SUPPLEMENTARY INFORMATION

Planar Inverted Cone Antenna based on Silver Nanowire Network with Enhanced Interfacial Adhesion after Surface Functionalization using (3-Glycidyloxypropyl)trimethoxysilane

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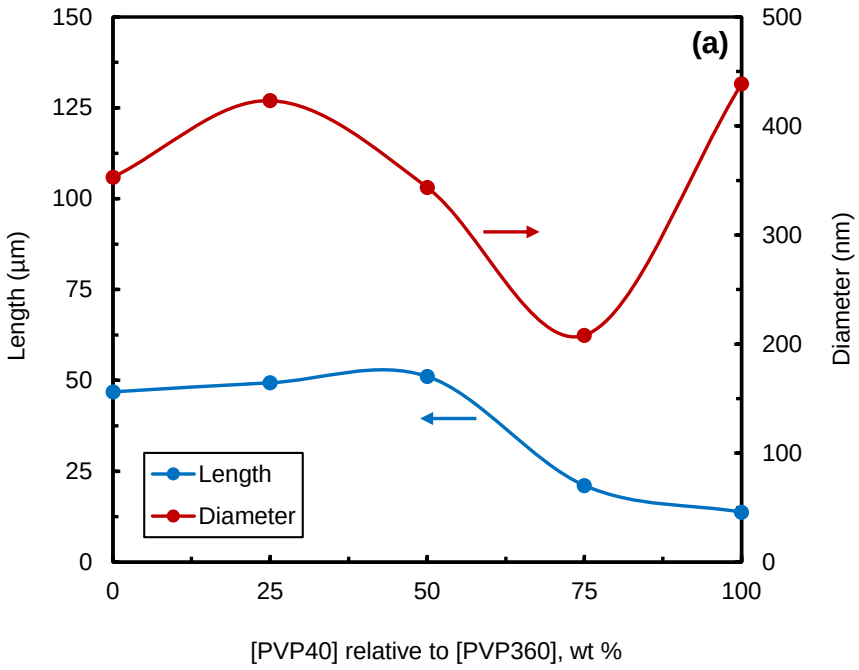
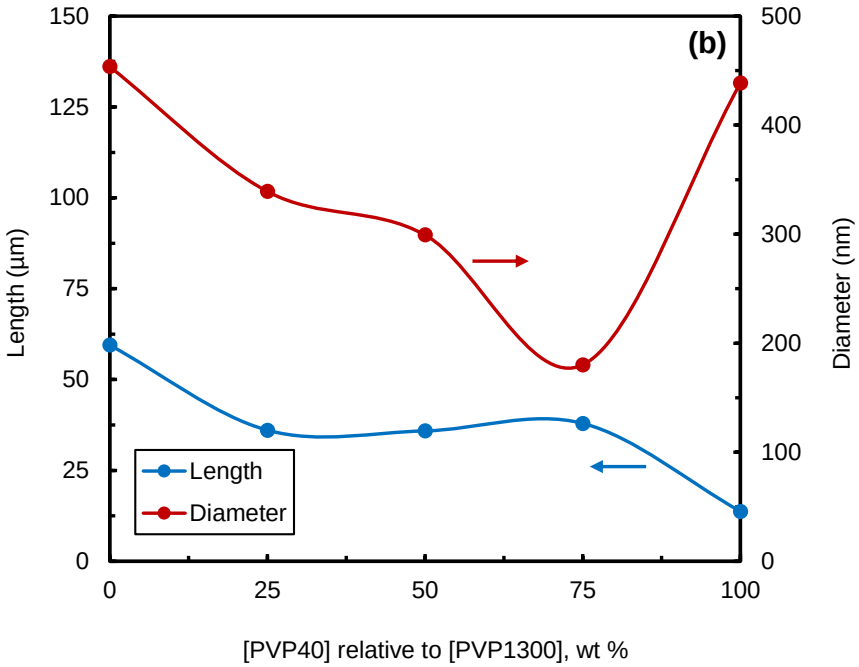
Synthetic Optimization of AgNW

Three different molecular weights of polyvinylpyrrolidone (PVP) were initially employed in the synthetic optimization reactions of silver nanowire (AgNW) to achieve a higher aspect ratio. These molecular weights are 40, 360, and 1,300 kDa (abbreviated by PVP40, PVP360, and PVP1300, respectively). The concentration of $AgNO_3$, PVP and $FeCl_3$ were maintained at 0.12 M, 0.18 M, and 0.18 mM, respectively. A combination of low and high molecular weight was targeted for each of these reaction, with w/w ratio combinations of 1:3, 1:1, and 3:1. The resultant length and diameter were analysed using scanning electron microscopy (SEM) and are described in Figure S1.





