Self-assembly and Polymerization of Diacetylene on Hexagonal Boron Nitride Substrates for Electrical Studies of Single Polydiacetylene Chains

Marina Makarova, Yuji Okawa, Takashi Taniguchi, Masakazu Aono

International Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for Materials Science (NIMS), 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan
MAKAROVA.Marina@nims.go.jp

Abstract

A novel method for connecting single conductive polydiacetylene chains to single organic molecules was recently developed in order to connect molecules each other and fabricate a practical single-molecule integrated circuit. The method was named “chemical soldering” [1]. This method uses the nanoscale control of chain polymerization of diacetylene compounds (general formula R–C≡C–C≡C–R′) in a self-assembled monolayer (SAM) on a substrate. The next step of our study is to measure the electric properties of such systems, and demonstrate the functions as a component of future single molecular circuits. Since graphite and MoS_2 substrates demonstrate rather high conductivity and leakage currents, we propose insulating hexagonal boron nitride (h-BN) as a substrate. Diacetylene self-assembly and polymerization were studied by atomic force microscopy (AFM).

We show that diacetylene monomers are able to form a flat-lying SAM on a (0001) surface of h-BN, which are similar to the ones on graphite or MoS_2 and undergo polymerization by UV irradiation or thermal heating. The polymerization rate is much faster than that on graphite or MoS_2. We also succeeded in fabricating gold electrodes on h-BN substrates by electron beam lithography. It was found that electrode deposition did not irreversibly contaminate the surface nor affect the self-assembly process of diacetylene. The formation of diacetylene SAM between the electrodes was clearly observed in the phase shift AFM image (Figure 1). Though we should further optimize the conditions for fabricating single polymers, h-BN is a promising insulating substrate for molecular electronics based on conductive polymers.

References

[1] Y. Okawa, M. Akai-Kasaya, Y. Kuwahara, S. K. Mandal and M.Aono, Nanoscale **4** (2012) 3013.

Figures

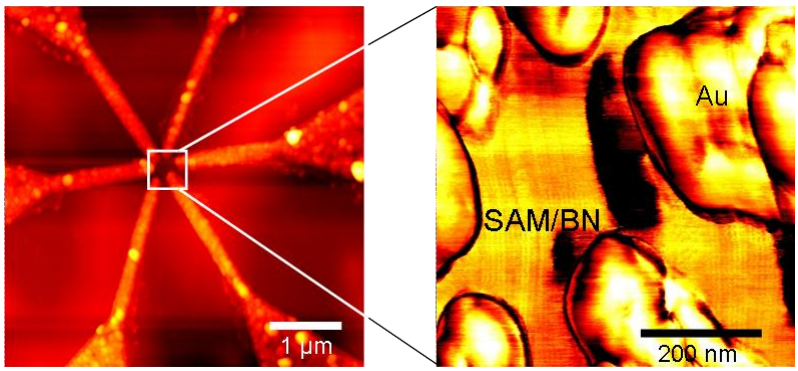

Figure 1
AFM topography (left) and phase shift (right) contrast images of gold electrodes on h-BN(0001). On the right image, diacetylene SAM is clearly seen as the stripes between the electrodes.