Supporting Information

High-Performance, Robust Metal Nanotrough-Embedded Transparent Conducting Film for Wearable Touch Screen Panel Application

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Fabrication of the metal nanotrough networks on glass for subsequent transfer process

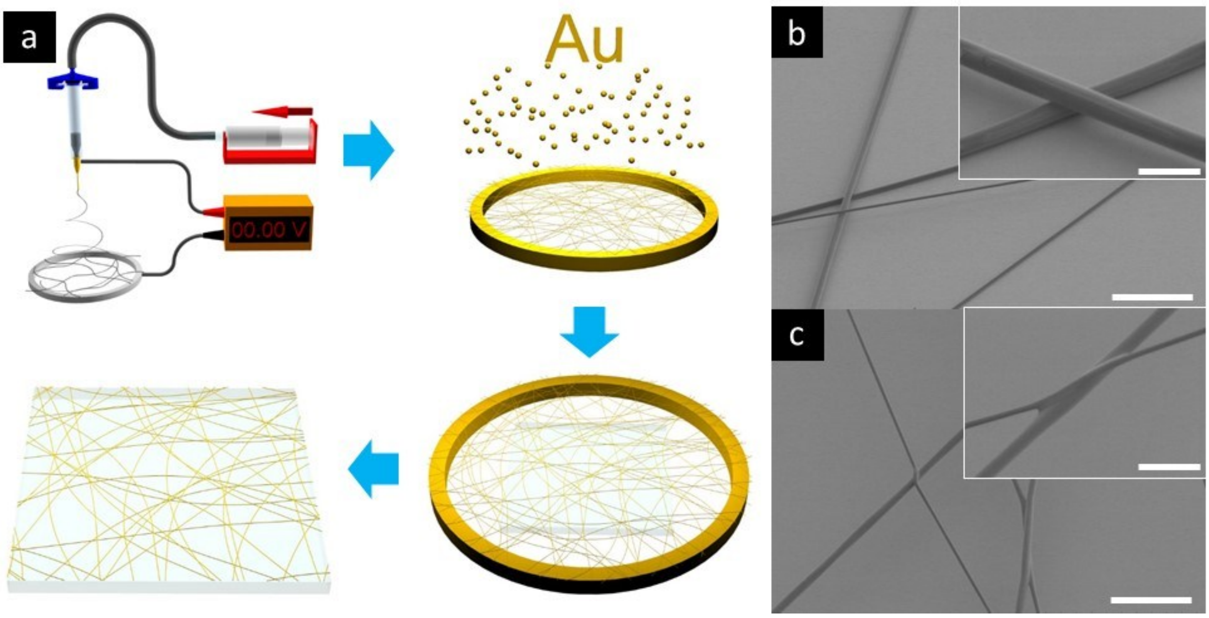


Figure S1. (a) Fabrication procedure of the metal nanotrough networks on glass. (b, c) SEM images for electro-spun polymer templates; (b) as-spun and (c) annealed (The insets represent magnified images). The scale bars are 10 μm (The inset scale bars are 2 μm).

A water-soluble polymer (PVP) was electro-spun on an Al frame; diameter of PVP template is ca. 1 μm. The use of conductive Al frame allows that generation of electric field between nozzle and Al frame, so one could form random/aligned free-standing PVP network. Maximum size of the Al frame used in this work is 4 in. As mentioned in Experimental Section, electro-spun polymer template was annealed at 150 °C for 1 h to promote welding of individual fibers. Note that the junctions of polymer fibers were welded as revealed in Figure S1c.

