Photothermoelectric Response in Asymmetric Carbon Nanotube Devices Exposed to THz Radiation

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Abstract This work reports on the voltage response of asymmetric carbon nanotube devices to sub-THz radiation at the frequencies of 140 GHz through 2.5 THz. The devices contain CNT's, which are over their length partially suspended and partially Van der Waals bonded to a SiO_2 substrate, causing a difference in thermal contact. Different heat sinking of CNTs by source and drain gives rise to temperature gradient and consequent thermoelectric power (TEP) as such a device is exposed to the sub-THz radiation. Sign of the DC signal, its power and gate voltage dependence observed at room temperature are consistent with this scenario. At liquid helium temperature the observed response is more complex. DC voltage signal of an opposite sign is observed in a narrow range of gate voltages at low temperatures and under low radiation power. We argue that this may indicate a true photovoltaic response from small gap (less than 10meV) CNT's, an effect never reported before.

While it is not clear if the observed effects can be used to develop efficient THz detectors we note that the responsivity of our devices exceeds that of CNT based devices in microwave or THz range reported before at room temperature. Besides at 4.2 K notable increase of the sample conductance (at least four-fold) is observed. Better efficiency could be obtained by using graphene or graphene nanoribbons with a bandgap of few meV. Such ribbons should have a width of about 100 nm and are easy to fabricate. Based on our results we suggest schematics of efficient optoelectronic devices based on graphene nanoribbons.

To further understand our data we calculated the TEP dependence on gate voltage within a model based on ballistic transport in a 1D semiconducting channel. Importantly our model is applicable both to carbon nanotubes and graphene nanoribbons.

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