Solution-processed flexible plasmonic nanodisk arrays for biomolecular detection

Jingxuan Cai[1], Chuwei Liang[1], Cuiping Zhang[1], Siyi Min[1], and Wen-Di Li[1]

[1]*Department of Mechanical Engineering, Univ. of Hong Kong, Hong Kong*

liwd@hku.hk

Localized surface plasmon resonance (LSPR) based sensors have found wide applications in medical diagnosis,[1] food safety evaluation,[2] monitoring of environmental pollution,[3] and detection of biomolecules[4] because of their unique properties of high-sensitivity, label-free, and high throughout real-time detection. However, the fabrication process of LSPR sensors is still sophisticated and expensive, which severely restricts the applications of LSPR sensors. To realize industrial standard LSPR sensors, fabrication of periodic metallic nanostructures with controllable defects, fine features, large-area patterns in a low-cost and reproducible manner is required. In this research, a solution-processed cost-effective fabrication process of flexible LSPR sensors was experimentally demonstrated. The fabrication method utilizes residual-layer-free thermal nanoimprint lithography, electrodeposition, and imprint transfer. After immobilization of bovine serum albumin (BSA) proteins on the surface, the fabricated LSPR sensor was capable of the detection of anti-BSA proteins with concentrations down to 1 ppm.

Figure 1 demonstrates the fabrication process of flexible LSPR sensors. After the imprint resist is spin-coated on a cleaned indium tin oxide (ITO) glass substrate (Figure 1a), thermal nanoimprint lithography is conducted to create nanostructured patterns (Figure 1b). Then gold is electrodeposited inside the nanotrenchs (Figure 1c). Next, the imprint resist is removed by immersing the substrate in acetone (Figure 1d). Thereafter, a thermoplastic film is placed on the metallic nanostructures and heated to above its glass transition temperature. Pressure is then applied to press the metallic nanostructures into the softened plastic film (Figure 1e). Finally, the stack is cooled down to a demolding temperature, and the plastic film can be separated manually from the ITO glass substrate (Figure 1f), leaving the metallic nanostructures fully transferred and embedded in the plastic film. Figure 2a and 2b displays the morphological characterization of the imprinted pattern on ITO glass and transferred gold nanodisk array on PET film. Figure 2c-f displays the biomolecular sensing performance of the BSA-modified flexible LSPR sensors for anti-BSA proteins. The results revealed that the flexible LSPR sensor is capable for detection of anti-BSA proteins with concentration down to 1 ppm.

[1] El-Sayed, I. H.; Huang, X.; El-Sayed, M. A. *Nano Lett.* **2005**, 5, 829-834.

[2] Situ, C.; Mooney, M. H.; Elliott, C. T.; Buijs, J. *TrAC* **2010**, 29, 1305-1315.

[3] Ashwell, G.; Roberts, M. *Electron. Lett.* **1996**, 32, 2089-2091.

[4] Hao D, Hu C, Grant J, Glidle A, Cumming DR. *Biosens. Bioelectron.* **2018**, 100, 23-27.