SEM analysis of the metal nanotrough network on a glass

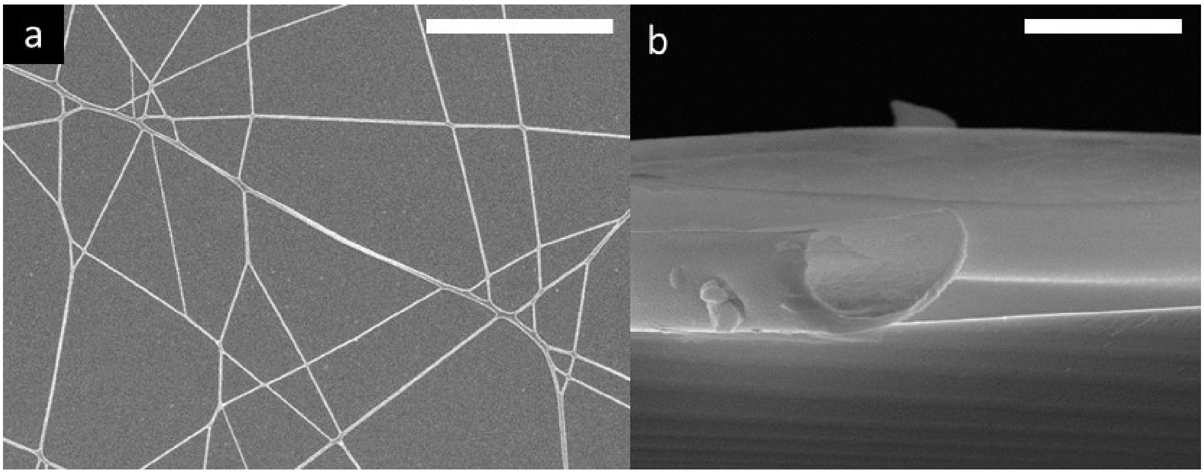
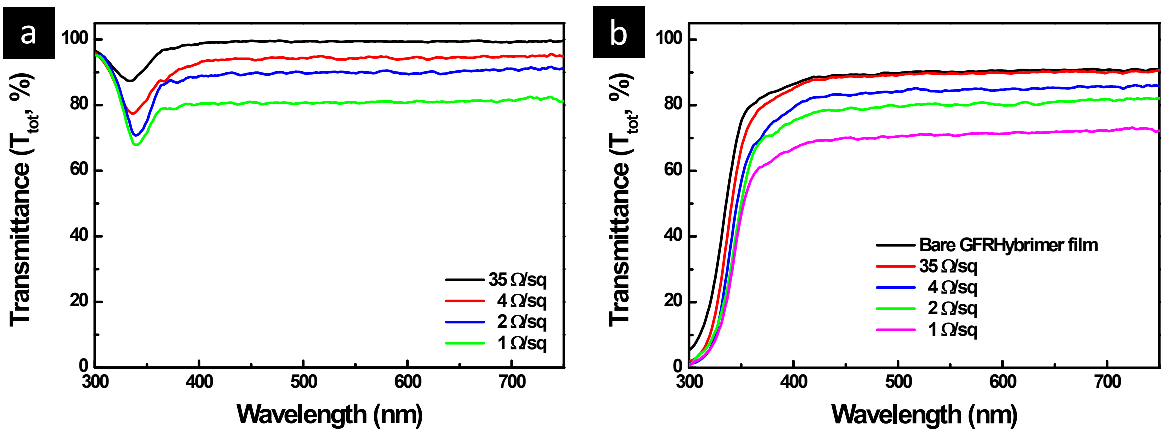


Figure S2. SEM images for metal nanotrough on a glass. (a) Top and (b) cross-sectional view. The scale bars are 50 and 1 μm, respectively.

The metal nanotrough network is continuous. The diameter of the metal nanotrough is ca. 1 μm.



Optical transmittance spectra of the metal nanotrough-GFRHybrimer films

Figure S3. Total transmittance spectra of the metal nanotrough-GFRHybrimer films with varying R_{sh} values. (a) Base-line with bare GFRHybrimer film, and (b) ambient air.

Opto-electrical performance of the metal nanotrough-GFRHybrimer films according to the electro-spinning time