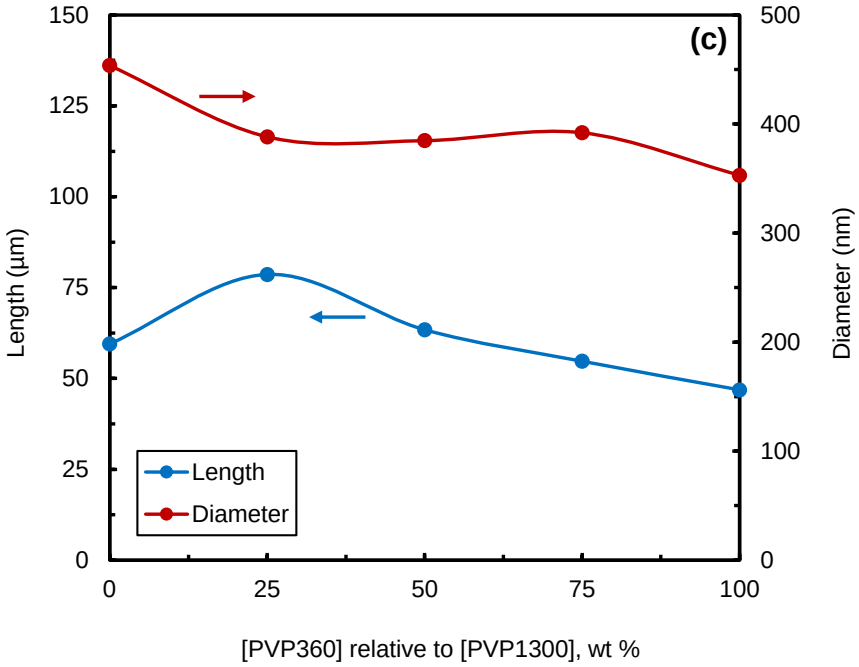


Figure S1. Average length (blue line) and diameter (red line) of AgNWs obtained by adjusting the weight ratio between (a) PVP40 and PVP360, (b) PVP40 and PVP1300, and (c) PVP360 and PVP1300. The x-axis shows the weight percentage of the lower molecular weight PVP, in comparison to the higher molecular weight PVP.

The next step in the optimization process involved varying the concentration of $FeCl_3$ (Figure S2) between 0.09 to 1.80 mM, while maintaining the concentration of $AgNO_3$ and PVP at 0.12 M and 0.18 M, respectively. Subsequently, the ratio between PVP and $AgNO_3$ was varied between 1.0 and 7.5 (Figure S3), while maintaining the concentration of $AgNO_3$ and $FeCl_3$ at 0.12 M and 0.18 mM, respectively.

