Scanning probe microscopy for in-situ analysis of carbon films growth by chemical vapor deposition.

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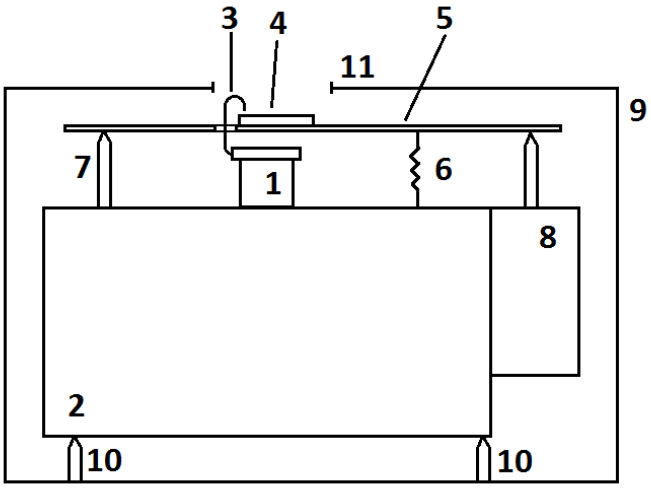
The new in-situ scanning probe microscopy method of carbon materials deposition study during DC or "hot fiber" activation of the gas phase is described. This method should get the films of carbon materials assembling processes is showed with up to atomic resolution. Also it is possible to take electrical properties variation (conductivity, width of band gap, Fermi level) of carbon materials during deposition.

The development of various sectors of nanotechnology poses multiple problems to find, create and explore new nano-objects. To solve these problems more effectively, it is necessary to study the synthesis of nano-objects. The in-situ study of the nano-objects self-organization is especially relevant because in this study new rules of self-assembly process can be traced and identified to be applied to form new nano-structures with predetermined properties in future. Particularly this method can be applied for our research area of pyramidal shaped single crystal diamonds formation in chemical vapor deposition (CVD) [1].

The basis for this work is the experience of the successful creation of a scanning tunnel microscope (STM, one of the scanning probe microscopy mode) for in-situ study of graphite wall re-deposition process in a fusion reactor Tokamak T-10 [2]. The head of this STM (showed on figure) was entered into fusion facility into nuclear plasm at extreme temperature and electromagnetic fields. The head of STM was burned in 10 minutes, but it managed to make up to 100 successive frames describing the changing in the Tokamak's graphite walls nanostructures. We decided to create the in-situ STM method for our CVD processes.

Piezo XYZ-scanner (1) is placed on the stainless steel body (2) with big heat capacity to avoid overheating and to make working time longer. Sample (4) lies on the plate (5) which protect scanner (1) from heat at the same time. Curved platinum STM-tip (3) comes from a top of the scanner, goes throw the hole in the plate (5) and comes close to the sample (4). To make coming heat lower the plate (5) is placed on two pointed columns (7). Sample approaches to the tip by linear motor (8) with pointed contact with the plate (5). The spring (6) presses plate (5) against the body to get rid of motor backlash. All the construction is placed on three pointed columns (10) inside the stainless steel heat shield (11).



Sizes of XYZ-scanner's piezo-tube were specially designed. Resonance frequency should be 14kHz at its length of 18mm, external diameter of 9mm and wall thickness of 0.5mm. It will protect from vibrations and should allow getting atomic resolution. Maximum field of view of this scanner at X/Y/Z is 2/2/0.5 microns. All of this should give possibility of observing the interesting initial stage of nucleation and evolution of carbon nano-objects from single atoms to 0.1-0.5 microns size.

[1] P.G. Kopylov, A.N. Obraztsov, M.A. Dolganov, and S.S. Abramchuk. Formation of pyramidal shaped single crystal diamonds in chemical vapor deposition. Protection of Metals and Physical Chemistry of Surfaces, 2009, V. 43, 5, pp. 553 – 557.

[2] L.N.Khimchenko, V.P.Budaev, M.I.Guseva, B.N.Kolbasov, A.M.Lebedev, B.A.Loginov, O.N.Makeev, K.A.Menshikov, V.G.Stankevich, N.J.Svechnikov, A.L.Suvorov. Investigation of TOKAMAK T-10 glogular films microstructure. 31st EPS Conference on Plasma Physics, 28 June - 2 July 2004, Imperial College, London.