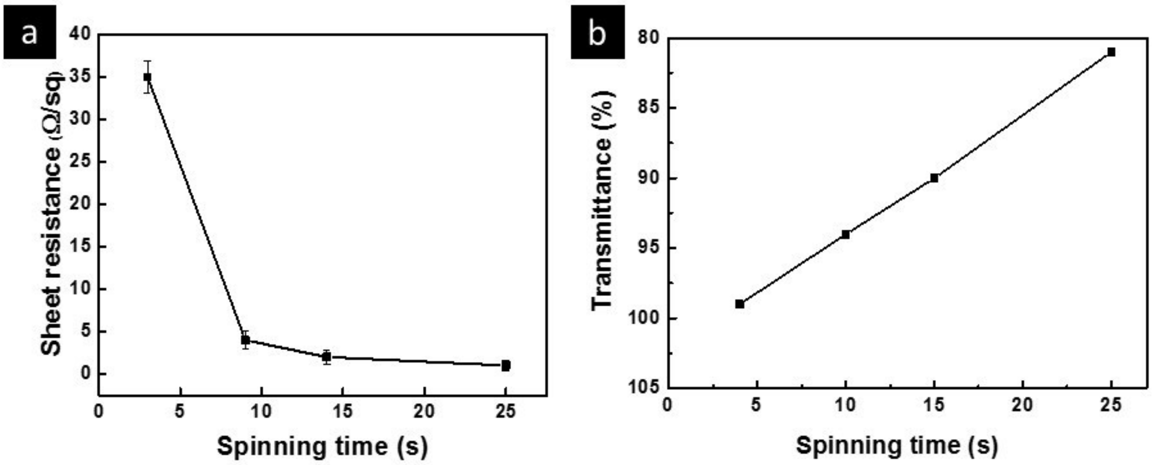
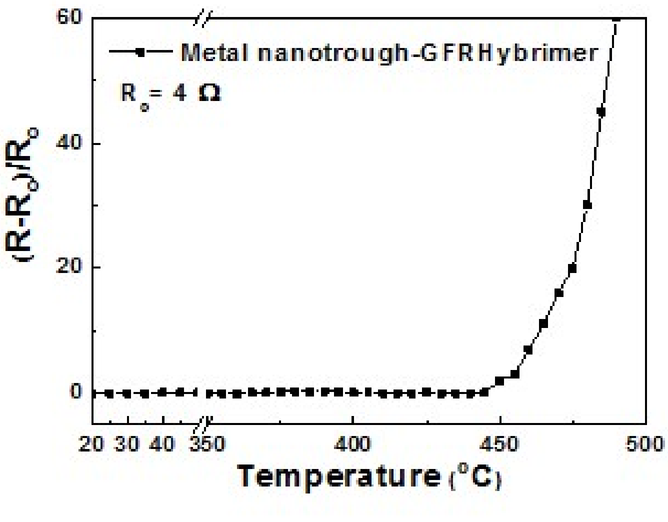


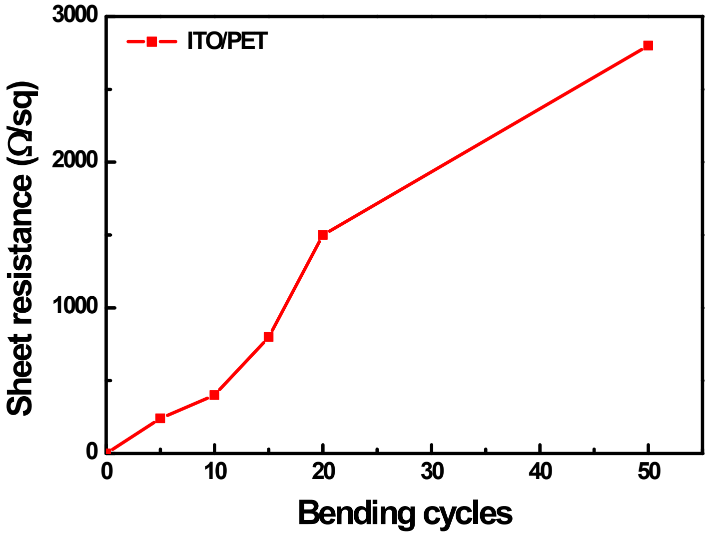
Figure S4. Sheet resistance (a) and transmittance (b) of metal nanotrough-GFRHybrimer films as a function of spinning time.

Note that the surface coverage of the metal nanotrough network can be controlled by electro-spinning time of polymer template. A longer electro-spinning time results in a denser metal nanotrough network. As increasing electro-spinning time, the metal nanotrough-GFRHybrimer films exhibit better electrical uniformity.



