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**Electronic Supplementary Information (ESI) for**

# Biocompatible, optically transparent, patterned, and flexible electrodes and radio-frequency antennas prepared from silk protein and silver nanowire networks

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**Fabrication process of a patterned AgNW network in a silk film**

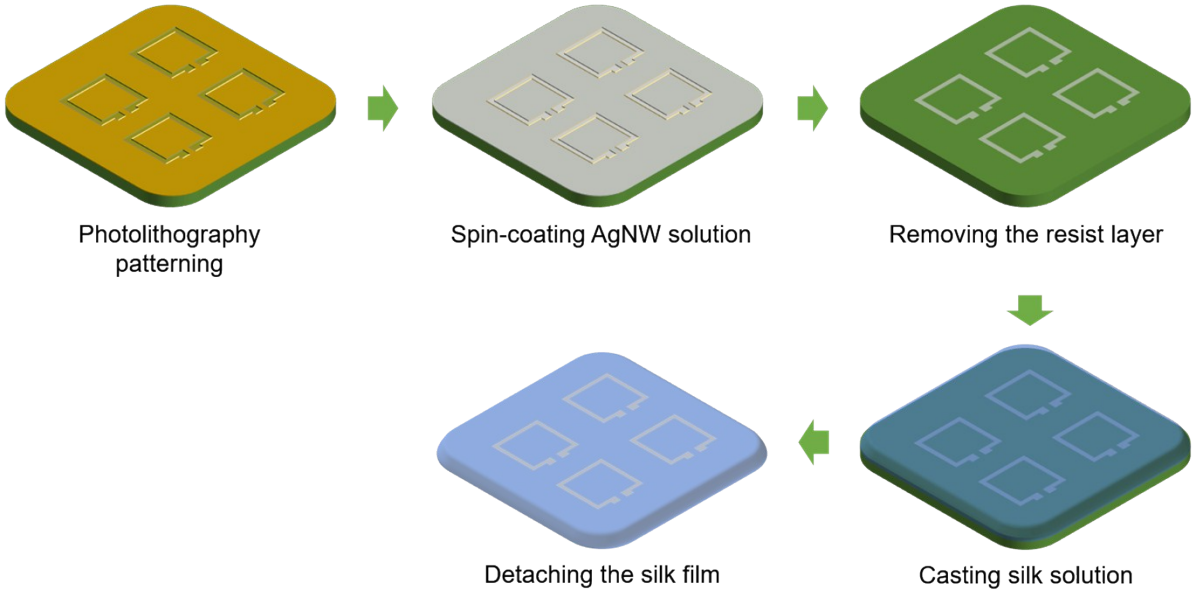


**Fig. S1.** Schematic diagram of the fabrication process.

**FDTD simulation of transmission and haze factor**

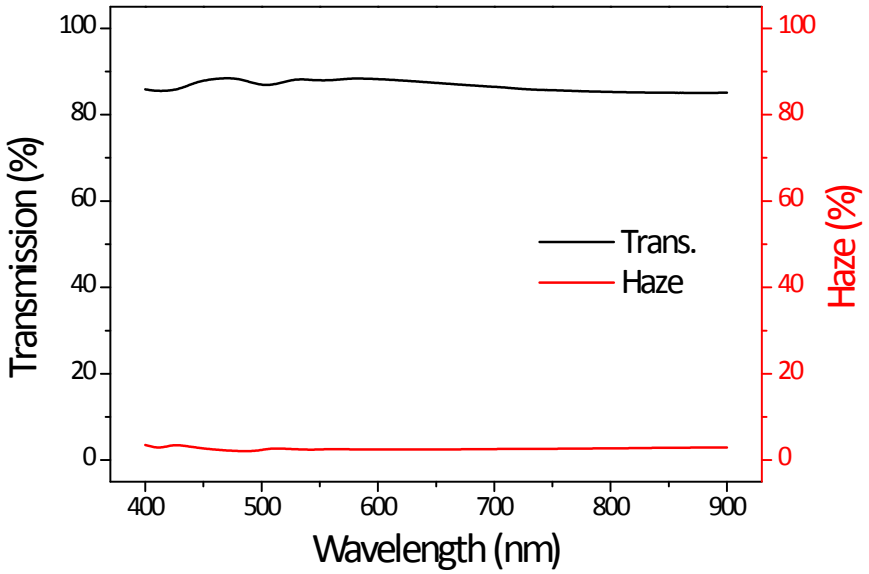


**Fig. S2.** FDTD simulation results of transmission (black line) and haze value (red line) of a AgNW embedded in the silk film. The diameter of the AgNW is 40 nm.

