On a more practical level, the controlled deposition of size-selected clusters [2], generated by magnetron sputtering and gas condensation followed by mass selection, represents a surprisingly efficient route to the fabrication of surface features of size 1-10 nm, the size scale of biological molecules such as proteins. STM and AFM measurements show the clusters can act as binding sites for individual protein molecules. For example, the pinning of size-selected AuN clusters (N = 1–2000) to the (hydrophobic) graphite surface presents bindings site for sulphur atoms and thus for the cysteine residues in protein molecules. Systematic studies of different proteins [3] provide "ground rules" for residue-specific protein immobilisation by clusters and have led to the development of a novel biochip for protein screening by a spin-off company. The 3D atomic structure of the clusters is highly relevant to such applications. We show that measurement of the scattered electron beam intensity - specifically, the high angle annular dark field (HAADF) signal - in the scanning transmission electron microscope (STEM) allows us (a) to count the number of atoms in a cluster on the surface and (b) to determine a 3D atom-density map of the cluster when an aberration-corrected STEM is used [4].

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