Selective electroless metallization of micro- and nanopatterns for flexible electronic application through imprint-transfer of palladium nanoparticles

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Recently, flexible electronics and optoelectronics have been attracting increasing research interest because of their promising applications in many practical fields, such as wearable electronics, medical implants, portable devices, to name a few.[1-3] Flexible conductive patterns play an important role in those flexible electronic and optoelectronic products. However, the most commonly used approach in flexible printed circuit industry is based on lithography and etching process, which wastes materials and is expensive, pollutant, and complicated. In this research, an environment-friendly and cost-effective metallization on thermoplastics by imprint lithography and electroless plating for mass production of metallic micro/nanopatterns were experimentally demonstrated. One major advantage of this metallization method is that it uses a hybrid imprint mold which could transfer both patterns and catalytic nanoparticles onto plastic substrates simultaneously. The imprint mold consists of nickel patterns on a hardened resin, the nickel patterns could adsorb catalytic nanoparticles while the resin couldn't, thus catalytic nanoparticles could be selectively transferred to the thermoplastics for subsequent metallization process.

Figure 1 shows the fabrication of a transparent electrode (TE) through this method. After immersing in a catalytical palladium nanoparticles (PdNP) colloidal solution, the hybrid nickel mold is used to directly transfer the micro/nanopattern and PdNP to a thermoplastic by a thermal nanoimprint process. Next, the imprinted thermoplastic is placed in a Cu electroless bath for various time for metallization of the micropattern. Figure 2a displays the morphological characterization of a hybrid mold consists of 50 μm pitch nickel mesh on NOA-61 during the fabrication process. Figure 2b and 2c displays the optical and electrical performance of a TE fabricated through this method. The TE consists of a 50 μm pitch hexagonal Cu mesh embedded on PET films. The maximum figure of merit (FoM) achieved via this method was 4×10^3 with a low sheet resistance of 0.38 ohm/sq, while the transmittance of the TE is still above 75%, which is better than commercial ITO or FTO.

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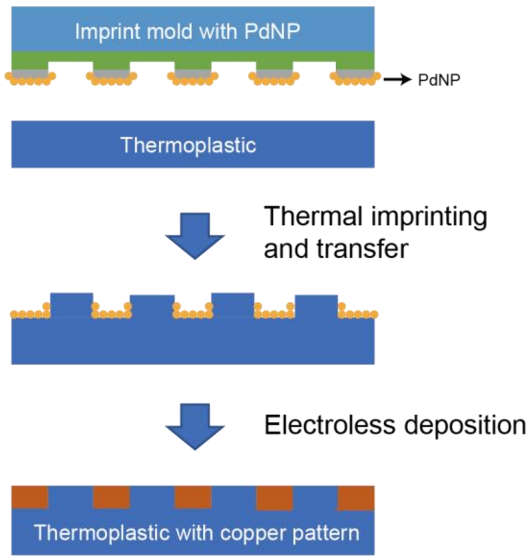

Figure 1. Schematic illustration of the fabrication of a Cu micromesh pattern using a hybrid nickel mold.

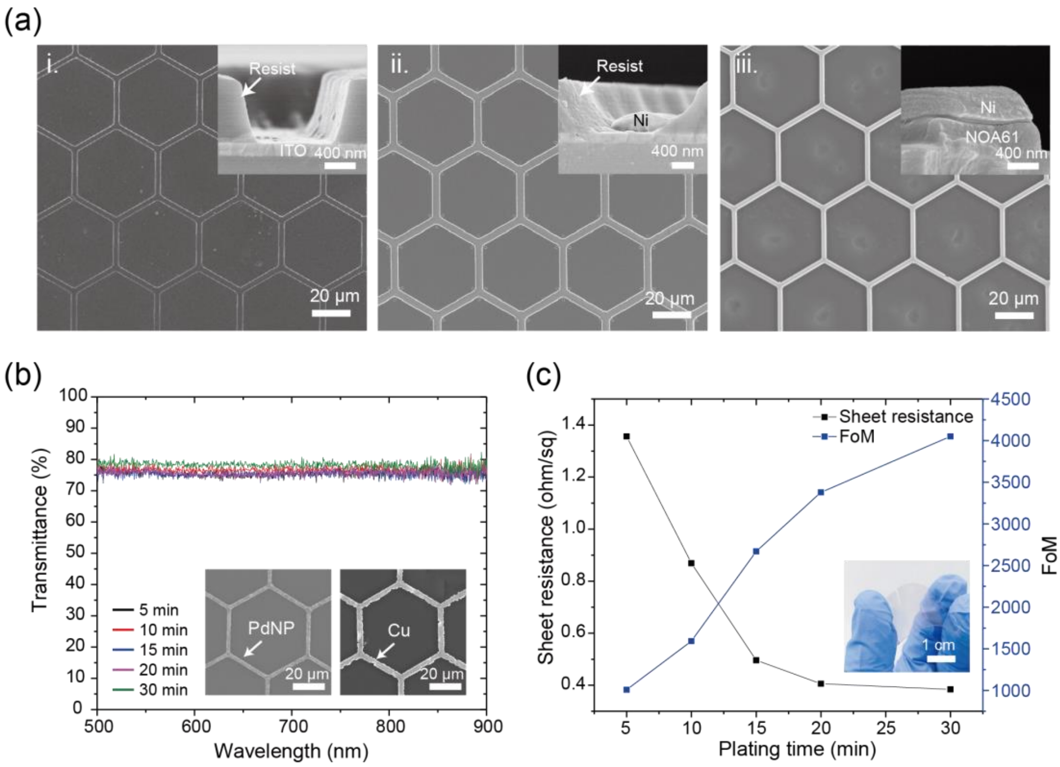

Figure 2. (a) SEM micrographs of (i) hexagonal micromesh in photoresist, (ii) electrodeposited nickel mesh, and (iii) hybrid nickel mold. (inset) Corresponding cross-sectional views. (b) Transmittance of a 50 μm pitch hexagonal Cu mesh on PET films after various electroless plating time ranging from 5 min to 30 min. (inset) SEM micrographs of the imprint-transferred PdNP and electroless deposited Cu mesh on PET films. (c) Electrical conductivity of the Cu mesh versus electroless plating time. (inset) Photograph of a typical TE after plating for 15 min.