Self-assembled Polymer Nanopillars Template for the Fabrication of Nanoporous Metal Oxide Film

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ABSTRACT

Porous metal oxide in nano scale was produced by using polymer methacrylic acid (PMMA) nanopillars template. The nanopillars were fabricated via a novel treatment method. The PMMA structure was obtained by spin-coating PMMA solution on clean silicon wafer followed proper treatment. The PMMA thin film will transfer into very rough on the silicon wafer. TiO_2 nanoarchitecture was produced by spin-coating TiO_2 sol on the PMMA nano semi-sphere template and further treated with ozone or calcination in furnace to remove the polymer template. Atomic Force microscope (AFM) was used to measure the proprieties of the structures.

Keywords: PMMA, TiO_2, AFM

1 INTRODUCTION

In recent years, periodic patterns have attracted increasing attention because of its potential application in electronics, magnetic storage, medical treatment and molecular separation. The common methods to make nanocscale pattern are self-assembly of co-polymer or block polymer[1-3] and nanolithography through electron beam, laser beam, etching of plasmas, Ion etching[4], STM and AFM. In this paper, we present a novel simple method to fabricate high-density and large-area polymer nanopillars on silicon wafer. This method is versatile and can be applied to pattern a wide variety of polymer thin film with various proprieties such as electronic conductivity, photo conductivity and photo resist. The as-prepared pattern also has great potential application as template for the fabrication of nanoarchitecture materials.

2 EXPERIMENT

2.1 Materials

Si (100) was cut into 1x1 cm and ultrasonically cleaned by acetone, ethanol and double deioned water (DDI) respectively for 30mins. PMMA with average molecular weight of 25000g/mol was dissolved by chlorobezene solution under vigorous stirring until completely transparent PMMA solution was obtained. 30ul of the as-prepared PMMA solution was spin-coated on clean silicon The sample was further treated in desired condition and then PMMA nanopillar structures were obtained. A layer of nanostructured anatase TiO_2 (0.05M) was obtained by spin-coating TiO_2 sol on PMMA pattern supported by silicon wafer. The sample was further treated by thermal oxidation to remove the polymer template to create a TiO_2 film with regular nanoholes in the top of the layer.

2.2 Measurements

The morphology observation experiments of the prepared PMMA nano semi-sphere on silicon wafer and TiO_2 nanoarchitectrue fabricated by using PMMA semi-sphere as template were conducted using AFM (Digital Instruments, Nanoscope IIIa). A piezoelectric scanner (type J) with a scan of $125\times 125\ \mu m^2$ and a vertical movement of $5\mu m$ was selected. AFM tapping-mode was choosed to image the structure change of PMMA film and TiO_2 nanoarchitecture.

3 RESULTS AND DISCUSSION

The data scale in Fig. 1 (a), (b) is 20 nm, 100nmrespectively. Fig. 1 (a) is the surface of the PMMA thin film spin-coated on clean silicon wafer before treatment, which shows that it is very smooth and homogenous. While the surface morphology changed from smooth to rough after controlled condition. Fig. 1 (b) shows the PMMA nanopillars are of high density and independent. The thickness of PMMA smooth film in Fig. 1 (b) was measured by Ellipsometric Thin Film Thickness Measurement System (L116C, Gaertner) before treatment and the thickness is 6.9nm

The data scale in Fig.2 50 nm. The TiO_2 nanoarchitectrue was obtained after removing the polymer

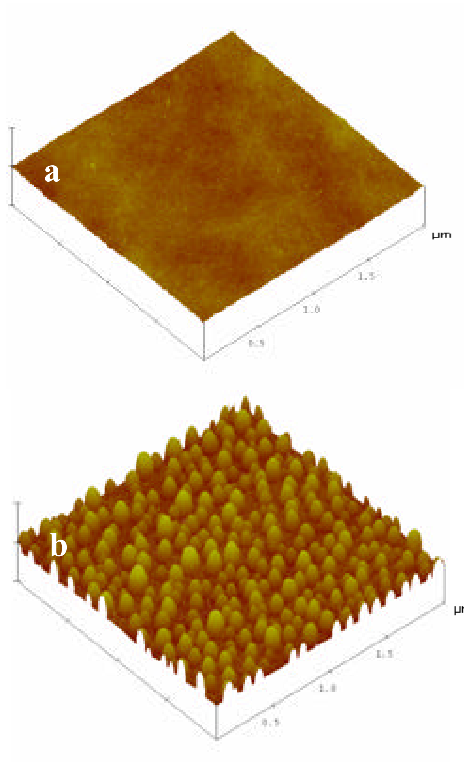

Figure 1: AFM images of PMMA film and nanopillar structure

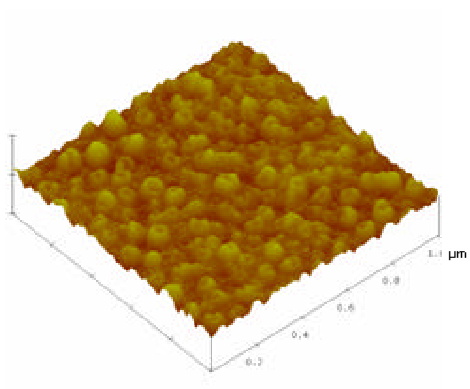

fig.2: AFM image of TiO_2 nanoarchitecture

template by ozonation or calcination. The TiO_2 layer was transferred into hollow semi-sphere structure with a hole in the top. The formation of the structure is caused of the spilling of gas obtained from the degrading process of PMMA during ozonation or calcination. From the AFM image we can get that the gas spilled out of the TiO_2 layer from the highest point of the layer.

CONCLUSION

PMMA nanopillar in nano scale was produced in a novel method. Nanoarchitectrue of TiO_2, which has been widely used as photocatalyst in recent years, was fabricated through PMMA template. The TiO_2 hollow semi-sphere structure in nano scale has potential to improve the catalysis effect of TiO_2.

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