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Fabrication of Diamond-Like Carbon Microgears in Room-Temperature Curing Nanoimprint Lithography Using Ladder-Type Hydrogen Silsesquioxane

Shuji Kiyohara[1], Yuto Shimizu[1], Ippei Ishikawa[1], Toru Harigai[2], Hirofumi Takikawa[2], Masahiko Watanabe[3], Yoshinari Sugiyama[3], Yukiko Omata[3], Yuichi Kurashima[4]

[1]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
[2]Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology, 1-1 Hibarigaoka Tempaku, Toyohashi, Aichi 441-8580, Japan
[3]Application and Technical Section, ELIONIX INC., 3-7-6 Motoyokoyama, Hachioji, Tokyo 192-0063, Japan
[4]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 convex diamond-like carbon (DLC) based microgears in room-temperature curing nanoimprint lithography (RTC-NIL) using the ladder-type hydrogen silsesquioxane (HSQ), as an application for the medical micro electro mechanical system (MEMS). The HSQ which is an inorganic polymer of sol-gel system turns into a gel when exposed to air and has the siloxane bond. Therefore, the HSQ was used as RT-imprinting material, and also used as an oxide mask material in electron cyclotron resonance (ECR) oxygen (O_2) ion shower etching. We fabricated the polydimethylsiloxane (PDMS) mold with concave microgear patterns which has 40, 50 and 60 μm-tip diameter and 300 nm-depth. We carried out the RTC-NIL process using the PDMS mold under the following optimum conditions of 0.10 MPa-imprinting pressure and 1.0 min-imprinting time. We found that the residual layer of imprinted HSQ microgear patterns was removed with ECR trifluoromethane (CHF_3) ion shower under the following conditions of 300 eV-ion energy and 2.0 min-etching time, and then microgears of the HSQ on the DLC film were etched with ECR O_2 ion shower under the following conditions of 400 eV-ion energy and 10 min-etching time. As a result, the convex DLC based microgears which have 40, 50 and 60 μm-tip diameter and 400 nm-height were fabricated with high accuracy in the new fabrication process of RTC-NIL.

INTRODUCTION

The diamond-like carbon (DLC) films has been conventionally used to coat such things as the surface of cutting tools and artificial joints because it has exhibited unique properties such as high hardness, high wear resistance, chemical stability, gas barrier and low coefficient of friction [1-3] and so it is expected to have various applications. For example, it can be used as DLC based microgears for medical micro electro mechanical system (MEMS) [4]. Therefore, the nanopatterning technique for a 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 room-temperature curing nanoimprint lithography (RTC-NIL) using glass-like carbon (GLC) mold, and then we fabricated the DLC film which has concave