Supporting Information for

THz Analysis of $CH_3NH_3PbI_3$ Perovskites Associated with Graphene and Silver Nanowire Electrodes

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S1. XRD curves of $MAPbI_3$ measured at room temperature and after annealing at 90 °C

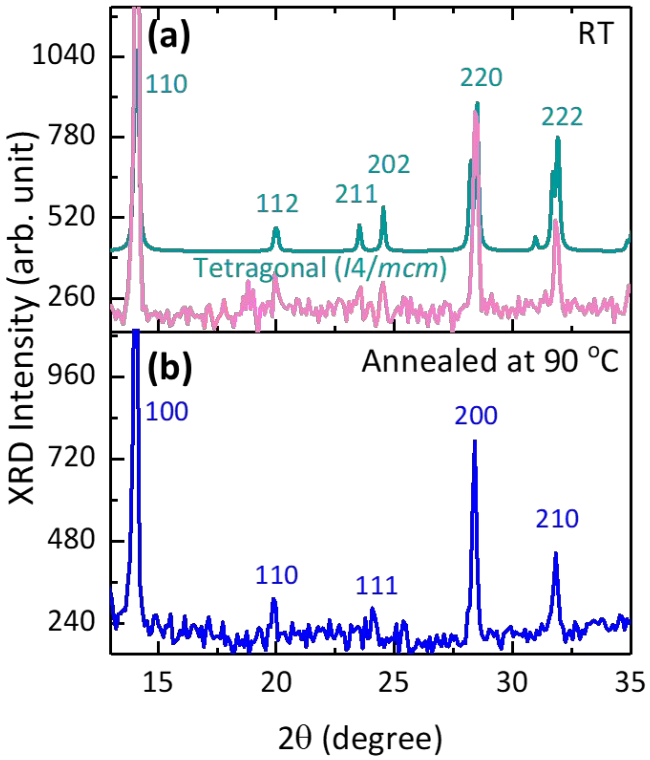

Figure S1. X-ray diffraction curves of as-grown $MAPbI_3$ measured **a.** at room temperature and **b.** after annealing at 90 ℃ in ambient atmosphere. The indexed peaks are for tetragonal phase (a) and cubic phase (b) of $MAPbI_3$. Green curve in **a** is the calculated result of $MAPbI_3$ with the tetragonal *I*4/*mcm* symmetry for comparison purposes.

