Supporting Information for

Graphene-Silver Nanowire Hybrid Films as Electrodes for Transparent and Flexible Loudspeakers

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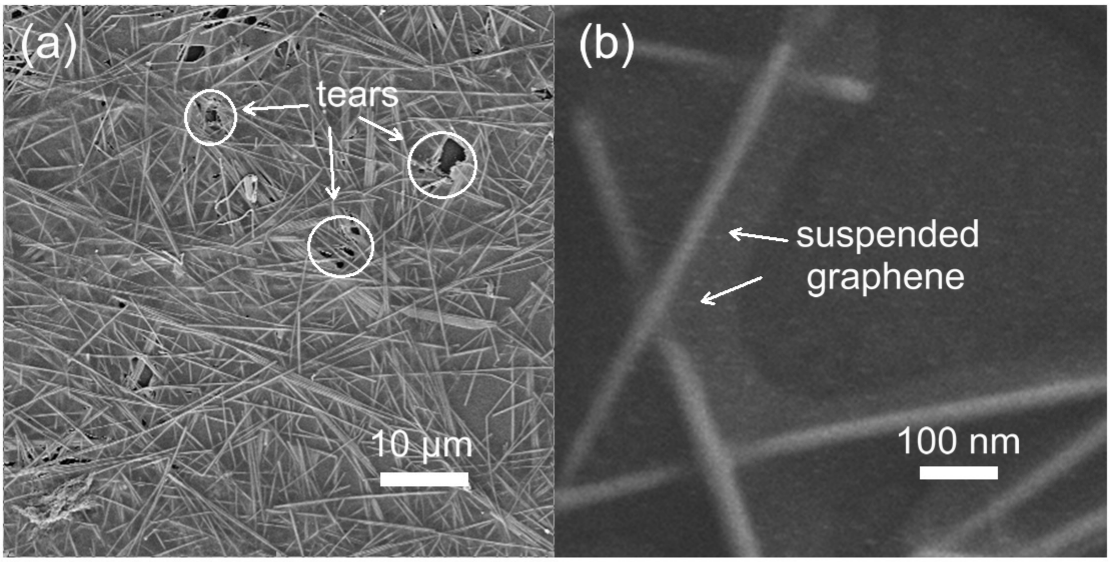

Figure S1. (a) FESEM image of the hybrid film transferred by a traditional wet transfer process. This transfer process result in poor quality transferred graphene. Many cracks or tears were formed, which would result in worsened transport properties of the hybrid film. (b) High-magnification FESEM image of hybrid film. The suspended graphene were present around AgNWs, especially in AgNW junctions.

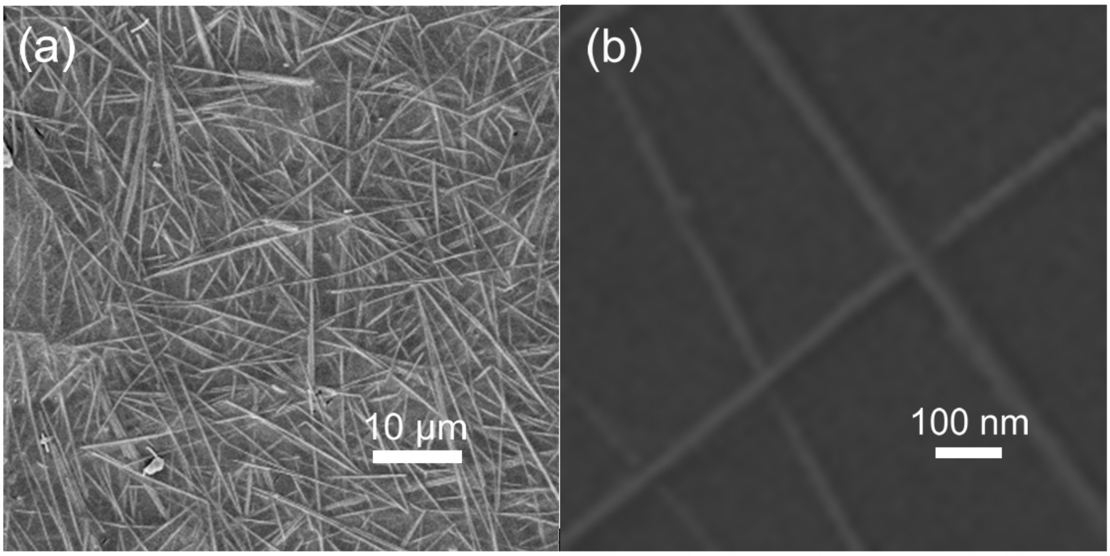

Figure S2. (a) FESEM image of the hybrid film transferred by the modified transfer method. In this transfer process, no damaged graphene was observed in the hybrid film, which can be attributed to the introduction of a second PMMA coating on the precoated PMMA/graphene/NW film. The redissolution of the precoated PMMA tends to mechanically relax the underlying graphene, leading to a better contact with surface morphology of the underlying AgNWs. (b) High-magnification FESEM image of hybrid film by the modified transfer method. No suspended graphene were present around AgNWs, even in AgNW junctions. The graphene layer follows the curvature of the underlying AgNWs, providing more intimate contact between graphene and AgNWs.

