**Supplementary Data**

**Free-standing nanocomposites with high conductivity and extensibility**

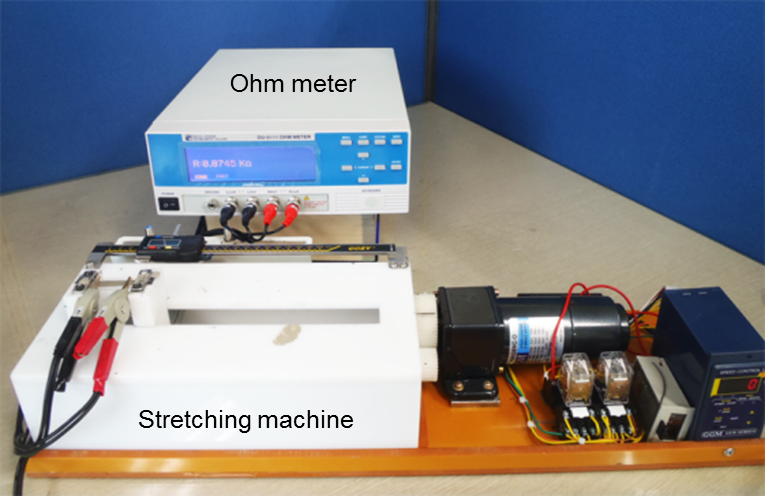
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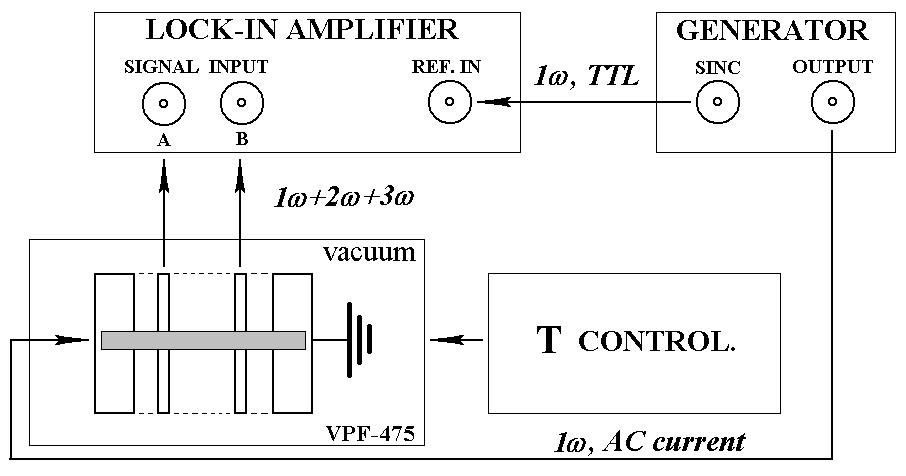
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**Figure S1.** Apparatus used for electrical conductivity measurements as a function of applied tensile strain.



**Figure S2**. Schematic diagram of measurement setup for *3****ω*** method.

**Thermal conductivity and electrical resistivity measurements:**

The thermal conductivity and thermal diffusivity of CNT composite were measured using the self heating 3-omega method. At low frequencies the 1D heat flow can be expressed in the terms of the third-harmonic voltage signal *U3ω* induced by an AC current *Io∙sinωt* applied through the elongated sample (metallic wire, carbon fiber, nanotube or bundle, yarns or sheet). The AC current with frequency *ω* creates a temperature fluctuation in the specimen at double the driving frequency, *2ω*. The interaction of the *2ω* modulated resistance *R* with the *1ω*current will create a third harmonic response on the potential electrodes [S1],

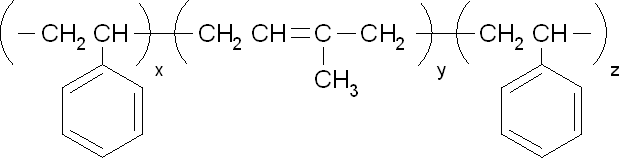
, (1)

where *I=UI /R* is the applied constant–amplitude AC current, *R* is the specimen resistance between the current electrodes, *R′=(dR/dT)* is the temperature gradient of the resistance at room temperature, *L* is the distance between potential electrodes, *S* is the cross-sectional area of the sample, *κ* is the thermal conductivity, *γ=L2/π2∙α* is the characteristic thermal time constant of the specimen for the axial thermal process, and *α = κ/ρ∙Cp*as defined above is thethermal diffusivity. The diffusivity can be obtained from the frequency dependence of the phase lag of the third-harmonic signal,

, (2)

or from the frequency dependence of the *3ω* signal, *U3ω*, from the Eq. (1). For thin and long specimens in the low frequency limit one obtains the thermal conductivity,

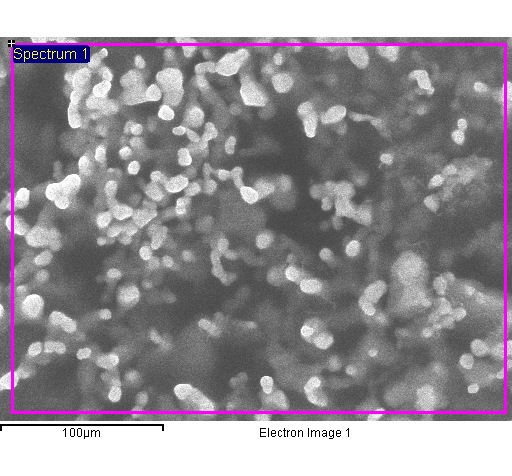
. (3)



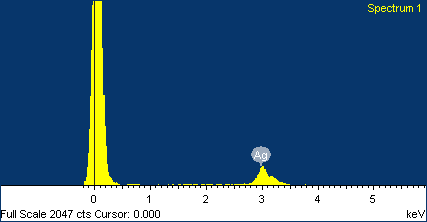


**Figure S3.** The chemical structure of the polystyrene-polyisoprene-polystyrene (SIS) polymer (top) and the stress-strain curve (bottom) of this SIS polymer, MWNT-SIS, and Ag-MWNT-SIS composites where the strain is engineering strain.

**a**



**b**



**Figure S4.** Data on the structure and composition of AMSN films in which Ag nanoparticles are mixed with MWNTs in a SIS matrix. The area bordered by the pink line in the SEM micrograph of (Fig. S2a) was characterized by energy dispersive X-ray analysis (EDS) (Fig. S2b). The concentration of Ag nanoparticles in this composite film was 29 vol% in the dried film corresponding to the 34 wt% of Ag in the initial mixture.



2 wt%

1 wt%

3.5 wt%

0.3 wt%



7 wt%

**Figure S5.** The morphology of composite (MWNT-SIS) films according to the concentration of MWNTs.The homogeneous MWNT films are prepared with blending with an ionic liquid and the polystyrene-polyisoprene-polystyrene (SIS) copolymer. However, the film is cracked from 3.5 wt%. The diameter of all glass petri-dishes is 5 cm.



**Figure S6.** Film resistance as a function of the concentration of MWNTs.

The concentration of MWNTs versus a SIS copolymer including ionic liquid is presented. The weight ratio of an ionic liquid versus MWNTs was 2.5 and the weight of SIS was 2.6g in the initial mixture.

**Movie S1.** Movie picture of the operation of PC fan using AMSN film as an electronic interconnect, where this film is strained up to 30% during fan operation.

**Reference**

[S1] Lu L, Yi W and Zhang DL, *3ω* method for specific heat and thermal conductivity measurements 2001 Review of Scientific Instruments **72** 2996.