

# Au Nanorods and Nanogap Split-Ring Structures Fabricated by Reactive-Monolayer-Assisted Thermal Nanoimprinting and Electrodeposition

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Noble metal Au and Ag nanostructures show unique optical properties originating in the surface plasmon resonance [1, 2]. In particular, metamaterials which consist of metal nanostructure arrays smaller than a wavelength of electromagnetic wave have attracted much attention as negative index materials [3, 4]. However, it is still in challenge to fabricate metal nanostructure arrays at a large area sufficient to measure their optical properties. We have reported reactive-monolayer-assisted thermal nanoimprint lithography (R-TNIL) as a simple and mass-productive metal nanofabrication method [5]. In this study, nanorods and nanogap split-ring (SR) structures previously proposed as a kind of metamaterial structures by Tanaka et al. [6] were fabricated by R-TNIL and electrodeposition (ED).

A cleaned Au-plated substrate (25 nm-Au/20 nm-Cr/silica) was modified by a photoreactive adhesive monolayer of 4-((10-mercaptodecyl)oxy)benzophenone [5]. Patterning was carried out as shown in Fig. 1. A thin film of poly(styrene) (PS) spincoated on the Au substrate was exposed to UV light to suppress dewetting of the PS resist layer. The resist layer was transformed by a fluorinated silicon mold having 100 × 500 nm rod patterns and SR patterns with two nanogaps (125 nm, width; 500 nm, outside diameter; 20 nm, gap) with the respective pattern areas of a 100- $\mu$ m square. Au was electrodeposited after removal of a residual layer. Underlying metals were removed by Ar ion milling and wet etching.

Both straight and curve lines were well transferred to PS resist layers from the mold. The depth of nanoimprinted patterns was about 70 nm, which agreed with the height of the mold. Au was deposited along shapes of the PS resist patterns as shown in Fig. 2 (a,b). Almost homogeneously deposited Au patterns could be obtained at whole area of a 100- $\mu$ m square. We compared pattern uniformity and defects of Au nanorods and SR structures after etching of underlying metal layers between wet etching and Ar ion milling. Fabrication of homogeneous Au patterns of nanorods and nanogap SR patterns at a larger area is under investigation using a mold having a 5-mm square area

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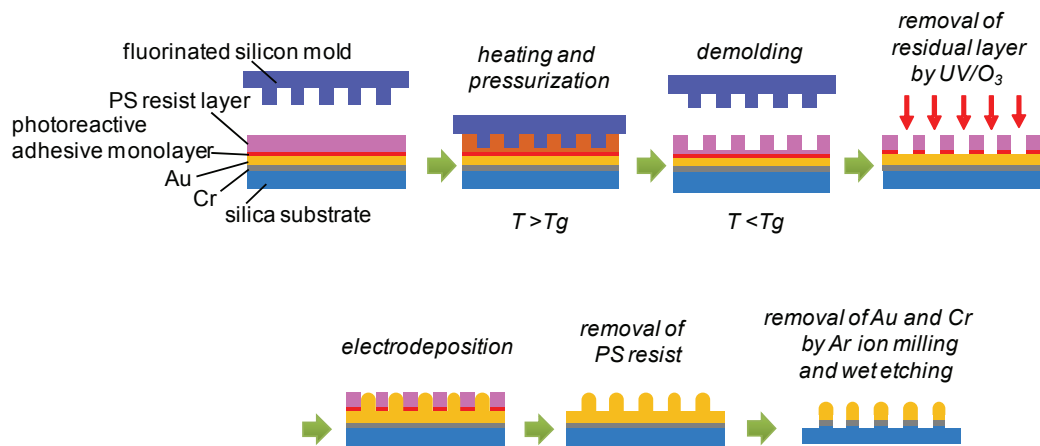


Fig. 1. Schematic illustration of the method for preparing Au patterns on a silica substrate by reactive-monolayer-assisted thermal nanoimprinting and electrodeposition

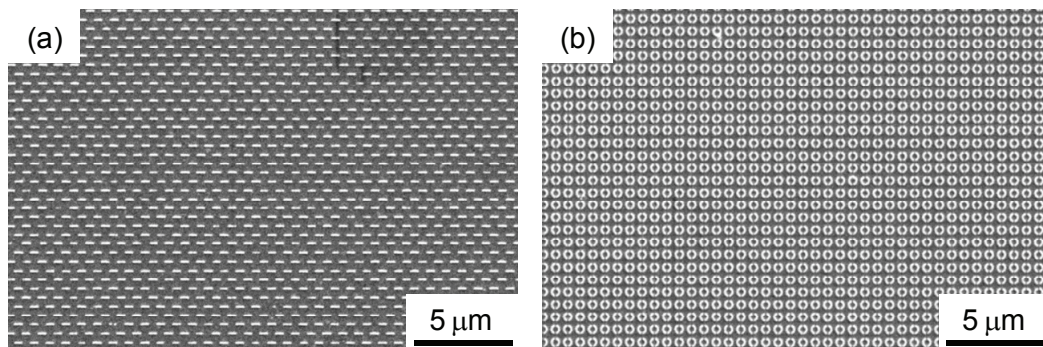


Fig. 2. SEM images of electrodeposited Au patterns of (a) nanorods and (b) SR patterns.