Microelectronic Engineering 127 (2014) 72–76

Contents lists available at ScienceDirect

Microelectronic Engineering

journal homepage: www.elsevier.com/locate/mee

Fabrication of hybrid structures using UV roll-typed liquid transfer imprint lithography for large areas

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ARTICLE INFO

Article history:
Received 7 April 2014
Accepted 22 April 2014
Available online 9 May 2014

Keywords:
Nano/micro hybrid patterns
Roll nanoimprint
Liquid transfer imprint lithography
Photolithography

ABSTRACT

Recently, nanoscale and micro-scale hybrid structures have become the focus of significant research interest due to their potential for use in anti-reflection films, anti-fingerprint films, solar cells, nanofluidic and microfluidic channels, and some functional optical films. Moreover, the nanopatterning lithography systems using roll-typed stamps have become increasingly appealing technologies for undertaking mass production and for continuous fabrication of hybrid patterns on large area substrates. In this study, we propose a roll-typed liquid transfer imprint lithography (R-LTIL) system and process for fabrication of nanoscale and microscale hybrid patterns on flat and micro lens substrates. Using the proposed system, nanoscale patterns that are 350 nm hole and 250 nm in height are flawlessly transferred to 6 in. Si wafer and microscale lens substrates.

1. Introduction

Recently, in order to improve the efficiency of solar cells, the brightness and diffusion rates of display units and the sensitivity of biosensors, much research has investigated three-dimensional nanoscale and microscale hybrid structures [1–4,7]. To date, combined nanoimprint lithography (NIL) and optical lithography processes have been used in order to fabricate three-dimensional nanoscale and microscale hybrid patterns [7]. Contact-based nanoimprint lithography (NIL) techniques, such as thermal and UV nanoimprint are considered to be the next generation lithography. In particular, the nanoimprint lithography technology has numerous advantages including process simplicity, low cost, high replication fidelity, and relatively high throughput. Furthermore, the roll-typed nanoimprint lithography (R-NIL), which has many advantages of high uniformity, low pressing load, and fast patterning, has become a significant lithography technology for fabrication of nanoscale and microscale patterns because it can be continuously produced patterns in large area substrates [5,6]. However, it has some disadvantages such as a slightly thick residual layer and high demolding force. Koo et al. proposed a liquid transfer imprint lithography (LTIL) process in order to control the residual layer thickness [3] and to minimize the nanoimprint proximity effect [4]. In this study, we propose a roll-typed liquid transfer imprint lithography (R-LTIL) system and process for fabrication of three-dimensional nanoscale and microscale hybrid patterns on flat and micro lens substrates.

2. Experiments

2.1. Roll-typed LTIL (R-LTIL) system

The liquid transfer imprint lithography (LTIL) process that can transfer uncured resists from a donor to an acceptor was proposed by Koo and co-workers [4] for fabrication of nanopatterns on small area non-uniform surfaces using a replicated PDMS stamp. The LTIL process is basically executed in two steps, as illustrated in Fig. 1. In the first step, a half-thickness of the coated resist on the donor side is detached using an inking process with a soft stamp. Next, the detached resist from the donor is moved to the acceptor. Then, the detached resist can be transferred to a flat surface using UV curing and demolding processes simultaneously. Furthermore, the LTIL process can fabricate nanoscale patterns on pre-shaped surfaces. In this study, we propose a roll-typed liquid transfer imprint lithography (R-LTIL) process in order to fabricate nanoscale and microscale hybrid patterns on large area flat and micro lens substrates. This process is executed on the R-LTIL equipment that was developed by Korea Institute of Machinery and Materials (KIMM), which is described in Fig. 2. The equipment consists of a roll-typed quartz stamp, an adjustable UV unit inside the quartz

