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Nano Honeycomb Patterned Au Transparent Electrode on Flexible Substrates Fabricated by Transfer Printing Using Self-Organized Porous Polymer Mold

Yuichiro Yanagi[1], Hirifumi Saito[1], Shunjiro Fujii[2,3], Akira Yoshida[1], Takanori Okukawa[1], Tatsuki Yanagidate[1], Masaya Ohzeki[1], Yuki Arai[1], Yurina Ohori[1], Daichi Kaneto[1], Ryo Nagata[1], Hiromichi Kataura[3,4], and Yasushiro Nishioka[1]
[1]College of Science and Technology, Nihon University
7-24-1 Narashinodai, Funabashi, Chiba 274-8501, Japan
[2]Nanosystem Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Higashi, Tsukuba 305-8562, Japan
[3]JST, CREST, Kawaguchi 330-0012, Japan
E-mail: nishioka@eme.cst.nihon-u.ac.jp

1. Introduction

Organic solar cells offer an alternative to inorganic solar cells due to their low cost, easy fabrication, and compatibility with flexible substrates over large areas [1]. Most of organic solar cells have been fabricated on indium tin oxide (ITO) substrates because ITO is transparent in visible light and highly conductive. However, the price of ITO drastically increased due to the limited supply of indium and the increasing demand from the rapidly expanding display markets. Moreover, fabrication of highly conductive ITO requires high temperature annealing, which is incompatible with plastic flexible substrate. In addition, the poor mechanical stability of ITO can cause device failure when the ITO coated flexible substrate is bent [2]. Several alternative materials as transparent conductive electrode including carbon nanotube networks [3] and random Ag nanowire mesh [4] have been recently investigated. However, they suffer from either low conductivity or high surface roughness. Recently, it has been reported on fabrication of transparent conductive electrode using transfer printing method [5, 6], which enabled to fabricate highly conductive transparent electrodes at low cost and without high temperature annealing. However this method required a semiconductor manufacturing process such as dry etching and lithography when the mold fabricated. In this research, we will report the method of the nano honeycomb patterned Au electrode on flexible substrates fabricated by transfer printing using self-organized porous polymer method [7] without using semiconductor manufacturing process.

2. Experimental results

Fig. 1 shows the schematic diagram of the fabrication of a polymer mold and transfer printing of nano honeycomb patterned electrode using the polymer mold.

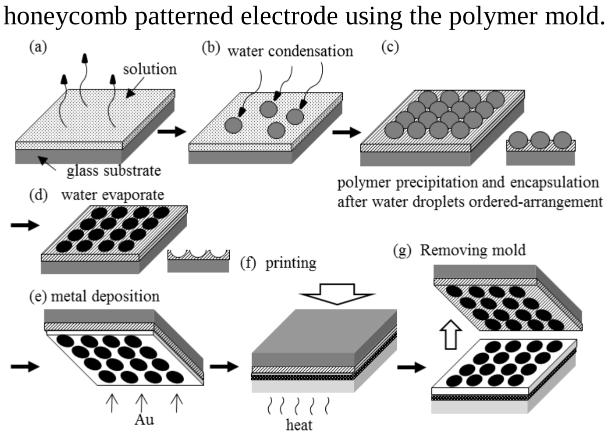

Fig. 1. Schematic diagram of fabrication of polymer mold and the transfer printing.

Firstly, the chloroform blend solution of Poly(Bisphenol A carbonate) and Polyacrylamide was then dropped on the glass substrate (Fig. 1(a)). The weight ratio of the Poly(Bisphenol A carbonate):Polyacrylamide was 10:1 (110mg/20ml) and the mold was fabricated by the method of the porous polymer film due to self-organization (Fig.1(b)-(d)). Then, an Au layer was deposited on the mold surface by thermal vacuum deposition (Fig. 1(e)). The Au mesh on the mold is transferred onto PEDOT:PSS coated PET substrate at 1MPa and 100^{o}C for 10 minutes (Fig. 1(f)). After cooling down to room temperature, lipping up the mold leaves the electrode on PEDOT:PSS co-ated PET substrate(Fig.1(g)).

Fig. 2 shows SEM images of the fabricated polymer mold. The mold has a line-width of 350 nm, a period of 1.5 μm, and a depth of 1.75 μm. Fig. 3 shows a photo image and a optical microscope image of the transferred Au patterns using the polymer mold. It was successful to transfer Au electrodes on PEDOT:PSS coated PET substrates using the mold under the pressure of 1 MPa at 100 ^{o}C for 10 min. The measured sheet resistance of the Au electrode is 3Ω/□, which 11 times lower than that of the ITO (33Ω/□).

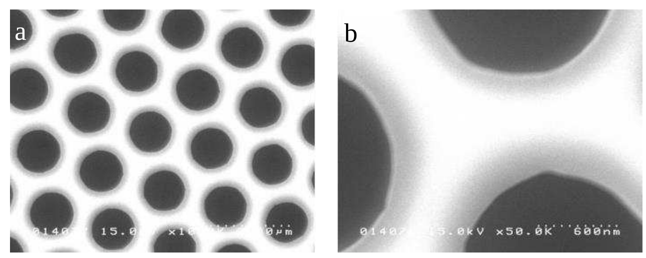

Fig. 2. SEM images of (a), (b) the polymer mold.

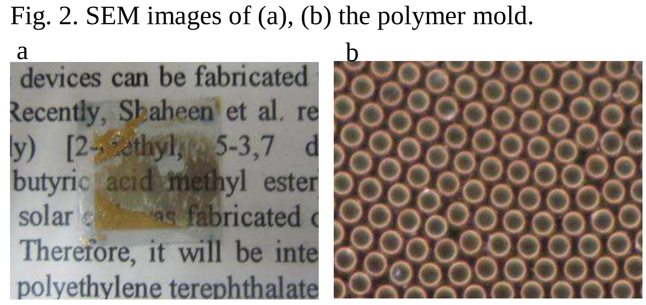

Fig. 3. (a) Photographs of nano honeycomb patterned electrode on PET substrate, and (b) optical microscope image of the Au transferred surface.

3. Summary

In summary, we have demonstrated the flexible optical transparency nano honeycomb Au patterned electrode fabricated by transfer printing using self-organized porous polymer mold. This method makes it possible to fabricate a transfer printing nano patterned mold easily without using semiconductor manufacturing process. Fabricated Au electrode has high optical transparency as well as high conductivity than that of the ITO. This method is suitable to apply for transparent electrodes of future organic solar cells.

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