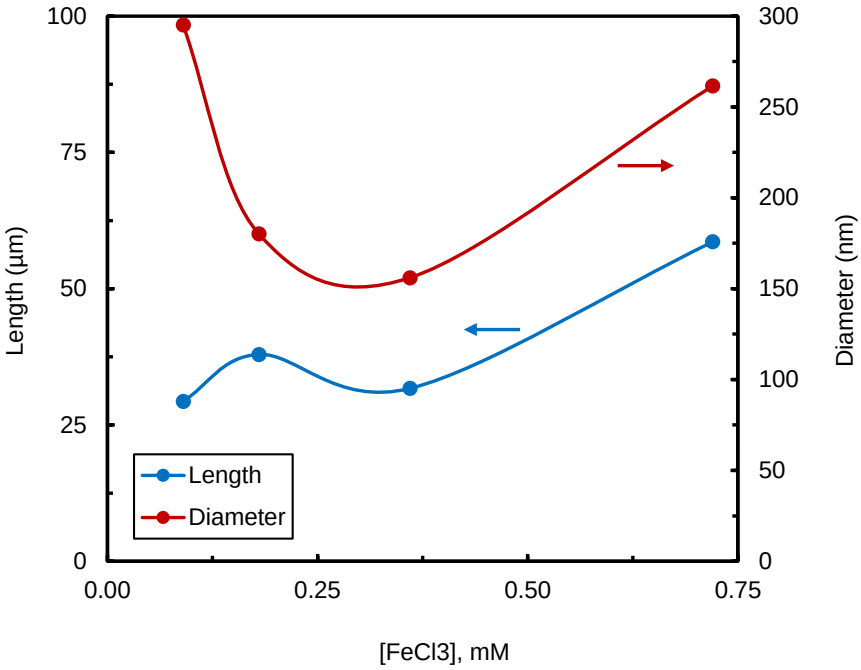


Figure S2. Average length (blue line) and diameter (red line) of AgNWs resulting from varying the concentration of $FeCl_3$ in the reaction mixture between 0.09 and 0.72 mM. Only silver nanoparticles were obtained at 1.80 mM and thus the length and diameter were not reported in the plot.

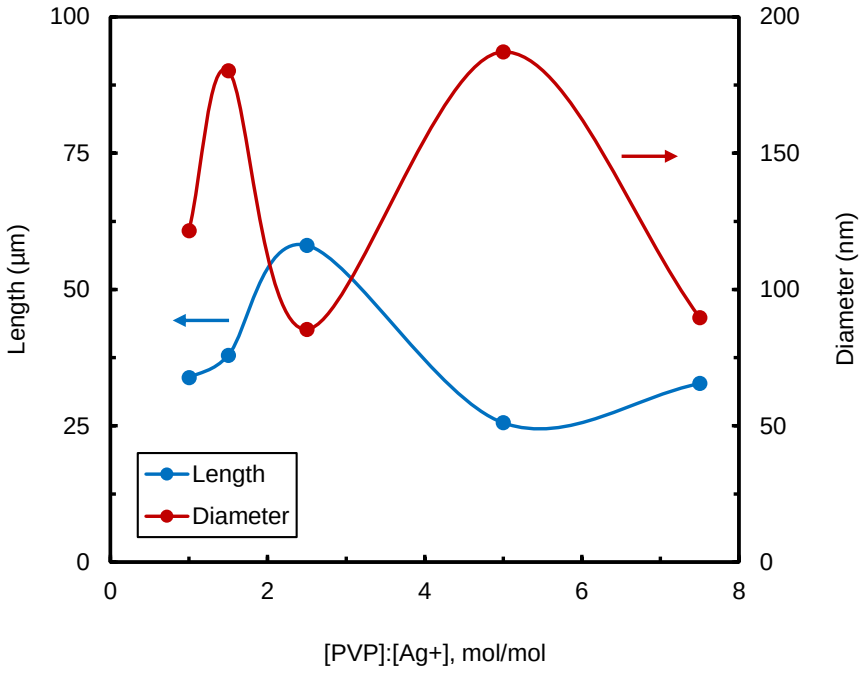


Figure S3. Average length (blue line) and diameter (red line) of AgNWs obtained where the ratio between PVP and the silver precursor $AgNO_3$ was varied between 1.0 and 7.5.

SEM Micrographs of AgNW

The final optimized AgNWs have an average length of 58±19 µm and an average diameter of 85±16 nm. SEM micrographs of these AgNWs are show in Figure S4 below.