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http://dx.doi.org/10.1016/j.mee.2014.04.031
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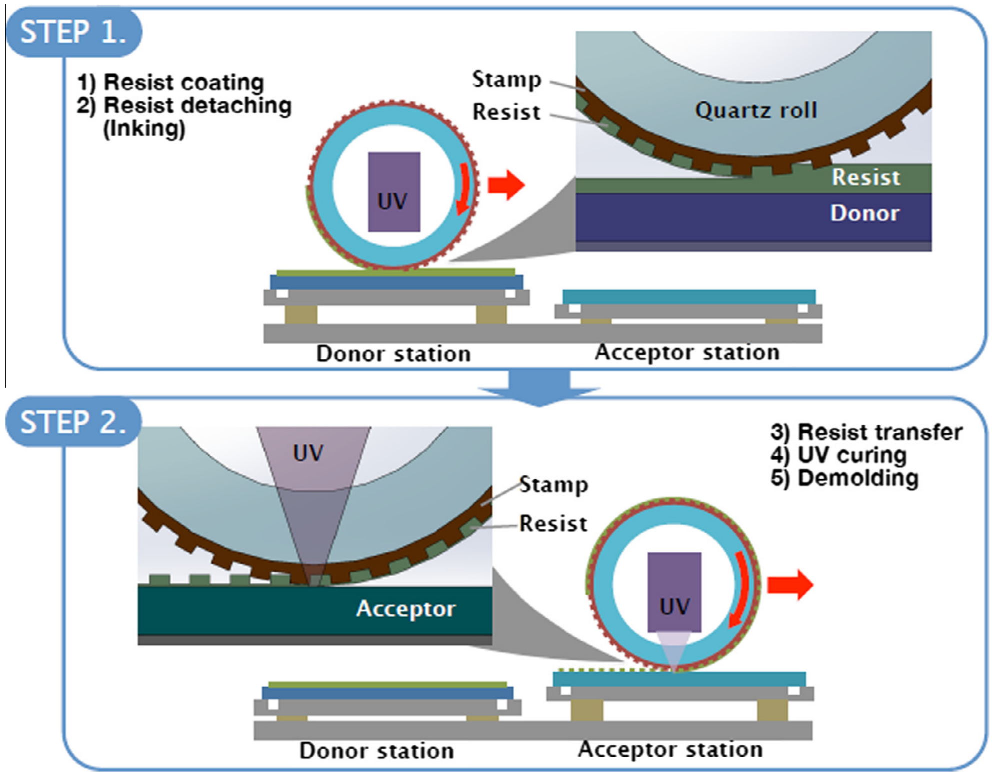

Fig. 1. Schematic flow of the fabrication process for the roll-typed liquid transfer nanoimprint lithography process.

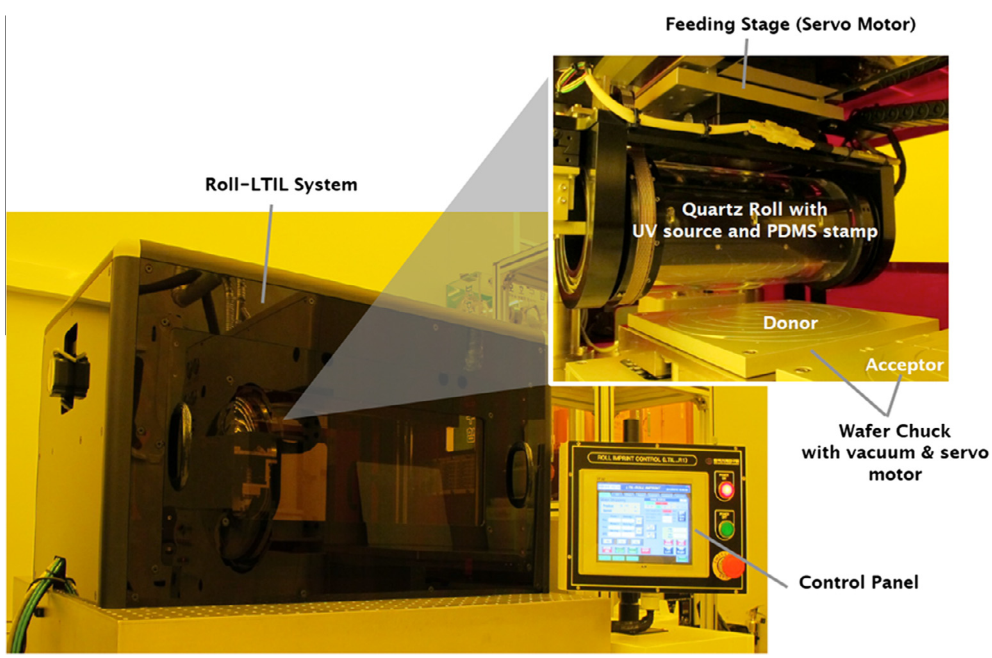

Fig. 2. R-LTIL equipment for 8 in. wafer (developed by KIMM).

roll, the donor and the acceptor stations with an actuator and a vacuum chuck, respectively, for 8 in. substrate, and rotational and feeding units. The donor and the acceptor can be independently operated in the vertical direction using an AC-servo motor each other to have uniform contact with the stamp during the process. The wavelength of UV light was 365 nm and the average power of the UV beam along the centerline was 25 mW/cm^2.

2.2. Stamp fabrication

A 6 in. soft mold for the R-LTIL was made from polydimethylsiloxane (PDMS; Sylgard 184, Dow Corning). In order to fabricate a high uniformity PDMS replica, a special purpose cast was used. A Si master with line patterns of 350 nm hole and 250 nm in height was placed in the bottom of cast. Then, a 10:1