Engineering graphene for energy conversion at nanoscale

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Abstract

Many modern machines produce heat dissipation during their operations, which is lost in the environment. Energy conversion by the thermoelectric effect, that is the ability of certain materials of generating a potential difference in the presence of a temperature gradient, could principally represent a reliable solution of recovering the energy dissipated in form of heat in any device. Energy conversion efficiency by a thermoelectric material is governed by the so-called figure of merit, $ZT = S^2\sigma T/\kappa$, where S, σ, T and κ are respectively Seebeck coefficient, electrical conductivity, environment temperature and thermal conductivity. Having high electrical conductivity and low thermal conductivity, which are the results of good charge carrier transport and poor phonon transport, is an essential requirement for maximizing figure of merit, a fundamental quantity in energy conversion [2].

Two dimensional (2D) materials are known to be good candidates for thermoelectric conversion due to their fully-surface nature and dimension-dependent density of states [4]. 2D materials, especially transition metal dichalcogenides (TMDs) because of their good charge carrier mobilities and low thermal conductivities, are ideal choices for developing new energy conversion solutions and thermoelectric devices [1]. Among the 2D material family, graphene (GN), which is the most well-known 2D material, despite its excellent mobility, presents a very high thermal conductivity which limits its energy conversion efficiency, enabling it as a better material for thermal cooling purposes [5].

Anyway, it has been demonstrated that nanostructuring (i.e. a network of holes [3]) or surface functionalization (i.e. electrografting [6]) can be useful strategies to reduce phonon mean free path without affecting significantly the electron mean free path. This will allow enhancing dramatically the figure of merit. In this context, I will present here my work on the fabrication of field effect transistors (FETs) based on Van der Waals heterostructures of 2D materials followed by thermal, electrical and thermoelectric characterization, as well as optimization of figure of Merit in fabricated FETs by nanostructuring of graphene.

Keywords: energy conversion; thermoelectricity; Seebeck coefficient; two dimensional material

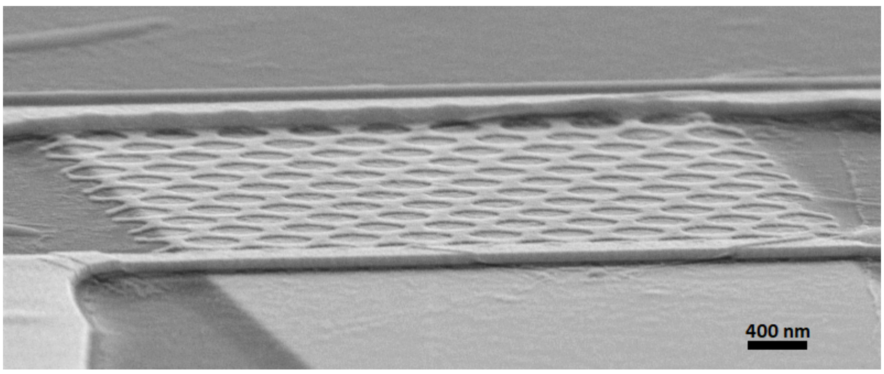

Figure 1. *SEM image of a fabricated (hBN/GN-nanomeshed)-based FET.*

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