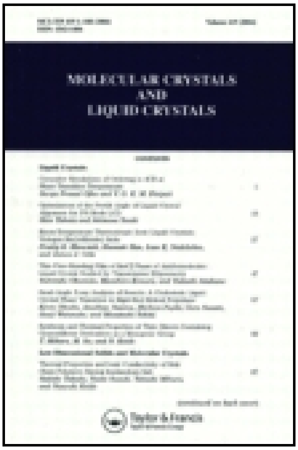

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

The Fabrication of Gold Nanoparticle Assemblies on the Functionalized Surface Patterned by AFM Lithography

Young Mee Jung [a] , Sang Jung Ahn [a] , Hyun Jin Chae [a] , Haeseong Lee [a] , Eung Ryul Kim [a] & Haiwon Lee [a]

[a] Department of Chemistry, Hanyang University, Seoul, 133-791, Korea

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2001, Vol. 370, pp. 231-234

The Fabrication of Gold Nanoparticle Assemblies on the Functionalized Surface Patterned by AFM Lithography

YOUNG MEE JUNG, SANG JUNG AHN, HYUN JIN CHAE, HAESEONG LEE, EUNG RYUL KIM and HAIWON LEE*

Department of Chemistry, Hanyang University, Seoul 133-791, Korea

Selective deposition of gold particles on a patterned substrate was studied for fabrication of a single electrons transistor. In the present study, a selective positioning technique was achieved using atomic force microscope (AFM). Various self-assembled monolayers (SAMs) on silicon surface such as hexamethyldisilazane (HMDS) and octadecyl dimethylmethoxy silane (ODMS) SAMs were prepared as a system for AFM lithography. A uniform pattern was engraved on the SAMs. The selective deposition of gold was efficiently accomplished. This gold particle assembly was characterized by AFM.

Keywords self-assembled monolayers (SAMs); atomic force microscope (AFM); nanolithography; gold nanoparticle

INTRODUCTION

Atomic force microscope (AFM) has recently received keen interest owing to both microscopic and lithographic capabilities [1,2]. Since thin and uniform resist films are required for a well-ordered pattern in AFM lithography, a self-assembly method is a good candidate for this study [1]. We have been undertaking the studies of patterning nanometer-scale self-assembled monolayer (SAMs) with AFM lithography [3,4]. The recent achievements in AFM lithography enable us to engrave a nano-scale pattern on well-ordered monolayers adsorbed on a substrate. Furthermore, more advanced studies using these nano-patterned systems have been accomplishing to fabricate molecular devices. This study consists of the two parts as follows: (i) obtaining a highly well-ordered pattern of SAMs on a conducting substrate, a primary electrode, with AFM anodization and (ii) attaching selectively a gold nanoparticle, a secondary electrode, on the SAMs. This proposed system was designed for a single electron transistor (SET). The detail discussion on the measurement results will be discussed

EXPERIMENTAL

Various SAMs using hexamethyldisilazane (HMDS) and octadecyl dimethylmethoxy silane (ODMS) as a system for AFM lithography were prepared on acid-cleaned p-type Si (100) wafers. The molecules were chemisorbed onto the Si substrate to form a monolayer. More detailed procedures to prepare the SAMs were described previously [3,4]. Thickness of films was measured by a Rudolph auto-EL II Ellipsometer using a halogen lamp (632.8 nm), at an angle of incidence $\phi = 70°$. UV-Vis spectra were obtained by using a diode-array spectrophotometer (HP8452A, Hewlett Packard). An AFM (Autoprobe CP. Park Scientific Instruments, Co.) with a home-made bias controller was used in all AFM experiments. AFM data were acquired under the ambient condition. Gold colloid was prepared by the method proposed by Frens [5]. The reduction of gold chloride acid (10^{-2} wt %) with sodium citrate (1 wt %) in an aqueous solution yields a series of monodisperse gold suspensions with widely different particle size depending upon the relative amounts of gold chloride, and it had red-violet color depending upon the particle size. The maximum absorption was observed near 530 nm.