S2. TEM image of $MAPbI_3$/AgNWs and $MAPbI_3/Al_2O_3$/AgNW systems

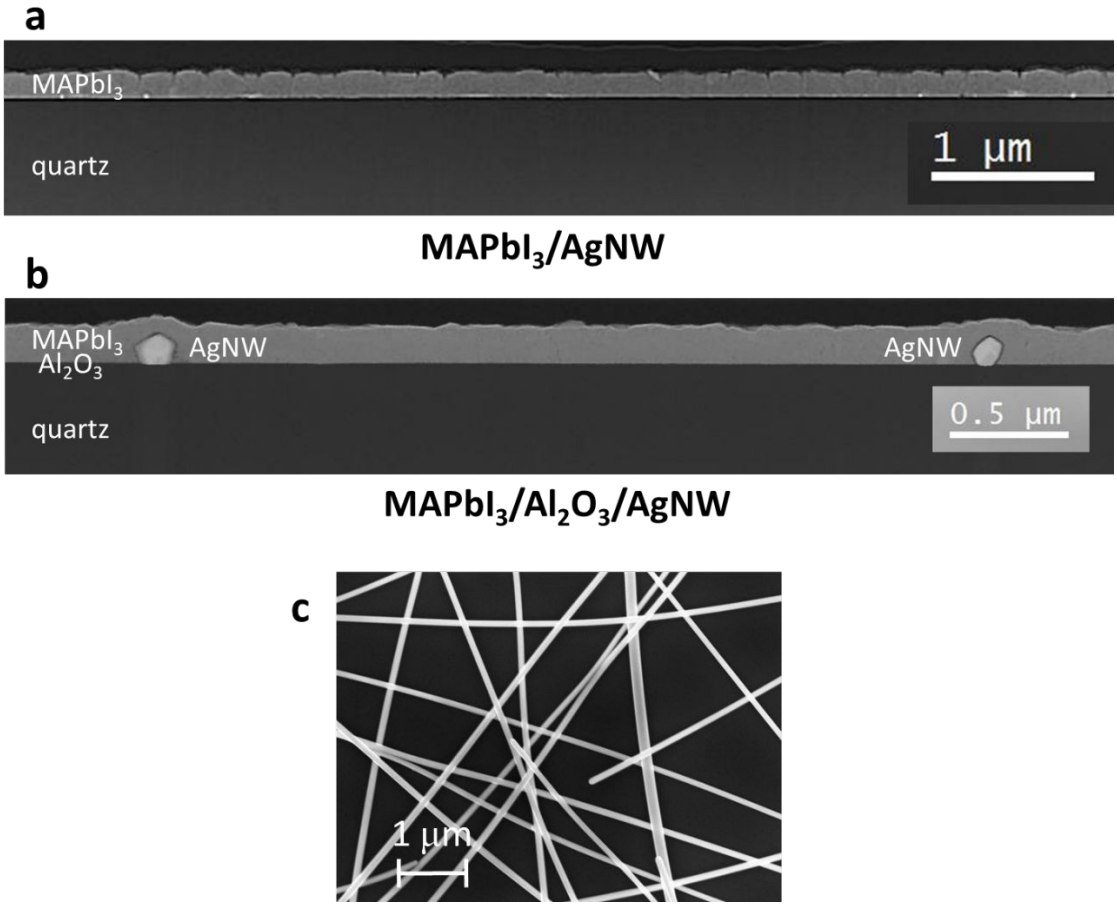

Figure S2. Cross-sectional TEM images of **a.** $MAPbI_3$/AgNW and **b.** $MAPbI_3/Al_2O_3$/AgNW taken at least two days after fabrication due to the preparation process of TEM measurement. While pentagonal AgNWs are clearly observed in $MAPbI_3/Al_2O_3$/AgNW, no trace of AgNWs can be found in $MAPbI_3$/AgNW. Instead, there are clear grain boundaries running through the film in $MAPbI_3$/AgNW. **c.** SEM image of typical AgNW layer.

Table S1. The electrical conductivity (σ) of AgNW layer covered by different thickness (*d*) of Al_2O_3 layer measured by the Hall measurement system.

d	0 nm	1 nm	5 nm
σ ($\times 10^3$ S/cm)	1.2	4.0	3.4

The electrical conductivity of 1-nm Al_2O_3/AgNW is about 20 % larger than that of 5-nm Al_2O_3/AgNW. It is also larger than the bare AgNW network since the commercial AgNWs are capped by a thin polyvinylpyrrolidone layer and the ALD process at the temperature of 150 °C can remove it and improve the junction contact.

Table S2. The best fit parameters for Figure 3 in the text. ω_p and τ_0 for each sample are estimated from the fitting process of complex photoconductivity with Drude and Drude-Smith model[1] for $MAPbI_3/Al_2O_3$/AgNW and $MAPbI_3$/AgNW, respectively. DC conductivity (c_{DC}) at ω=0 Hz for $MAPbI_3$/AgNW is calculated from the relation, $c_{DC} = \varepsilon_0 \omega_p^2 \tau_o (1 + c)$, where c is a parameter describing the fraction of the electron's original velocity after some number of scattering events and varies between –1 and 0.[1]

Sample	$\omega_p/2\pi$ (THz)	τ_0 (fs)	c_{DC} ($\Omega^{-1}\text{cm}^{-1}$)
$MAPbI_3/Al_2O_3$/AgNW	48	18	148
$MAPbI_3$/AgNW	45	21	13

Reference

1. Smith, N.V. Classical Generalization of the Drude Formula for the Optical Conductivity. *Phys. Rev. B* **2001**, *64*, 155106–4.