**Adhesive test between the silk and AgNWs**

A simple and straightforward adhesive test, which is commonly known as the "Scotch tape test" was performed. We used a sticky 3M tape for the adhesive test, and the appearance and the sheet resistance of the film remained nearly unchanged after the tape test.

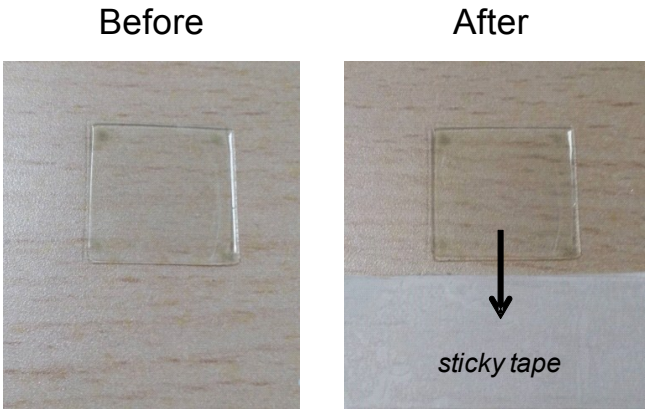


**Fig. S3.** Adhesive test using a sticky 3M tape. The buried AgNW network was not damaged before (left) and after (right) the tape test.

**Table S1.** The sheet resistance of the buried AgNWs network through repetitive Scotch tape tests. The sheet resistance of the film was well-preserved.

| Adhesive test (times) | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| **Sheet resistance (Ω/sq)** | 37.6 | 39.9 | 38.3 | 39.2 |

**Mechanical stability of the AgNW–silk surface conductors**

The mechanical stability of a AgNW network in silk was investigated by subjecting the sample to 1,000 cycles of bending. The bending radius was 7.5 mm, half of the length of one side of the square sample. As shown in Fig. S4a, the sheet resistance of AgNWs of all densities was well-preserved after the bending test, demonstrating their mechanical stability in the silk matrix.

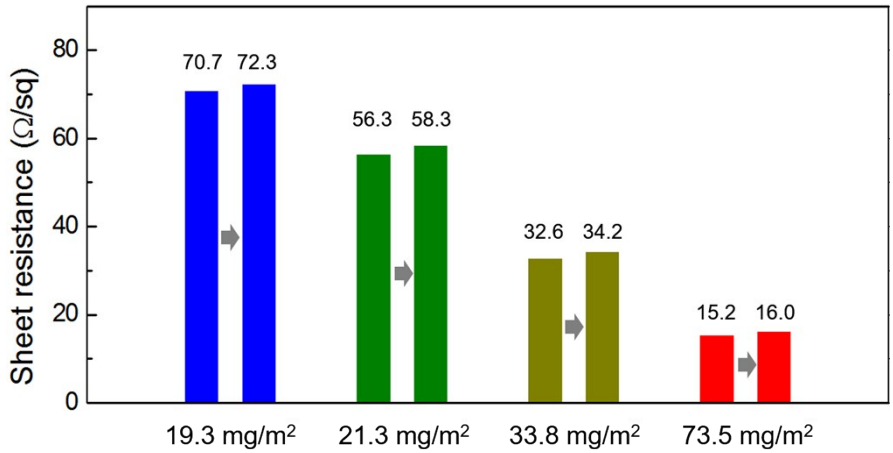


**Fig. S4a.** Mechanical stability of the AgNW network in a silk matrix. The sheet resistance of AgNW networks coated on silk samples at all densities was well-preserved after 1,000 cycles of bending.

The performances, including sheet resistances and optical transmissions through bending tests, of silk/AgNWs films with various thicknesses were also investigated. The thicknesses of films were 45, 70 and 100 μm, respectively, which were controlled by changing amounts of the drop-casted silk solution. As shown in Figs. S4b (sheet resistance) and S4c (optical transmission), performances of silk/AgNW films were not affected by their thicknesses.

