Microelectronic Engineering 87 (2010) 1707–1710

Contents lists available at ScienceDirect

Microelectronic Engineering

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

Fabrication of a two-step Ni stamp for blind via hole application on PWB

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ARTICLE INFO

Article history:
Received 28 May 2009
Accepted 10 July 2009
Available online 19 July 2009

Keywords:
Two-step stamp
Blind via hole
Hot embossing

ABSTRACT

This study examined imprint lithography with a two-step Ni stamp to solve the laser process problems and simultaneously form a blind via and layer pattern. The Ni stamp was fabricated by electroplating on a dry-etched Si mold, made from a SOI (silicon on insulator) wafer, and pattern replication. For the pattern transfer of the Ni stamp, hot embossing was performed on SU8-coated BT and Si wafer substrates. The residual layer was of a uniform thickness with an embossed shape of acceptable squareness.

1. Introduction

The fabrication of a blind via using a laser brings with it contrasting reliability issues, notably, damage of polymeric dielectrics due to laser overexposure or remaining polymeric dielectrics by underexposure. Particularly, remaining polymeric dielectrics in via holes from underexposure of easily form cracks between the line pattern and filled copper due to generated shear stress by their thermal expansion differences. In addition, low productivity is one of the weaknesses of laser drilling i.e., one beam produces one via at a time. This means that throughput is affected by the pattern density. These issues can be solved by imprint lithography which is low-cost and high-throughput [1–3]. Imprint lithography can replicate micro- and nanostructures for a variety of applications, such as interdigitated electrode structures, Fresnel zone plates, and high-density magnetic recording media [4–6]. One of the main advantages of conformal molding over other replication techniques, such as micro-contact printing [7], is that structures with high aspect ratios can be directly reproduced by embossing a thermoplastic material. This study herein examines imprint lithography by a two-step Ni stamp to address the laser issues and simultaneously form a blind via and layer pattern. The Ni stamp was fabricated by electroplating on a dry-etched Si mold, made from a SOI (silicon on insulator) wafer, and pattern replication.

2. Experiment details

The process in this work is schematically described in Fig. 1. To fabricate the two-step Nickel stamp, SOI (silicon on insulator) Si wafer, 50-μm thick Si, 1-μm thick insulator, and a 600-μm thick dummy wafer was used. It was cleaned in a solution (H_2SO_4:H_2O_2 = 3:1) for 1 h and washed by QDR (quick-dump rinse) seven times. The SOI wafer was patterned by a PMER (TOK, NCA 3000) negative photoresistor. An exposure process was examined using mask aligner (Karl Suss, MA6), with 400 nm-wavelength UV light at 15 mW-power per second, for 60 s. It was then etched by an ICP (inductively coupled plasma) etcher (STS, ASE^{HR}) using the Bosch process performed at 3 mtorr (85 sccm flow rate of C_4F_8) for 3 min, generating 1 kW of power. The Si wafer was etched to a depth of 800 nm for the one-step Bosch process. The created scallop in the process was etched by BOE (buffered oxide etcher) for 1 h, after wet-oxidation by LPCVD (low pressure chemical vapor deposition) at 1173 K for 2 h. A Ni stamp was fabricated by electroplating on a Ti sputtered (Varian, VKS-35) Si mold. The Ti thin film was then used as an electrode in the electroplating (Technotrans GmbH, microform 200). After Ni-electroplating, the surface was ground by CMP (chemical mechanical polishing) to render the surface fletness. The Ni-electroplated Si mold was immersed in an aqueous solution of 1.0 mol KOH for 24 h to separate the Ni stamp and Si mold. The Ti thin film was then used as an electrode and etched in an aqueous solution (1.0 mol ammonia aqueous solution:H_2O_2:H_2O = 2:3:5) for 30 min. The fabricated Ni stamp was deposited on a 30-nm thick SiO layer by PECVD (plasma enhanced CVD) (BMR, bmr's highdep^{TM}) to induce strong bonding with the SAM (self-assembled monolayer, 1H,1H,2H,2H-perfluorooctyltrichlorosilane) that was deposited on the Ni stamp to reduce its adhesion with an imprint resin (Microchem, NANO^{TM} SU-8 2000). The SAM coating process was carried out in a vacuum (50 mtorr) chamber at 423 K for 4 h, which was first evacuated under 5 mtorr. The SAM solution (10 μl) was then injected into the chamber. A pattern transfer through hot embossing (EVG, EVG 520 HE) was

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0167-9317/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.mee.2009.07.016

