Cloning clusters

The unique properties of nanostructures make them potentially useful in technological applications, but in order to fully exploit these properties it is important to be able to control both their size and their structure. Single-sized nanoclusters of aluminium atoms can now be produced, and these clusters spontaneously form a two-dimensional lattice on crystalline silicon.

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Over the past decade, research into nanoscale materials has led to a host of new structures and forms, including nanotubes, nanoscale polymers, and quantum dots with very different properties to bulk materials. But the principles of reliable mass fabrication have not yet reached the nanoscale realm. Unfortunately, nanoscale structures are usually formed with a broad distribution of sizes, shapes, and spatial arrangements. Greater control over their size and structure needs to be achieved for these materials to make the most of their technological potential.

Inhomogeneity arises because of the influence of random thermal fluctuations and other variations in the processes that control nanoscale growth. The most promising approach to solving these problems is to use growth processes that involve self-assembly. Writing in Applied Physics Letters, Jinfeng Jia and colleagues describe just such a technique for forming identical aluminium clusters in an almost perfect two-dimensional lattice on the surface of a crystalline silicon substrate.

The authors have found that as aluminium atoms are deposited from a pure atomic beam onto a clean Si(111) surface, they naturally aggregate to form identical nanoclusters. Moreover, scanning tunnelling microscope images of the silicon surface show that, as more and more atoms deposit, these nanoclusters organize themselves into an almost perfectly ordered two-dimensional array (see figure). First-principles total energy calculations performed by the authors indicate that the size and shape of the nanoclusters result from a particular interaction between the aluminium atoms and the silicon atoms at the surface.

The authors have previously had similar results with other metal atoms such as indium and manganese. But what is striking about this result is that although the growth of aluminium on silicon is commonplace within the microelectronics industry, this is the first time either the formation of Al clusters or their self-ordering has been observed.

Potential applications for the well-ordered metallic cluster lattice systems include ultrahigh-density digital information storage and chemical nanocatalysis.
Artificial nanocluster crystal: Lattice of identical Al clusters
A two-dimensional artificial crystal, which is made up of artificial atoms—identical Al clusters with nanometer size and spacing, was fabricated by taking advantage of surface-mediated clustering on a growth template. In situ scanning tunneling microscopy analysis and first-principles total energy calculations were used to determine the atomic structure of the Al nanoclusters. The Al clusters exhibit more remarkable thermal stability than the In clusters we reported previously. Based on our systematic observations and calculations, the formation mechanism and the high stability of these magic clusters are discussed.
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