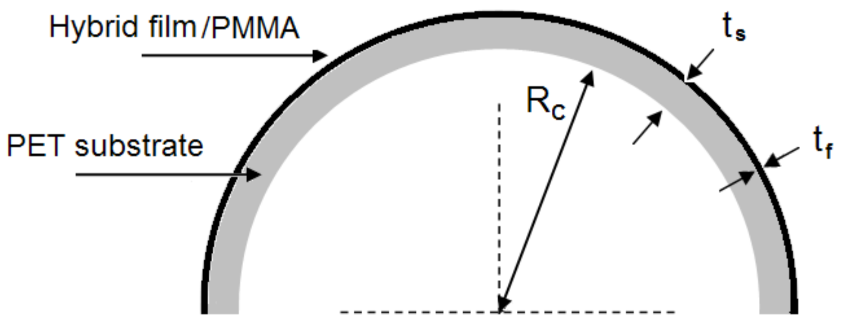

Figure S3.Schematic of PET substrate coated by hybrid film at bending condition.

Strain (%) = $F\,(t_s + t_f)/2R_C$ (1)

$F= (1+2t_r+Y_r t_r^2)/\,(1+Y_r t_r)$ (2)

$t_r=t_f/t_s$ (3)

$Y_r=Y_f/Y_s$ (4)

where R_C is the radius of curvature, t_s is the thickness of PET substrate, t_f is the thickness of hybrid film, Y_s is the Young's modulus of substrate and Y_f is the Young's modulus of hybrid film

if $t_s >> t_f$, F= ~1

In our case, the PMMA and hybrid film is only hundreds of nanometers thick and PET substrate is 300 µm. Therefore, PET thickness alone is used in the tensile strain calculation. We can simply use F=1 in the case of thin film on a thick PET substrate. The parameter and equations used to calculate the strain are from Ref. S1.

S1. Suo, Z.; Ma, E.Y.; Gleskova, H.; Wagner, S.; Mechanics of Rollable and Foldable Film-on-Foil Electronics. Appl. Phys. Lett. 1999, 74, 1177-1179.