RESULTS AND DISCUSSION

A high-resolution pattern of SAMs on a silicon substrate was obtained by using AFM anodization, when a negative DC voltage was applied to a tip of AFM. The patterned self-assembled silicon surfaces were modified with immobilized organosilane polymers, such as 3-aminopropylmethyldiethoxysilane (APS) or 3-metcaptopropyl trimethoxysilane (MPTMS), to organize gold particles. Self-assembling gold surfaces can be prepared by covalent attachment of colloidal gold to functional groups on surface-confined organosilanes. To characterize the fabricated APS layer on the silicone surface patterned by AFM lithography, AFM and lateral force microscopy (LFM) were measured. Figure 1 compares the AFM images of the fabricated APS layer on the silicone surface patterned by AFM lithography with the silicone surface itself patterned by AFM lithography. As shown in AFM images, the height of protrude line by AFM lithography on HMDS layer is 12 Å while that on APS layer is 15.4 Å. It suggests that APS selectively deposited on the silicone surface patterned by AFM lithography.

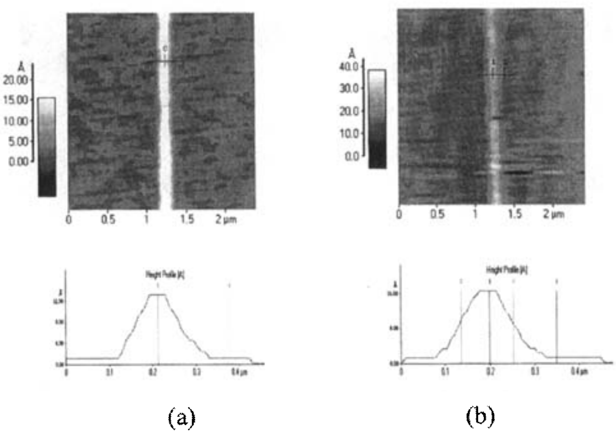

FIGURE 1. AFM images of the fabricated APS layer on the silicone surface patterned by AFM lithography on HMDS layer (a) and the silicone surface itself patterned by AFM lithography on HMDS layer (b).

Figure 2(a) and 2(b) shows the LFM images of APS/Si and silcone itself patterned by AFM lithography on HMDS layer, respectively. In the comparison of Figure 2(a) and 2(B), the height differences were 0.757 V and 0.45 V, respectively. It is confirmed again that APS selectively deposited on the HMDS/Si surface patterned by AFM lithography.

CONCLUSIONS

A selective positioning technique of gold nanoparticles on a patterned silicone wafer has been developed. Using this technique, gold nanoparticles were selectively deposited on the APS/patterned HMDS/Si. This multilayered system will contribute to the fabrication of an SET.

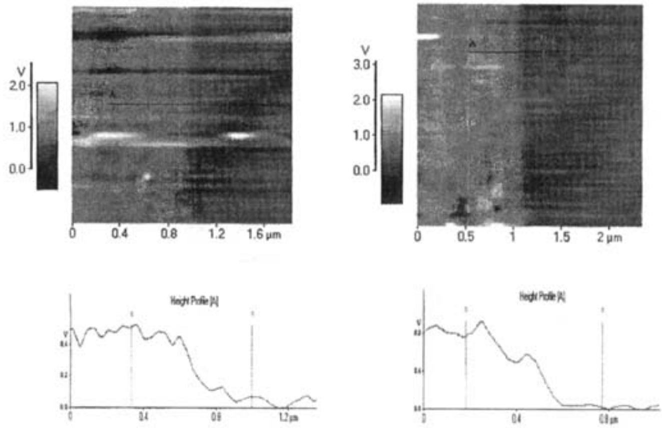

FIGURE 2. LFM images of the fabricated APS layer on the silicone surface patterned by AFM lithography on HMDS layer (a) and the silicone surface itself patterned by AFM lithography on HMDS layer (b).

ACKNOWLEDGMENT

This study was supported by the Brain Korea 21 Project.

REFERENCES

[1] H. Sugimura and N. Nakagiri, J. Vac. Sci. Technol. A. **14(3)**, 1223, (1996).

[2] E. Dubois and J.-L. Bubbendorff, Solid-State Electronics **43**, 1085, (1999).

[3] J. C. Kim, Y. Oh, Y. W. Shin, S. W. Park, and H. Lee, Japan J. Appl. Phys. **37**, 324, (1998).

[4] Y. Oh, J. C. Kim, and H. Lee, Mol. Cryst. Liq. Cryst. **337**, 7. (1999).

[5] G. Frens, Nature Phys. Sci. **241**, 201, (1973).