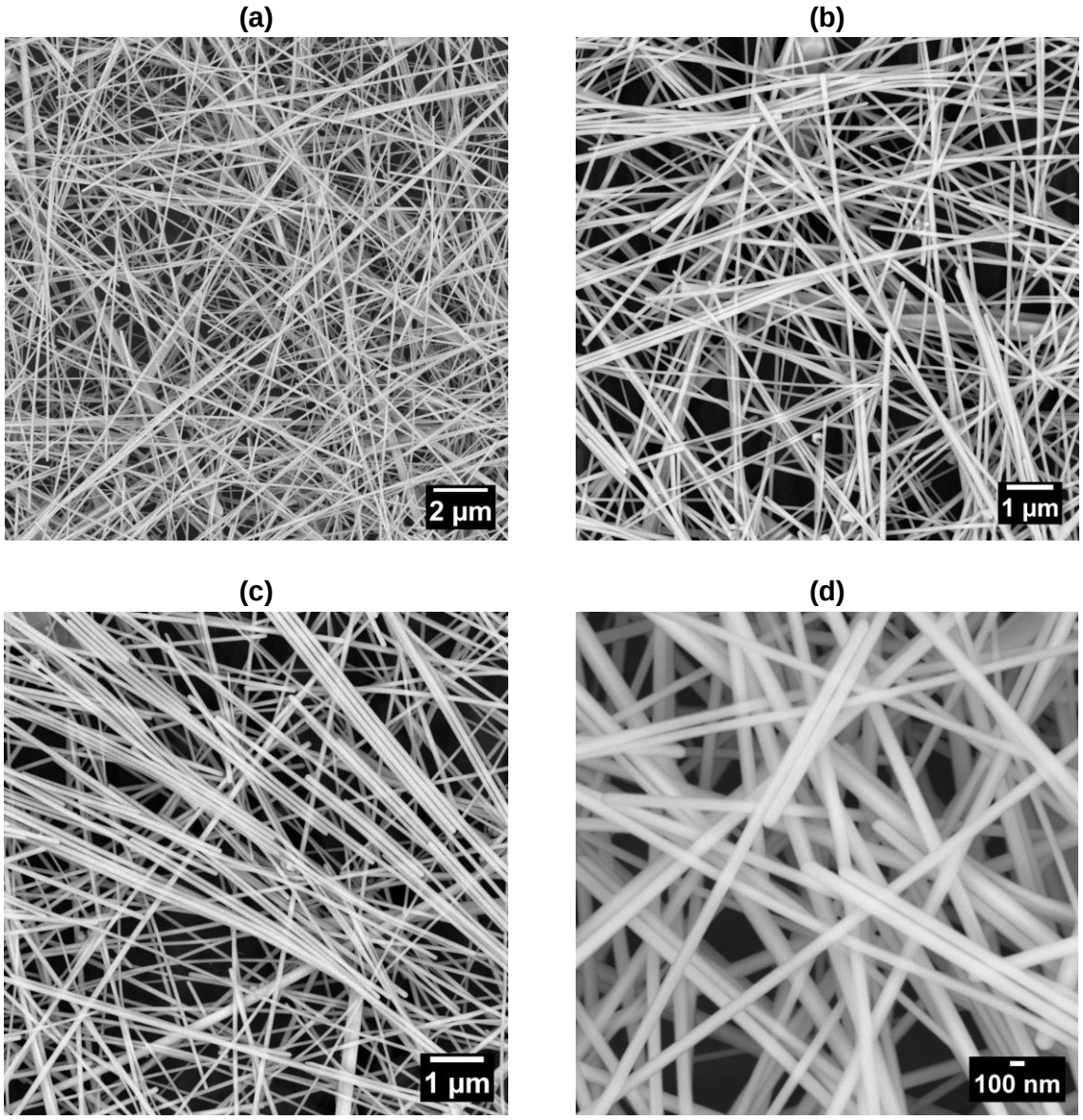


Figure S4. SEM micrographs of optimized AgNW obtained from an Apreo field emission scanning electron microscope (FESEM). These AgNWs have an average length and diameter of 58 µm and 85 nm, respectively.

To improve interfacial adhesion, the AgNW was treated with (3-glycidyloxypropyl)-trimethoxysilane (GPTMS). However, at high concentration of silane, this can have an adverse effect on the overall conductivity of the AgNW network, and thus a simple plasma treatment process can be used to remove the upper layer of silane to expose the AgNWs, while leaving a lower layer of silane to maintain interfacial linkage between the AgNWs and the substrate. This plasma treatment was investigated at three different standoff heights of 1, 1.5, and 2 cm, and the resulting effect of this is shown in Figure S5.

