

## Fabrication of Diamond-Like Carbon Emitter Patterns by Room-Temperature Curing Nanoimprint Lithography with PDMS Molds Using Polysiloxane

Shuji Kiyohara<sup>1</sup>, Shogo Yoshida<sup>1</sup>, Ippei Ishikawa<sup>1</sup>, Toru Harigai<sup>2</sup>, Hirofumi Takikawa<sup>2</sup>, Masahiko Watanabe<sup>3</sup>, Yoshinari Sugiyama<sup>3</sup>, Yukiko Omata<sup>3</sup>, Yuichi Kurashima<sup>4</sup>

<sup>1</sup>Electric and Electron System Engineering Course, Department of Multidisciplinary Engineering, Faculty of Advanced Engineering, National Institute of Technology, Maizuru College, 234 Aza Shiroya, Maizuru, Kyoto 625-8511, Japan

<sup>2</sup>Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology, 1-1 Hibarigaoka Tempaku, Toyohashi, Aichi 441-8580, Japan

<sup>3</sup>Application and Technical Section, ELIONIX INC., 3-7-6 Motoyokoyama, Hachioji, Tokyo 192-0063, Japan

<sup>4</sup>Research Center for Ubiquitous MEMS and Micro Engineering, National Institute of Advanced Industrial Science and Technology, 1-2-1 Namiki, Tsukuba, Ibaraki 305-8564, Japan

### ABSTRACT

We investigated the fabrication of diamond-like carbon (DLC) emitter patterns by room-temperature curing nanoimprint lithography (RTC-NIL) with polydimethylsiloxane (PDMS) molds using polysiloxane, as an application to the emitter for the next generation flat panel display.

The DLC which has excellent properties similar to diamond properties was used as a pattern material. A PDMS was used as a mold material and fabricated by the following optimum conditions of the first curing time at RT for 36 h and the second curing time at the temperature of 150 °C for 15 mins. The polysiloxane is in the state of sticky liquid at RT and stable in air. Therefore, the polysiloxane was used the electron beam (EB) resist and oxide mask material in EB lithography, and also used as RT-imprint material.

First, we fabricated the PDMS mold with pit array. Each dot is 5 μm-diameter and 400 nm-depth. We carried out the RTC-NIL process with PDMS molds using polysiloxane under the following optimum imprint conditions of 0.5 MPa-imprinting pressure, 1.5 min-the time between spin-coat and imprint, and 5 min-imprinting time. Next, the residual layer of imprinted polysiloxane pattern was 450 nm and then was removed with electron cyclotron resonance (ECR) trifluoromethane (CHF<sub>3</sub>) ion shower under the conditions of 300 eV-ion energy and 3 min-etching time. Then, we processed the imprinted polysiloxane patterns on the DLC film with an ECR oxygen (O<sub>2</sub>) ion shower under the conditions of 400 eV-ion energy and 12 min-etching time. As a result, we succeeded in fabricating convex DLC emitter patterns with high accuracy which has 5 μm-diameter and 500 nm-height.

### INTRODUCTION

The diamond-like carbon (DLC) film exhibits unique properties such as wear resistance, chemical stability, biocompatibility, gas barrier, low coefficient of friction and negative electron affinity [1,2], and so it is expected to have various applications. For example, it can be used