Technická zpráva – Funkční vzorek

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Umístění: Vysoká škola chemicko technologická v Praze

Název: **Kovové raznice pro replikaci mikrofluidních čipů**

Description

We have developed a new alternative way for production of hybrid gold-copper stamps intended for fast and cheap replication of microfluidic structures. The developed method enables an easy separation of fabricated metal stamps from plastic substrate (mechanical separation or wet etching in organic solvents), which favors this method over the metal stamp fabrication directly on SU8 substrate. The fabricated hybrid gold-copper stamps were tested as embossing templates for production of different microstructures. Their functionality was proven in production of microstructures for several applications, e.g., AC electroosmotic micropumps or dielectrophoretic separators.

Fabrication

A novel fabrication technique for production of hybrid gold/copper stamps in lab-scale was developed. This procedure relies on the polydimethylsiloxane (PDMS) casting process, transferring of microstructures into UV curable methyl-metacrylate (MMA) resin and galvanic deposition of copper. The whole process is proposed as follows:

(i) In the first step, the required micropattern is copied by a standard UV photolitography from a mask to the SU8 photoresist (epoxy based negative resist,Microresist Technology). A thin primary layer of the SU8 photoresist diluted in cyclohexanone (SU8 2025:cyclohexanone 1:1 v/v) is spin coated on a phosphorbronze (PB) wafer and baked on a hot plate (200°C, 35 min) to provide a sufficient adhesion of the SU8 structures to the metal substrate. Another SU8 layer is then spin coated and prebaked on the primary SU8 layer. Thickness of the SU8 layer determines height of future microstructures (typically 25, 40 or 80 μm). The SU8 layer is then exposed to UV light and developed (developer mr-Dev 600, Microresist Technology). Duration of these steps depends on the SU8 layer thickness. Typical exposure time for 80 μm high SU8 layer is about 10 min.

(ii) PDMS is casted against the SU8 master. PDMS prepolymer (Sylgard 184, Dow Corning) is prepared according to a recipe, degassed in vacuum and poured over the SU8 master. After curing (95C, 60 min), the PDMS cast is peeled off the SU8 master.

(iii) UV curable MMA resin is casted against the PDMS master. The casting process consists of several steps: pouring the MMA resin Acrifix 192 (Degussa) onto the PDMS master, covering up the resin with an auxiliary PMMA plate (2 mm thick), curing the resin under UV light trough the PMMA support plate for 50 min, and peeling off the cured PMMA layer. (iv) The hardened MMA resin (PMMA) is used as a master for galvanic electrodeposition. The surface of the PMMA master is coated with a thin gold layer (about 100 nm) via sputtering (SCD 050, BALZERS).

(v) The master is then placed in a galvanic copper bath (220 g/l $CuSO_4$ in 7.5% H_2SO_4),. The PMMA master with sputtered gold layer is connected as the cathode, on which the copper ions are reduced. The metal deposition starts with a low electric current density 0.01 Am^{-2} in order to provide uniform formation of a copper layer on the microstructures. After a certain period (typically 60 min), the electric current density is raised up to $0.06Am^{-2}$ to form a 1.5 mm thick body of the copper stamp (about 10 hours).

Adhesion of gold to the PMMA surface is good enough and the gold layer remains compact during the galvanic deposition. The PMMA master and the final metal stamp can be easily separated. The surface of the final stamp is fine and smooth. The optical and SEM images of microstructures on the gold/copper stamp are shown in Fig. 1.

The fabricated gold-copper stamps were consequently replicated into PMMA wafers. The used hot-embossing procedure is shortly described:

(i) In order to avoid deformation, the PMMA substrate is inserted into a stainless steel holder. The PMMA plate is aligned with the gold-copper metal stamp and placed in a stamping machine (hydraulic press).

(ii) The whole system is heated up to the temperature of 140°C.

(iii) Pressing force of 20 kN is then applied on the stamp/substrate sandwich for 5 min followed by cooling provided by an air vent. During the cooling process, the pressing force is kept at the constant value of 20 kN.

(iv) After reaching the laboratory temperature, the pressing force is released and the PMMA plate with replicated microstructures is obtained.

The fabricated hybrid gold/copper stamps were tested for hot embossing of different microstructures. Their functionality was proven on fabrication of AC electroosmotic micropump, Fig. 2. The fabricated microchips showed high precision of embossed structures. Moreover, the durability of these stamps pretends them to be a cheap and achievable alternative to metal stamps fabricated by the common techniques.

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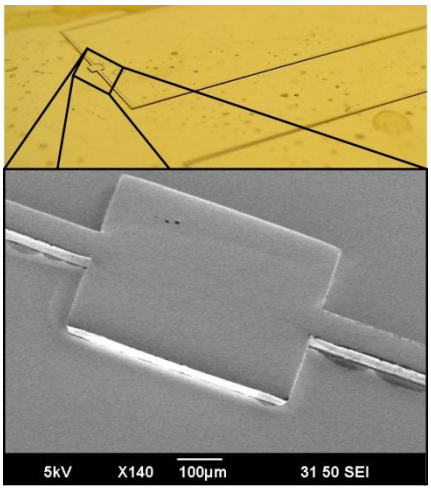

Figure 1. Optical microscope and SEM images of micro structures on copper-gold stamp

Figure 2. AC electroosmotic pump, detail on the PMMA microchannel accros the microelectrode array