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Greatly Enhanced Photothermoelectric Voltage in Plasmonic Au Nanowires and Nanogaps[1]

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We report a study of the thermoelectric effects in plasmonic Au bowtie devices with nanoscale junctions. A laser scanning microscope is used to locally heat the metal nanostructure via excitation of a plasmon resonance and direct absorption at room temperature and at 5 K. The increase of the local temperature of the unbroken nanowire is quantified by a bolometric approach. Finite element modeling of the heat dissipation reveals that the local temperature increase of the nanowire at temperatures below 50 K is determined by the thermal boundary resistance of the metal–substrate interface. A study of spatial dependence of the photothermoelectric response in this system revealed a number of unexpected results. In nanowires shorter than the spot size of the laser beam we observe a thermoelectric voltage distribution that is consistent with the local Seebeck coefficient being spatially dependent on the width of the nanowire. In longer structures we observe extreme variability of the net thermoelectric voltage as the laser spot is scanned along the length of the nanowire, including multiple sign reversals and sensitivity to the metal grain structure and surface conditions. In the nanowires with tunneling nanogaps, we observe a 1000x increase in the photothermoelectric voltage up to tens of mV. We discuss a range of possible explanations for the extraordinarily enhanced thermoelectric voltage focusing on the role of nonequilibrium, "hot" carriers generated upon the plasmon excitation.

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