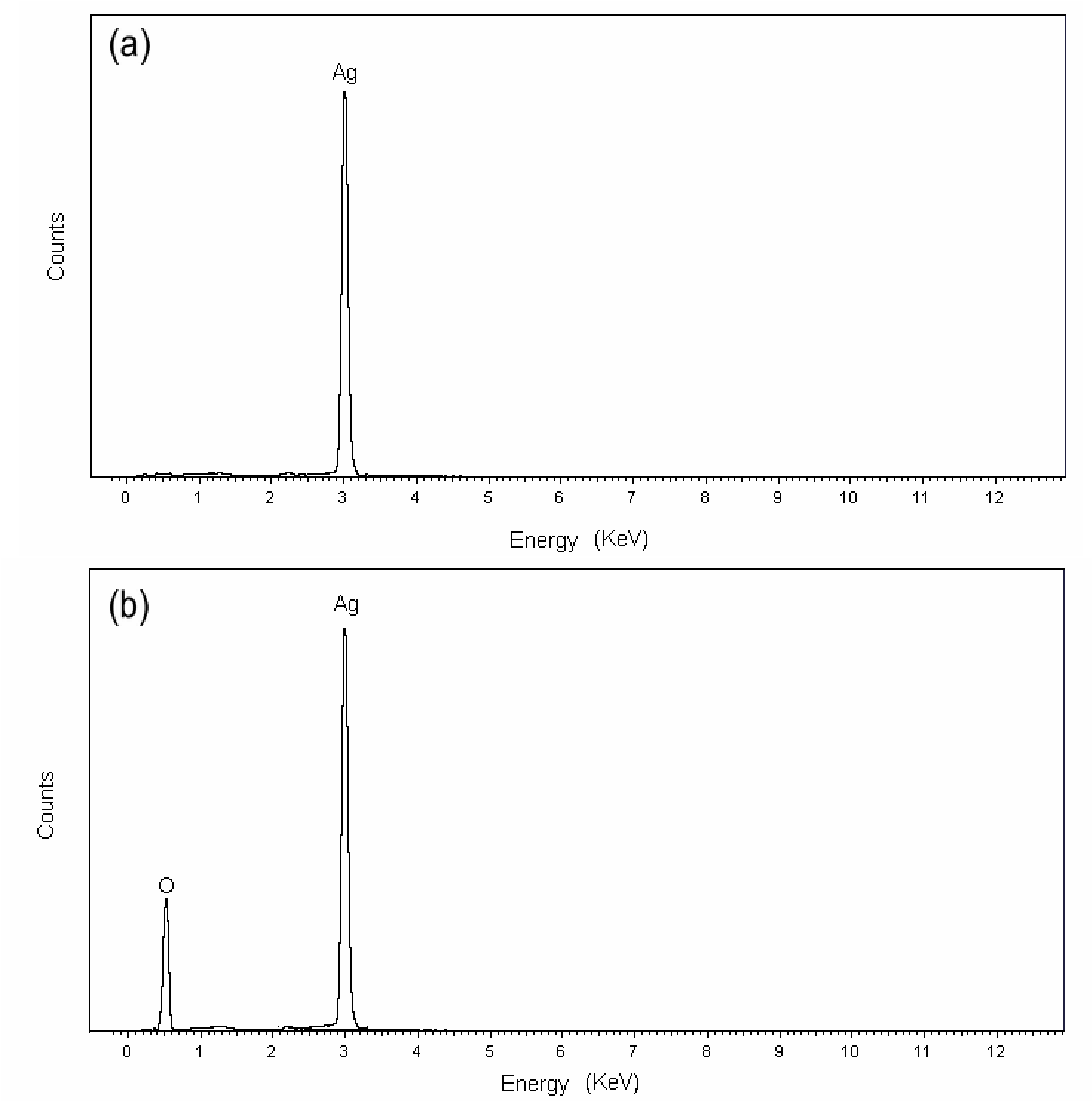

Figure S4. EDS measurements of AgNW film (a) before and (b) after of the thermal oxidation stability test. The existence of oxygen confirms formation of silver oxides.

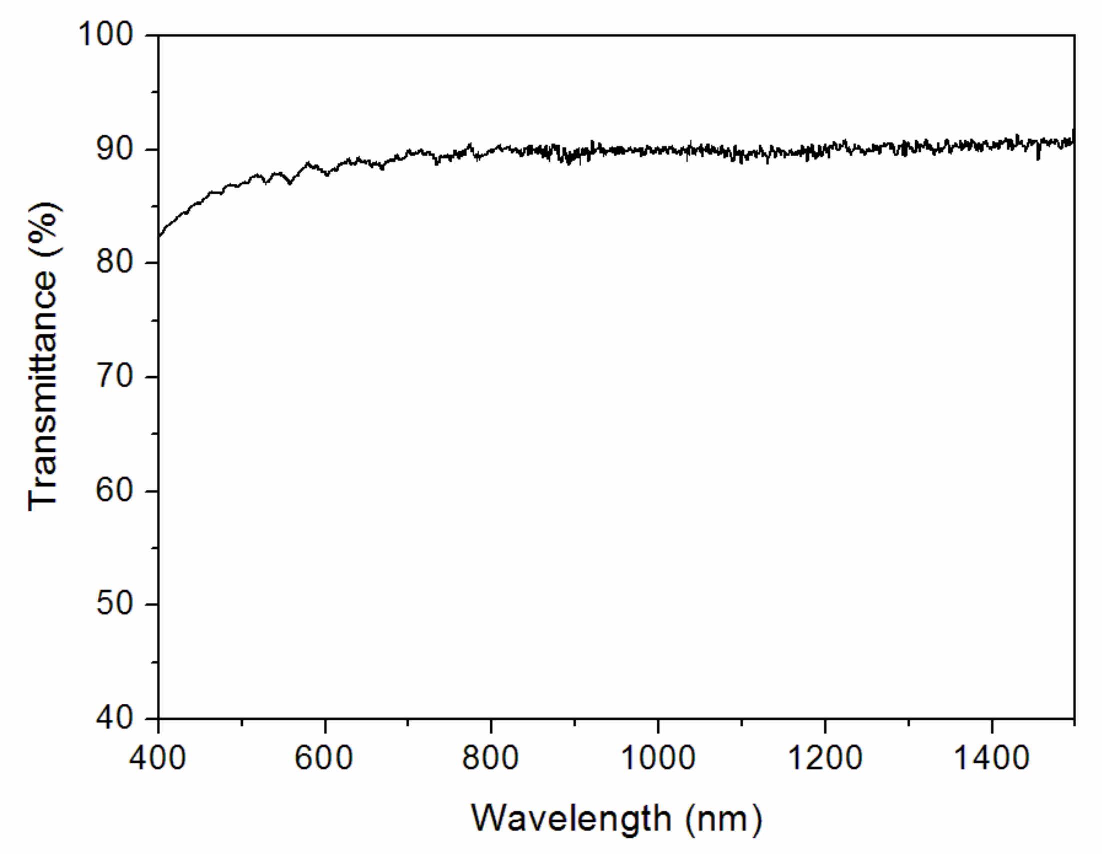

Figure S5. Transmittance of the compound structure of PMMA/PVDF/PMMA, showing a transmittance of 87 % at 550 nm.

In order to understand the contributions to $T_{loudspeaker}$ for one-layer PVDF film and two-layer PMMA, we coated only PMMA layer on both side of PVDF film (PMMA/PVDF/PMMA structure) and measured its transmittance.