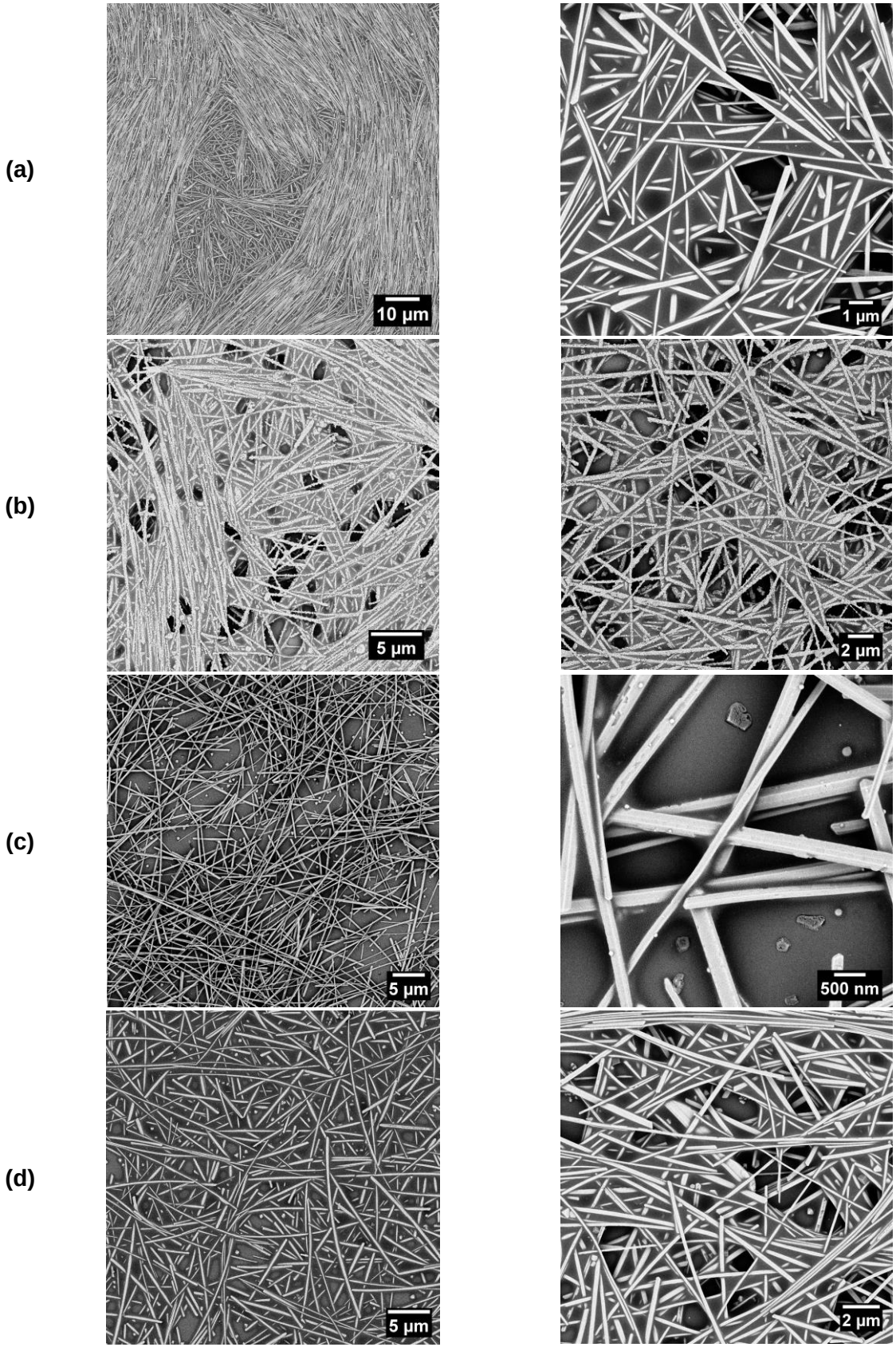


Figure S5. SEM micrographs of GPTMS-treated (1 vol%) AgNW films with (a) no treatment of plasma, and one pass of atmospheric plasma treatment with standoff distance of (b) 1 cm, (c), 1.5 cm, or (d) 2 cm.