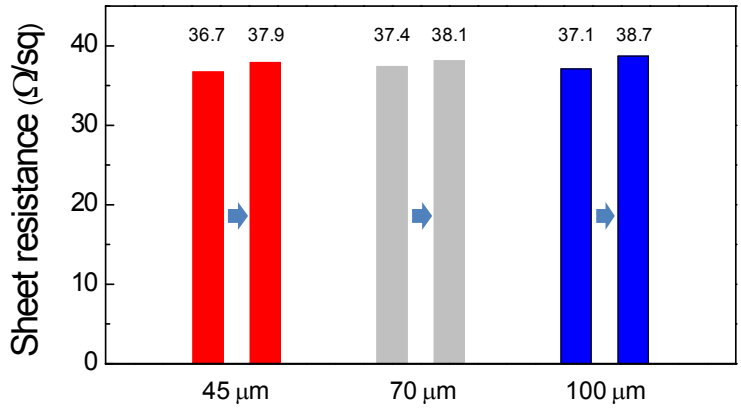


**Fig. S4b.** Mechanical stability of AgNW networks buried in the silk film with thicknesses of 45, 70 and 100 μm. The sheet resistances of AgNW buried silk films were nearly preserved after 1,000 cycles of bending.

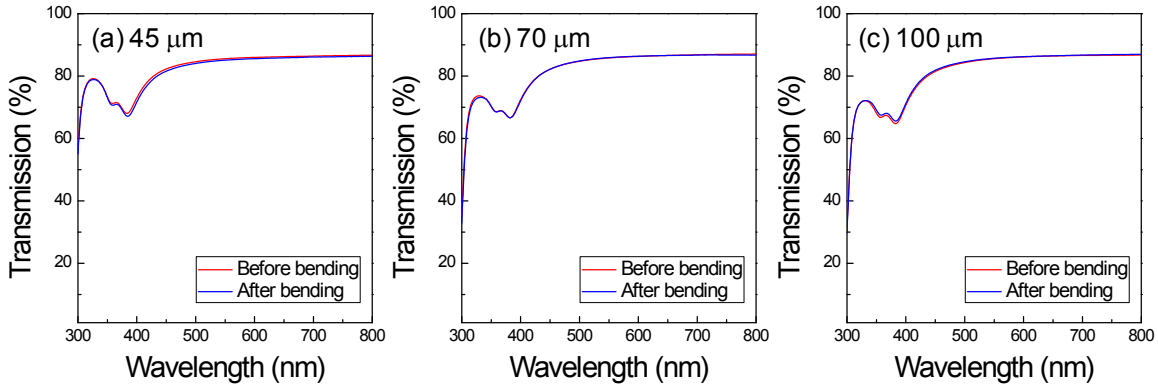


**Fig. S4c.** Transmission spectra of the AgNW buried silk films with thicknesses of 45, 70 and 100 μm. The optical transmissions of the AgNW buried silk films were well-preserved after 1,000 cycles of bending.

**Comparison of simulated and measured reflectance patterns of a loop antenna**

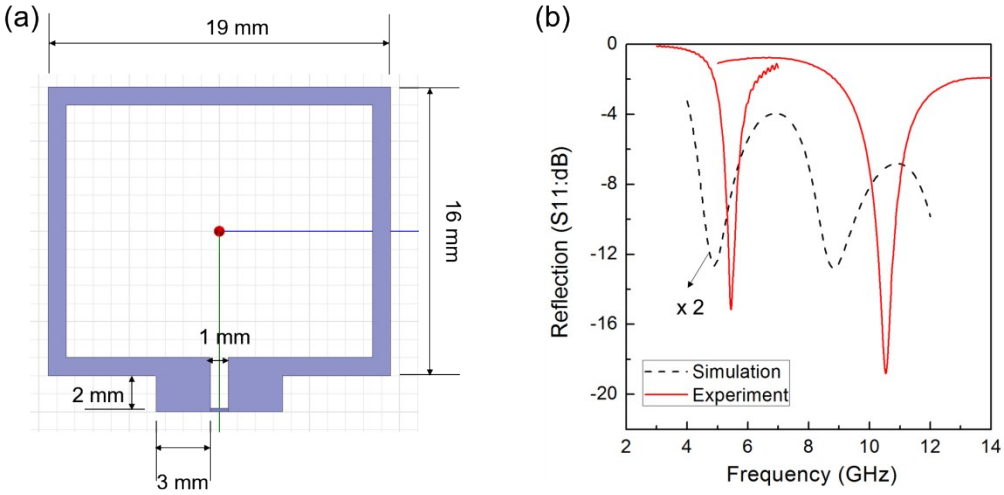


**Fig. S5.** (a) Schematic of a simple loop antenna. (b) Comparison of measured (red solid) and simulated (black dashed) reflection of the AgNW–silk RF antenna.