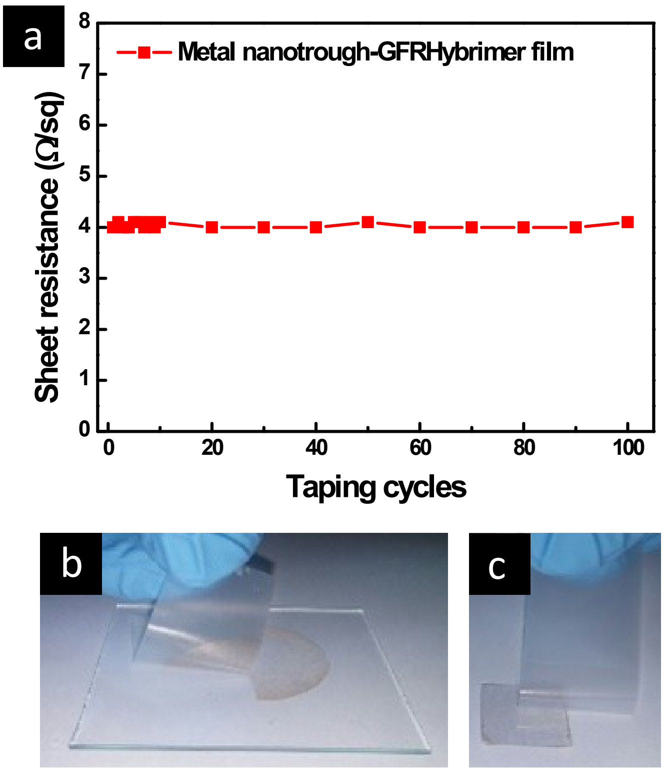
Thermal stability of the metal nanotrough-GFRHybrimer film with elevating temperature

Figure S5. Normalized R_{sh} values of the metal nanotrough-GFRHybrimer film with elevating temperature (ramp rate = 5 ^{o}C min^{-1}). R_{sh} was maintained up to 440 ^{o}C and then increased rapidly.



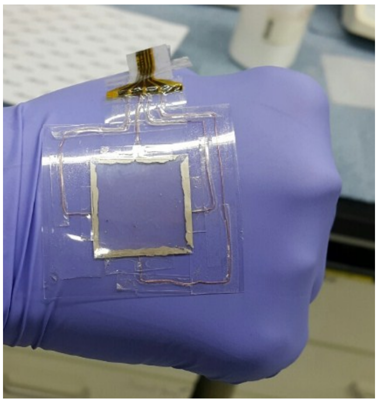
Mechanical stability of the reference ITO/PET

Figure S6. Bending test result of commercial ITO/PET sample. Bending radius is 1 mm.



Adhesion stability of the metal nanotrough-GFRHybrimer film

Figure S7. (a) 3M tape test result of the metal nanotrough-GFRHybrimer film. Test images of (b) the metal nanotrough on glass, and (c) the metal nanotrough-GFRHybrimer film. Note that the metal nanotrough on glass sample shows delamination of TCE network after taping.



Touch screen panel device

Figure S8. Fabricated touch screen panel on a back of a human hand.

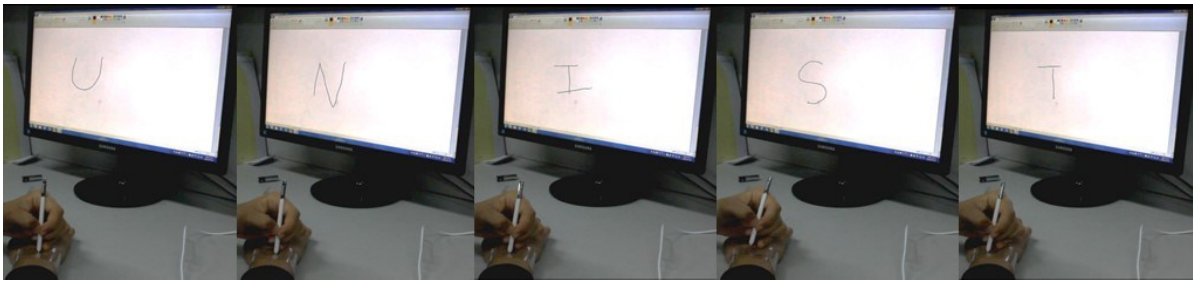


Figure S9. Photographs for the operation of the TSP device integrated on the wristband. Written characters are "UNIST".