Thermoelectric Properties of Bimetal-catalyzed $InGaO_3(ZnO)_4$ Nanowire

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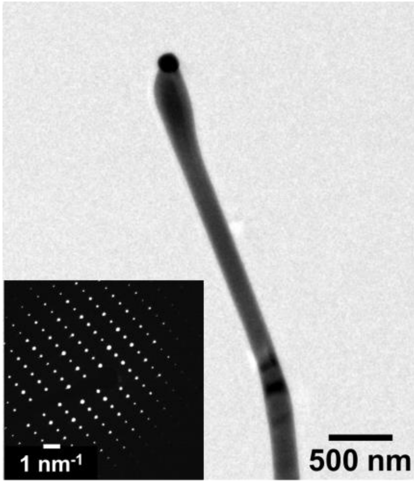
Single crystalline $InGaO_3(ZnO)_m$ NWs (IGZO NWs) are potentially promising thermoelectric (TE) materials since they possess natural superlattice structures, combining the inherent quantum confinement effects of a nanowire and the increased interface phonon scattering of a superlattice oxide thin film into a single TE material. However, very little attention has been given not only to the TE properties of IGZO NWs, but even to their mere fabrication. We have previously reported an efficient, low temperature $InGaO_3(ZnO)_4$ NW fabrication technique using a Mo/Au-catalyzed growth from amorphous thin film [1]. In this present study, the TE properties of a single IGZO NW grown via the bimetal-catalyst technique is reported. In order to measure the Sebeck coefficient (S) and electrical conductivity (σ), Pt/Ti electrodes were deposited onto a single NW via standard photolithographic techniques. A self-assembled thermal analysis system employing an infrared microscope as the thermometer, a nanovoltmeter as the heat source and a probe station connected to an SP analyzer to measure the TE properties.



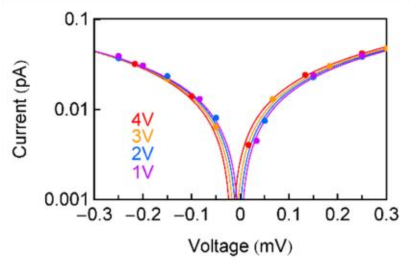


Fig. 1. (a) SEM image of IGZO NWs, (b) I-V curves at varying applied heater voltages.

Shown in Fig. 1a is a TEM image of the as-synthesized IGZO NW, with its corresponding SAED pattern revealing perfect single crystallinity. Shown as inset in Fig. 1b is the single NW device. Its corresponding I-V curves under varying applied heater voltages reveal perfectly ohmic behaviors within -0.3 to 0.3 mV, wherein their logarithmic plots are shown in Fig. 1b. The leftward shift with increasing heater voltage is typical for an n-type semiconductor. The σ of the NW sample at 298 K is 178 mS/cm. The S is -398 μV/K, which was calculated when the slope of ΔV vs ΔT was taken. The low dimensionality of the NW could have induced slight changes to the electronic density of states near the Fermi level, while the superlattice structure likely introduced potential barriers which helped in phonon scattering. The resulting power factor is then 0.0028 mW/mK^{-2}. These bimetal-catalyzed IGZO NWs could pave the way to efficient, transparent TE devices.

[1] J. C. Felizco, M. Uenuma, D. Senaha, Y. Ishikawa, Y. Uraoka, Appl. Phys. Lett. 111, 033104, 2017.