Autorganization of nano-graphene clusters deposited by laser graphite ablation

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Carbon atoms can bond in a variety of structures from the tetrahedral typical of diamond to the stacking of graphite planes, to the recently discovered fullerenes and nanotubes.
However even if we concentrate our attention only on the family of graphitic materials, we notice that the rich variety of properties and structures that they show largely arise because these materials are not simple graphite crystals, but rather collections of graphene layers.
These consist of planar units with the basic two-dimensional structure of graphite stacked in different three-dimensional configurations. The graphite lattice is highly anisotropic in its bonding characteristics and consequently in its physical properties.
Electrical conductivity, elastic modulus, strength, thermal conductivity are much higher within the covalently bonded sp^2 planes then across them.
As a result of the graphite lattice anisotropy the arrangement of graphene domains in carbon materials (i.e. the carbon nanostructure) strongly influences the directional dependence of the bulk properties of most *graphitic* carbon materials.
A key to tailor carbon materials properties is therefore associated to the ability to design their nanostructure.
To understand how to tailor carbon materials it is needed to analyse their formation and autorganization process, thus to determine the spatial arrangement of the graphene layers when this is initially set up [1-2].
Nanostructured carbon films with high percentage of sp^2 coordination were deposited in vacuum by pulsed laser deposition on a Si surface at increasing substrate temperature, ranging from room temperature to 900°C.
A detailed characterization by synchrotron X-ray diffraction measurements established the formation of nano-sized graphene structures at 800°C [3].
Clusters of graphenes with $\hat{c}$ axis parallel to the substrate surface were observed.
To analyse the phenomenon of the autorganized-orientational grow of the graphene clusters we consider that the structure and form of the most man made modern materials are developed outside the

thermodynamic equilibrium. Gradients and fluxes, imposed by the external ambient, condition their growth. Thus the structure acquired during the growth does not usually result from the minimization of the free energy of the system but by the dynamics of the growth.
When the forces and/or fluxes determining the growth stop, the form and structure generally relax slowly toward equilibrium forms. However this is generally very slow and the form created by the growth conditions remains practically stable.
We analyse the evolution of an oversimplified geometrical two-dimensional model system made by rectangular objects constrained in order to grow to occupy only the free surface remaining in the system at each time [4].
We observe that the growing objects are constrained to autorganised in order to occupy in the most efficient way the space available.

Keyword: nano-graphene clusters, autorganization, modelling.

Reference

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