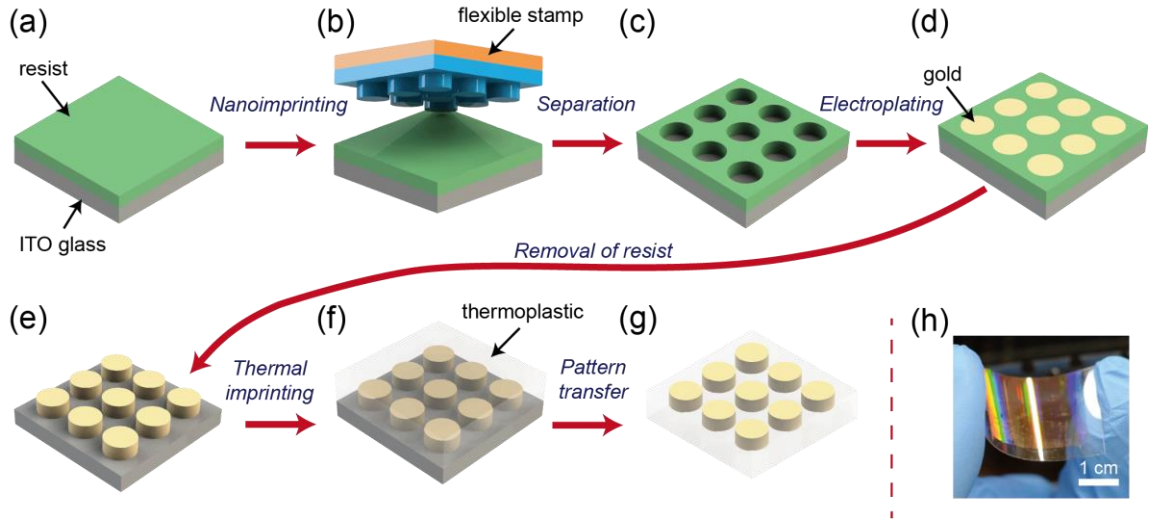

Figure 1. Schematic illustration of the fabrication of a flexible LSPR sensor.

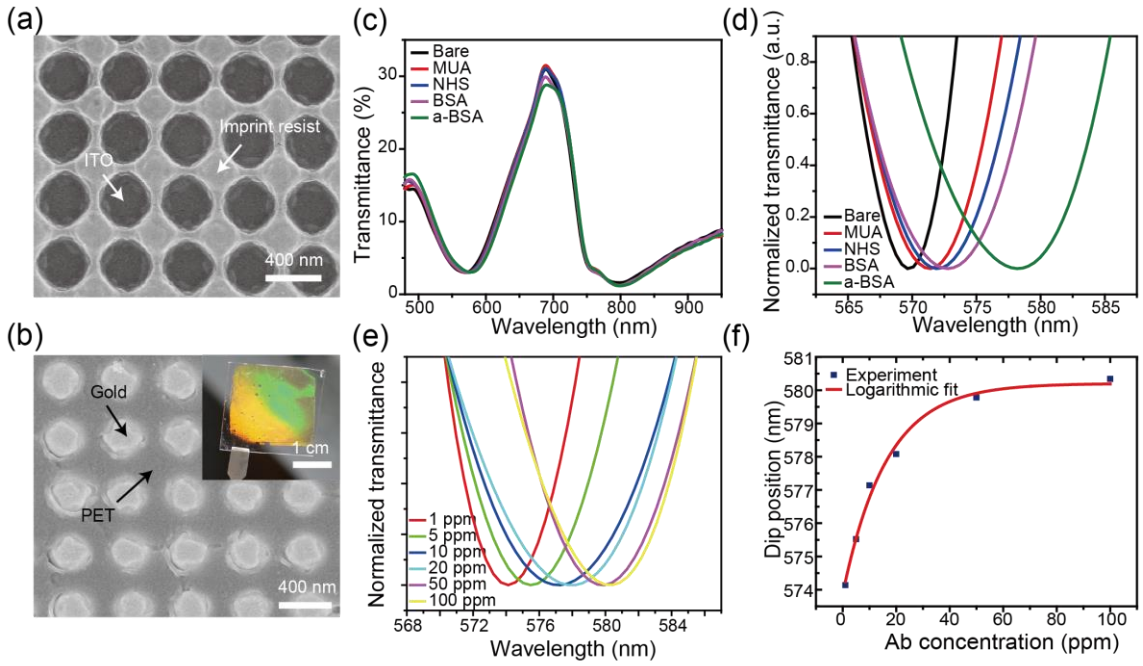

Figure 2. (a) SEM micrographs of nanohole array in imprint resist, and (b) transferred gold nanodisk array embedded in PET film. (inset) corresponding photograph of visible spectrum diffraction from the film. (c) Transmittance spectra of the plasmonic film during each step of modification. (d) Detailed spectral information around the plasmonic dip at 570 nm wavelength. (e) Transmittance of the BSA-modified plasmonic film after interaction with anti-BSA with different concentrations for 15 min. (f) Measured LSPR displacement as a function of anti-BSA concentration. The red line is a logarithmic fit with anti-BSA concentrations from 1 to 100 ppm.