NESTED FULLERENES ON GRAPHITE

Submitted to: NATURE
Scientific Correspondence

Author: Mark S. Anderson
Jet Propulsion Laboratory
California Institute of Technology
Space Material Sciences and Engineering Section
4800 Oak Grove Drive
Pasadena CA, 91109
MS 125-112

NESTED FULLERENES ON GRAPHITE

Sir -- Ugarte has described a novel method of forming nested fullerenes by irradiation of carbon soot using the high energy beam in a 300-kV electron microscope.[1] I have observed similar structures on freshly cleaved Highly Oriented Pyrolytic Graphite (HOPG) with a scanning tunneling microscope (STM). The spherical surface features occur at the edge of the graphite layers and resemble the nested fullerenes seen by Ugarte. Figure 1. shows a STM image of a HOPG surface with stepped layer edges. The image shows possible nested fullerenes closely aligned along the graphite steps. The structures have a diameter of approximately 3.1 nanometers.

HOPG is a commonly examined surface by STM because it can be atomically flat over relatively large areas[2]. This image was acquired in order to catalog various surface defects on the otherwise flat HOPG surface. The goal of the experiment was to characterize freshly cleaved surface prior to depositing proteins on HOPG for infrared analysis and STM imaging[3].

The edge of a graphite sheet would be a ideal location for forming fullerene structures. The tendency of the graphite edges to reach the lowest energy available would cause a strain relieving mechanism to eliminate dangling bonds and curl at the edges[4]. The structures may have been formed at internal defects during the high temperature synthesis of the HOPG and exposed by cleaving the crystal.

HOPG is a potentially valuable material for studying the fullerene forming processes. It approximates single-crystal graphite in which the hexagonal sheets are packed at near theoretical density. Cleaving HOPG produces freshly formed stepped layers. HOPG has a relatively uniform, flat surface which may give more experimental control in the electron beam formation of nested fullerenes. Alternatively, one could imagine a miniature Kratschmer process using a helium back filled vacuum STM. Pulsing with high tip voltage could form fullerenes and tubes on HOPG in a organized pattern. The ability of the STM to interactively alter and image the graphite surface may give insight to the fullerene forming process.

References:

1. Ungarte. D. Nature 359, 707-709 (1992).

2. Moore A.W., in Chemistry and Physics of Carbon, P.L. Walker, Jr., and P.A. Thrower, Eds. (Decker, New York, 1973), Vol. 11, pp 69-187: ibid. (1981), vol. 17, pp 234-286.

3. Anderson, M.S. Infrared Phys. Vol. 31, No 5, pp (1991).

4. Robertson. D. H., Brenner. D. W. & White, C. T., J. Phys. Chem. 96, 6133-6135 (1992).

Acknowledgement:

The work described here was carried out at the Jet Propulsion Laboratory, California Institute of Technology, through an agreement with the National Aeronautics and Space Administration.

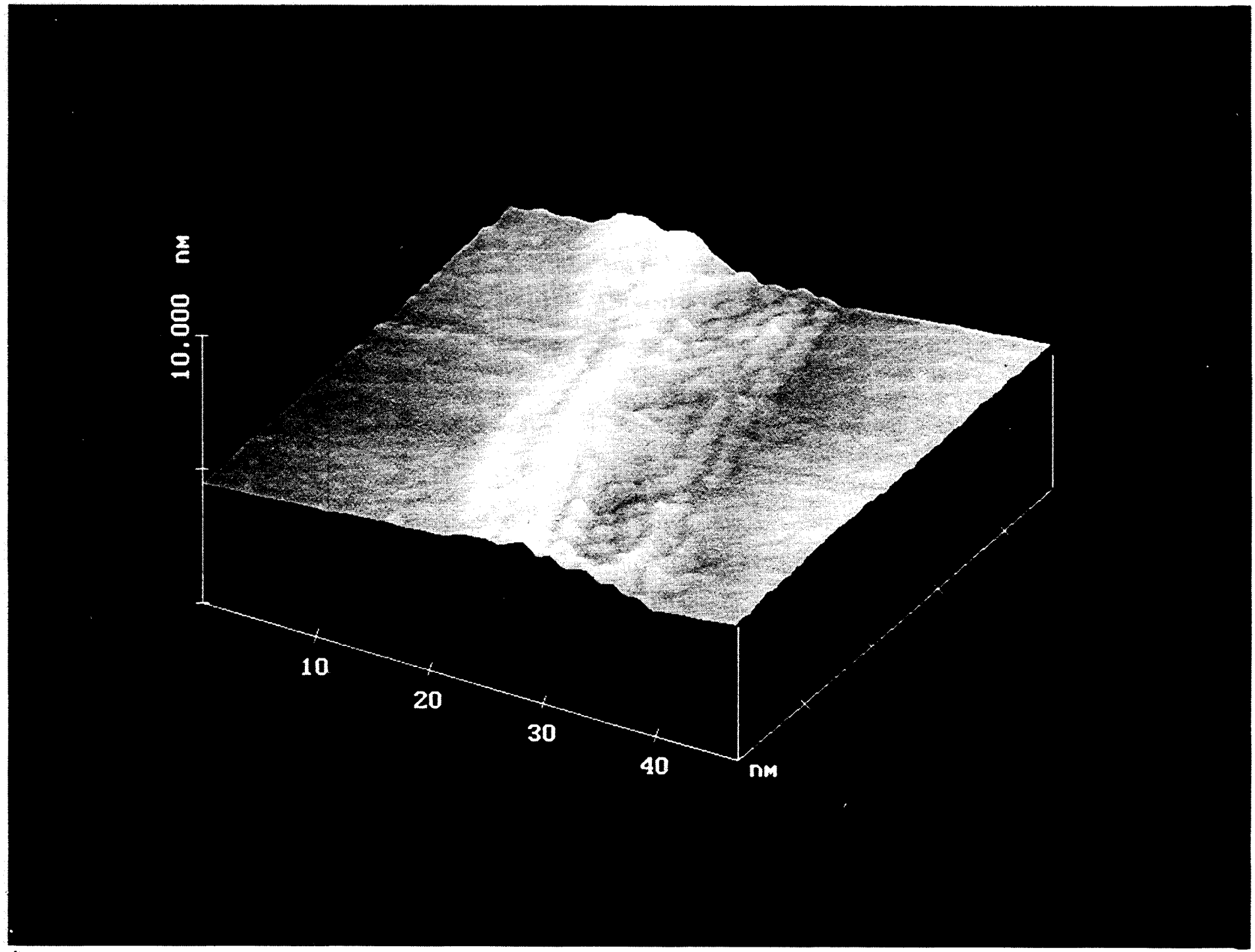
10.000 nm
10
20
30
40
nm

FIG. 1 Possible nested fullerenes on the layer edge of Highly Oriented Pyrolytic Graphite. The STM image was obtained with a bias voltage of 80 mV and a set current of 4 nA .