**Flexibility and frequency shifting of the AgNW–silk RF antenna**

We performed bending tests on the RF antenna on a curved surface to confirm its flexibility. Bending the RF antenna on the curved surface shifted its resonant frequency to a higher value, and the resonant frequency returned to the initial value after the RF antenna was removed from the curved surface. This change in the resonant frequency was due to the reduction in effective dimensions of the RF antenna after bending. The experimental results showing the shift of the resonance were confirmed by a simulation of the antenna reflection.

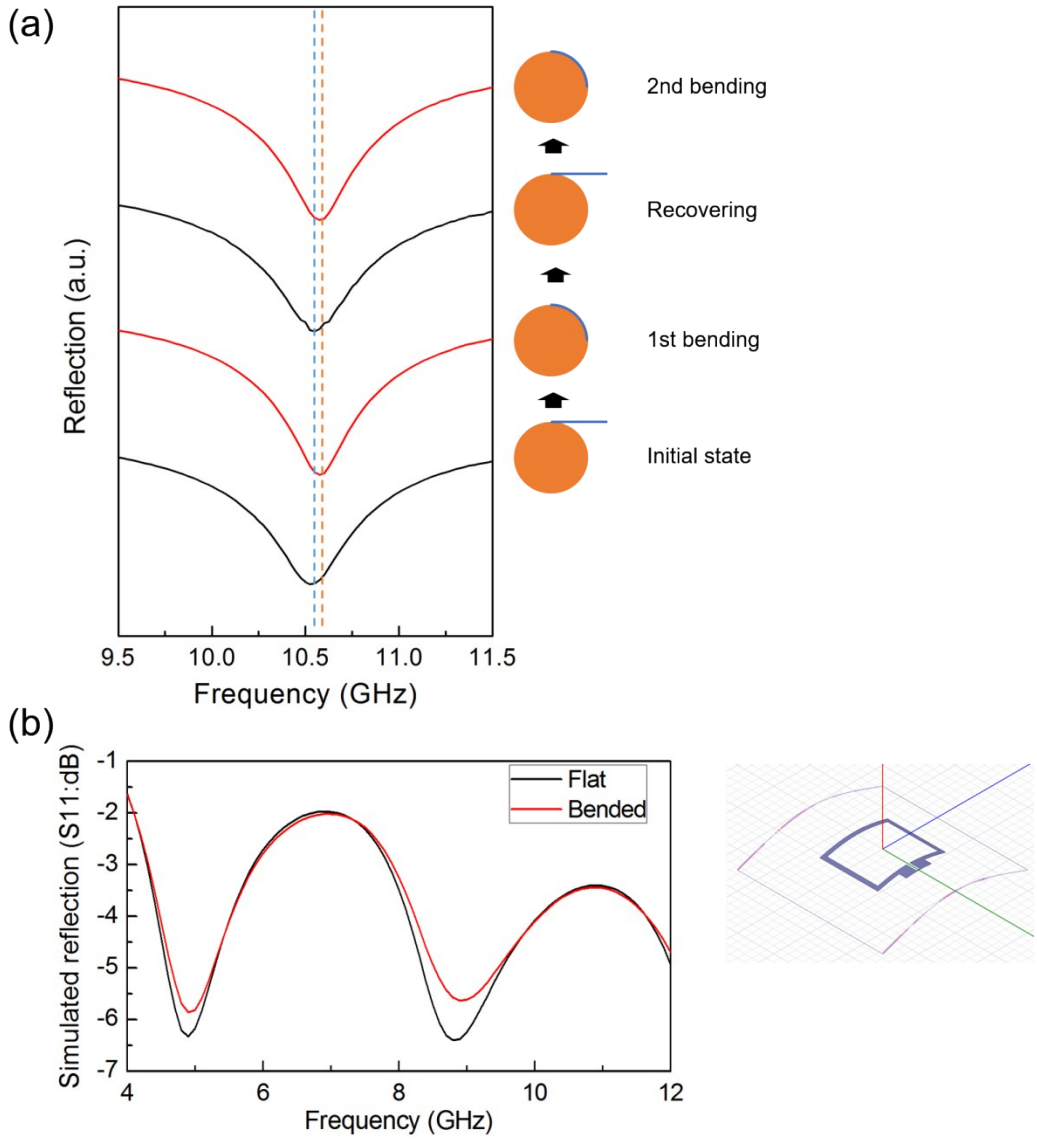


