Fabrication of Polyimide Screen Masks with Through Holes by Laser Drilling for Print and Imprint Method

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Introduction: UV nanoimprint lithography (UV-NIL) has attracted much attention as one of next-generation micro/nanofabrication technologies at high throughput and low cost. Leveling residual layer thickness (RLT) in imprinted resist patterns is essential for subsequent lithography process by dry etching. Instead of ink jet coating process for low-viscosity resins, we propose screen printing process for high-viscosity resins to deposit resin droplets position-selectively on substrate surfaces.[1] The screen printing process combined with UV nanoimprinting is named a print and imprint method (Fig. 1)[2]. In this study, we investigated how to prepare through-hole screen masks of engineering plastics. We demonstrated position-selective deposition of high-viscosity (11,000 mPa s) resins with durability to oxygen reactive ion etching and Ar ion milling. The fabrication of Au microelectrodes was investigated.

Experimental: Laser drilling was carried out with a picosecond laser (λ 532 nm, pulse width 12.5 ps, pulse energy 1.2 μJ, irradiation time 0.1 s) under different repetition rates. Approximately 12 μm-thick films of four engineering plastics, polyimide (PI), poly(ethylene terephthalate) (PET), poly(phenylene sulfide) (PPS), and poly(ether ether ketone) (PEEK) were used. The diameters and heights of cured resin droplets deposited by screen printing were determined with a fluorescence microscope and a surface profiler as previously reported. A silica mold for fabrication of microelectrodes was made by photolithography processes.

Results and Discussion: Figure 2 shows the optical microscope images of PI through-hole masks. The diameters of through holes became large with increasing a laser repetition rate from 1.0 to 50.0 kHz. We determined 12.5 μm-thick PI films to be suitable for screen masks from standpoints of hole morphologies (circularity, flatness, etc.) after laser drilling in addition to thermal and chemical stability. A fluorescent bisphenol-A-based UV-curable resin (η = 11,000 mPa s) was successfully deposited on a Si substrate in dot form by screen printing using a prepared screen mask as shown in Fig. 3. The average volumes of resin droplets were tunable from 0.02 to 0.54 pL by using different hole diameters. We demonstrated that position selective deposition of the high-viscosity resin droplets in accordance with the shape of a silica mold for fabrication of Au electrodes (Fig. 4).

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[1] Tanabe et al., Jpn. J. Appl. Phys. **55**, 06GM01 (2016)
[2] T. Uehara et al., J. Vac. Sci. Technol. B. **34**, 06K404 (2016)

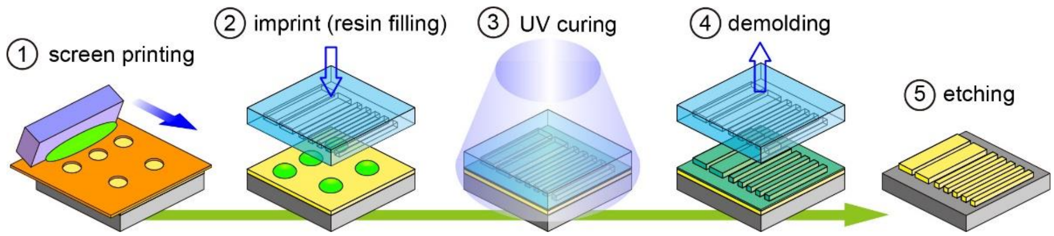

Figure 1: Illustration of procedures of print and imprint method.

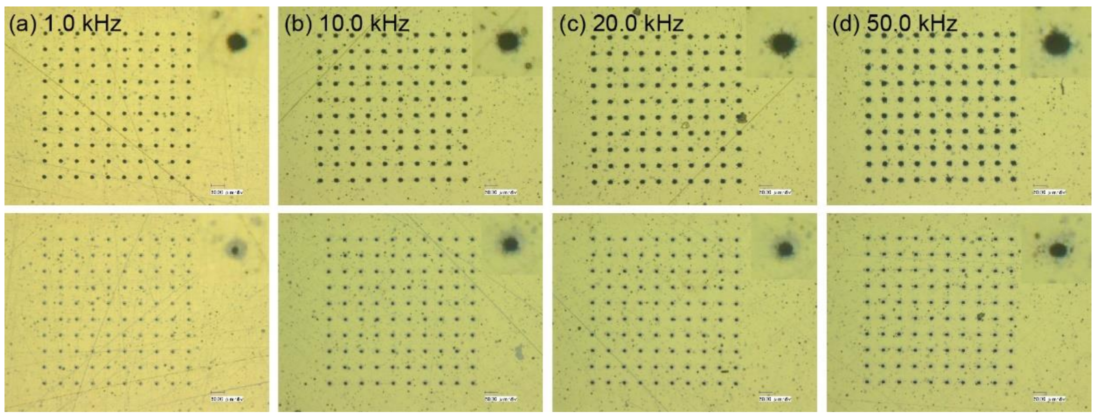

Figure 2: Optical microscope images of through holes of (upper) frontside and (lower) backside polyimide (PI) surfaces fabricated by laser drilling with a repetition rate of 1.0 - 50.0 kHz.

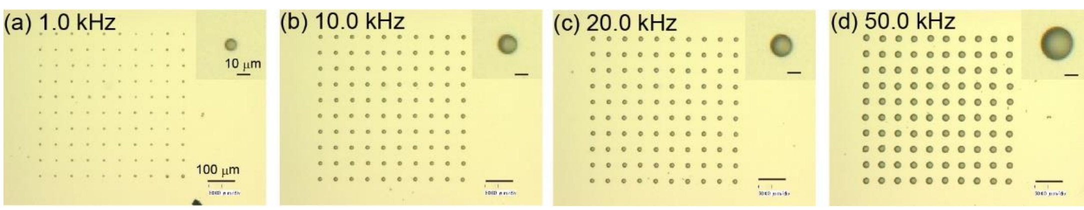

Figure 3: Optical microscope images of UV-curable resin droplets deposited on a Si substrate by screen printing with a PI through-hole membrane.

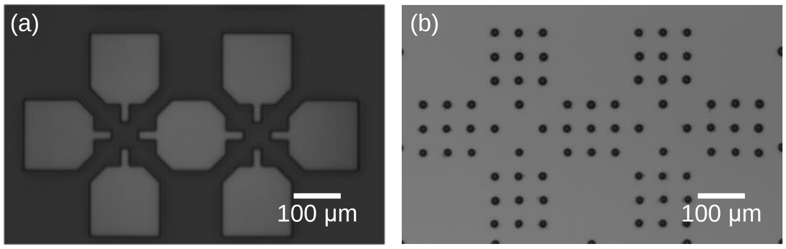

Figure 4: Optical microscope images of (a) a silica mold containing electrode patterns and (b) resin droplets deposited on a Au-deposited surface by screen printing.