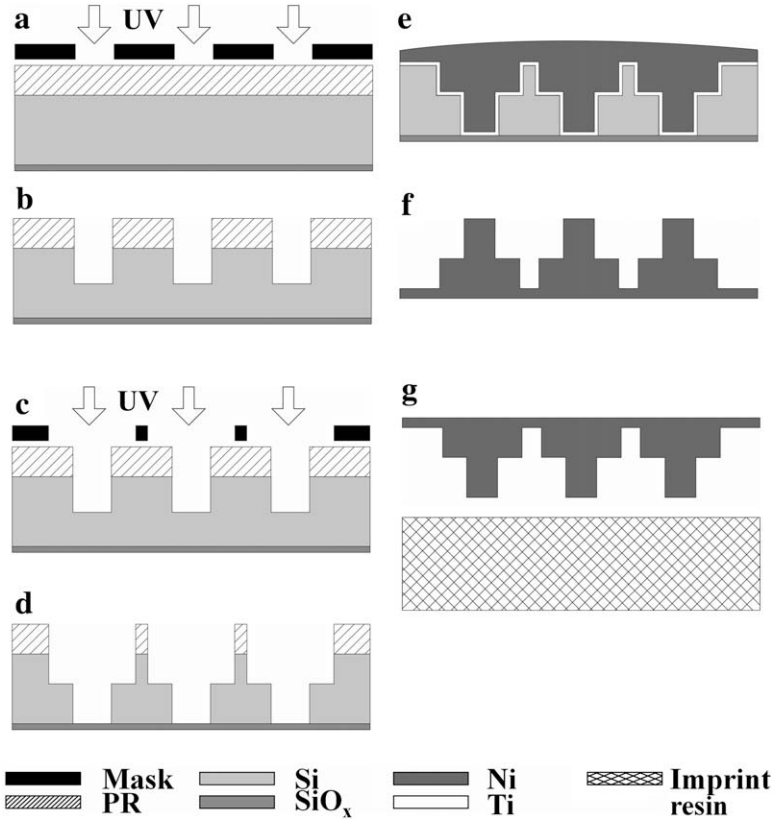

Fig. 1. Process layout of the fabrication of two-step Ni stamp. (a) One-step exposure, (b) one-step etching, (c) two-step exposure, (d) two-step etching, (e) seed layer sputtering and Ni-electro plating, (f) planarization and de-molding, and (g) embossing.

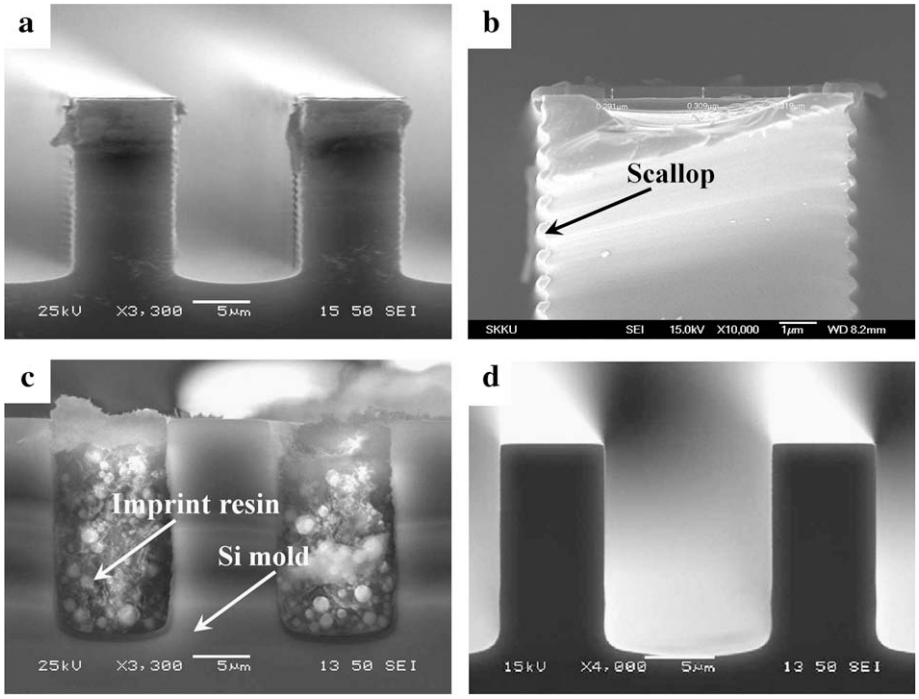

Fig. 2. SEM cross-sectional images of (a), (b) as etched Si wafer, (c) Si wafer mold after imprint, and (d) scallop removed Si mold.

performed on a substrate of the imprint resin-coated Si wafer. The fabricated Ni stamp and patterns were observed by SEM (JEOL, JSM-6460) and optical microscopy (Olympus, STM6-F10-2), respectively.

3. Results and discussion

To confirm the effects of the scallop, the hot embossing process was carried out using the scallop existed-Si mold that was