Poster

ELECTRICAL FIELD-INDUCED NANOLITHOGRAPHY OF THIN TA-C FILMS UNDER AMBIENT CONDITIONS

V.D. Frolov [1], *E.V. Zavedeev* [1], *V.A. Gerasimenko* [1], *S.M. Pimenov* [1], *H.-J. Scheibe* [2]

[1] *A.M. Prokhorov General Physics Institute, Vavilov str 38, Moscow 119991, Russia*
[2] *Fraunhofer Institute for Material and Beam Technology, Dresden, Germany*
Contact e-mail: frolov@ran.gpi.ru

We report on nanostructuring of tetragonal-bonded amorphous carbon (ta-C) films using a Scanning Probe Microscope (SPM)-based nanolithography technique. The original ta-C films were deposited on Si substrates by special pulsed vacuum arc techniques (Laser-Arco® process) as described elsewhere [1]. These amorphous, hydrogen-free carbon films, called as Diamor® films, are characterized by a high content of tetrahedral sp^3 bonds and high hardness that, along with their high smoothness and low adhesion activity to other materials, result in superior behavior concerning wear resistance and friction.

The Diamor® films of 85 nm thickness were further examined for the purpose of nanoscale modifications under the action of local electric field. The experiments were carried out in an air-operated SPM setup Solver P47 (NT-MDT Co., Russia) using conducting cantilevers coated with DLC layers as the probes for SPM actions in contact mode, and also for testing the samples in tapping mode before and after the actions. To induce the electric field underneath the probe, rectangular voltage pulses with the magnitude up to U=10 V and duration T= 10 ms – 5 s were applied between the sample and the grounded probe at given points of the scanned area. In the course of experiments, the ambient relative humidity (RH) was controllably changed in the range from 5% to 50%.

The obtained results can be summarized as follows. It is established that, above a threshold of U~5 V, the point actions lead to the formation of hill-like nanoprotrusions on the film surface. The nanoprotrusion is found to permanently grow in height with increasing voltage but tends to saturation in diameter (the diameter is 50-150 nm depending on the pulse duration). Experimental data on the nanoprotrusion height H fit in the formula $H=H_0\cdot\log(T/T_0)$,where H_0 is a function of U, T_0 is the characteristic exposure (at $T=T_0$ H=0). It is particularly remarkable that T_0 is reversely proportional to RH; i.e. $H\rightarrow 0$ when $RH\rightarrow 0$. It means that the presence of absorbed water vapors on the ta-C film surface is the necessary condition of the nanolithography processing. The formed nanoprotrusions show a lower electrical conductivity as compared to the conductivity of the as-grown ta-C film.
The developed SPM-based process is highly reproducible that allowed us to draw images with the surface density of ~ 5×10^{10} elements/cm^2 (Fig. 1). Possible mechanisms of SPM-based nanostructuring of the ta-C films will be discussed.

References

[1] H. Schulz, H.-J. Scheibe, P. Siemroth, B. Schultrich, Appl. Phys. A, **78** (2004) 675–679.

Figures:

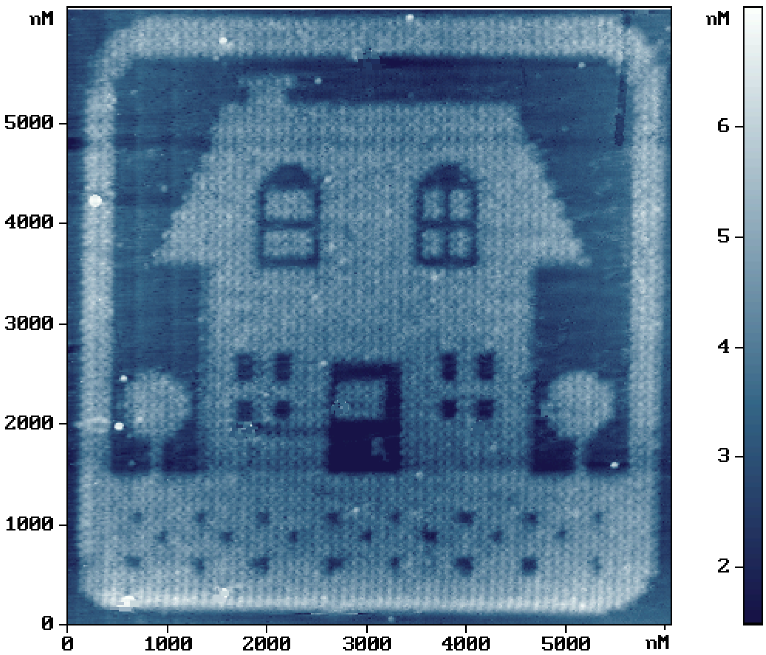

Fig. 1. The SPM nanolithography image (128×128 pixels) on the ta-C film surface.