**Fig. S6.** (a) Reflection of the AgNW–silk RF antenna. The resonant frequencies before and after bending were consistently preserved during two cycles of bending. (b) Simulated reflection of the RF antenna before (black line) and after (red line) bending. A bending radius of 30 mm was used in the simulation.

**Response of the RF antenna on the surface with larger curvature**

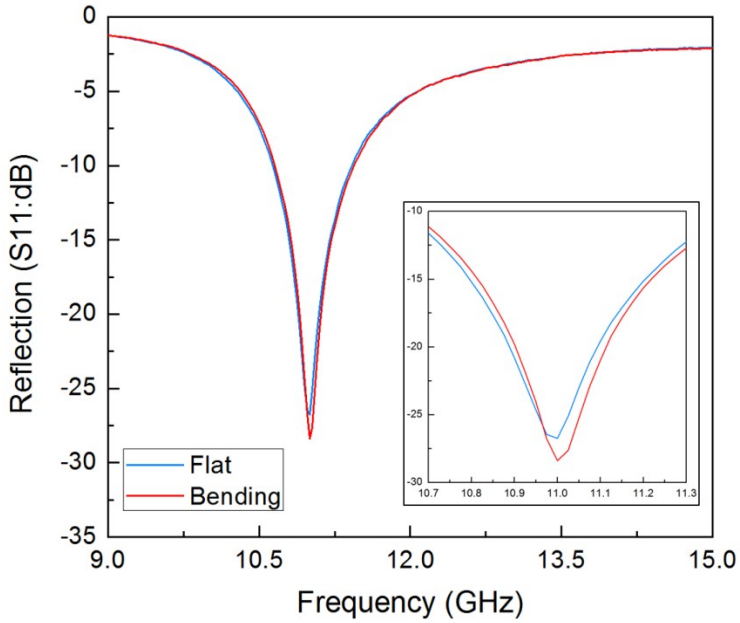


**Fig. S7.** Reflection of the RF antenna on a surface with a radius of curvature of 90 mm, which is larger than that shown in Fig. 3d, before (blue line) and after (red line) bending.

**Corrosion test of the AgNWs**

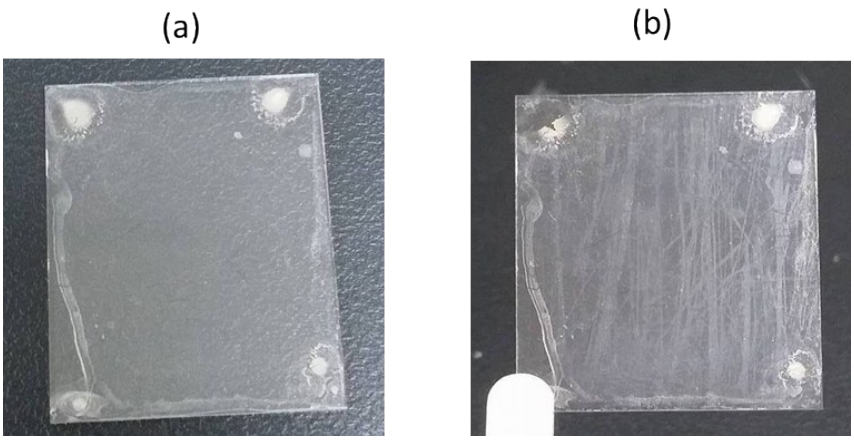


**Fig. S8.** Photographs of the AgNW-coated glass substrates (a) before and (b) after the sample was exposed to spoiled chicken.