Mechanical Peel Testing of AgNW Networks

The GPTMS-treated AgNW networks were coated at three different working areal densities of 0.08, 0.27, and 0.53 mg.cm^{-2}. GPTMS was incorporated at four different concentrations of 0.1, 0.5, 1.0, and 2.0 vol% to determine its effect on interfacial adhesion. Once coated, five cycles of peel testing was performed on the AgNW and the images of resultant AgNW films are demonstrated in Figure S6.

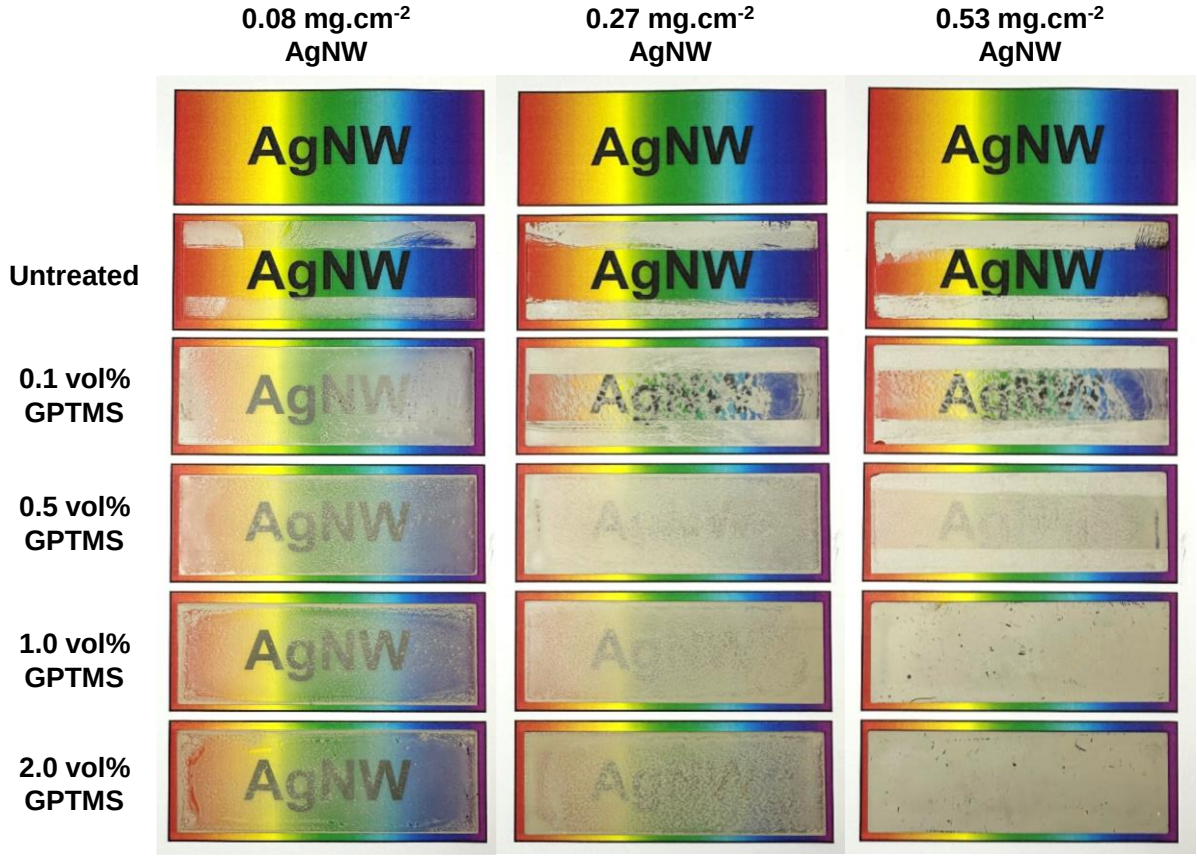


Figure S6. Images of GPTMS-treated AgNW networks after 5 cycles of peel testing. Comparison is shown between three different areal concentrations of AgNW (0.08, 0.27, and 0.53 mg.cm^{-2}) and four different concentrations of GPTMS (0.1, 0.5, 1.0, and 2.0 vol%). Untreated AgNW is completely removed from the glass substrate after 5 peel cycles.