Mater. Res. Soc. Symp. Proc. Vol. 1511 © 2013 Materials Research Society
DOI: 10.1557/opl.2013.21

Fabrication of DLC-Based Micro-Gear Patterns by Room-Temperature Curing Nanoimprint Lithography Using Glass-Like Carbon Molds

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ABSTRACT

The fabrication of diamond-like carbon (DLC) micro-gear by room temperature curing nanoimprint lithography (RTC-NIL) using glass-like carbon (GC) molds as applications to the DLC-based medical MEMS (Micro Electronic Mechanical Systems) was investigated. The DLC film which has excellent properties similar to chemical vapor deposited (CVD) diamond films was used as the patterning material. We propose GC as mold material because GC has higher etching selectivity than a diamond film. The etching selectivity of polysiloxane film against a GC substrate is about 5 times as high as that of a diamond film. Therefore we fabricated the GC molds that have micro-gear patterns with 30 μm-tip diameter and 500 nm-tooth thickness. We carried out the RTC-NIL process using the GC micro-gear molds under the following optimum conditions. 1 min-time from spin-coating to imprint: t_1, 0.5 MPa-imprinting pressure: P and 5 min-holding time: t_2, and then the imprinted polysiloxane pattern on DLC film was processed with an electron cyclotron resonance (ECR) oxygen ion shower. However, we were not able to fabricate micro-gear patterns in high accuracy because of a remaining residual layer on the DLC film. Therefore we propose the removing process for the residual layer with trifluoromethane (CHF_3) ion shower under the optimum conditions of 300 eV-ion energy and 4 min-etching time. As a result, we succeeded to fabricate concave DLC-based micro-gear patterns in high accuracy which has 30 μm-tip diameter and 1 μm-depth.

INTRODUCTION

The diamond-like carbon (DLC) film exhibits unique properties such as high hardness, low coefficient of friction, negative electron affinity, high biocompatibility, infrared transparency [1 - 3] and so it is expected to have mechanical, electrical, chemical and optical applications. For example, it can be used as micro-gear for medical MEMS (Micro Electronic Mechanical Systems) [4], emitter for plasma display panel [5], medical stent [6] and infrared optic window for image pick-up device [7]. Therefore, the nanopatterning technique for the DLC film is essential to the fabrication of functional micro- and nano-devices.

We have already investigated the nanopatterning of chemical vapor deposited (CVD) diamond films in RTC-NIL using diamond molds [8]. The diamond molds have been fabricated with electron cyclotron resonance (ECR) oxygen ion shower etching using polysiloxane with the