Thermoelectric response of graphene quantum rings

Francisco Domínguez-Adame*, Marta Saiz-Bretín, Andrey V. Malyshev

Departmento de Física de Materiales, Universidad Complutense, 28040-Madrid, Spain
*adame@ucm.es

We study the thermoelectric properties of rectangular graphene rings connected symmetrically or asymmetrically to the leads. The system consists of a square graphene ring connected symmetrically or asymmetrically to two leads, as shown in the left panel of Fig. 1. We assume that the leads are two semi-infinite armchair graphene nanoribbons with $N \neq 3n-1$, N being the number of hexagons across the nanoribbon and n a positive integer. In this case the band structure has a width-dependent gap and the corresponding dispersion relation near the gap is parabolic [1, 2].

We focus our attention to the figure of merit $ZT = S^2\sigma T/\kappa$, which reflects the thermoelectric efficiency of the system. Here S is the Seebeck coefficient, and σ and κ are the electric and thermal conductances at a given temperature T, respectively. We have numerically found that the transmission patterns can be grouped into two categories, depending on the value of N. If $N = 3n-2$ the transmission coefficient displays resonant peaks, whose shape is Lorentzian close to the resonance energy for both configurations (Breit-Wigner line-shapes). A typical example is shown in the middle panels of Fig. 1, corresponding to $w = 15.0$ nm, i.e., $N = 61$, for both symmetric (dashed line) and asymmetric (solid line) rings. When $N = 3n$ the transmission coefficient strongly depends on the symmetry of the ring. As shown in the right panels of Fig. 1, for $w = 15.5$ nm, i.e., $N = 63$, the transmission coefficient for symmetrically connected rings only presents Breit-Wigner line-shapes (dashed line). On the contrary, if the ring is connected asymmetrically, the transmission coefficient shows Fano line-shapes (solid line). When the nanoribbon width is increased, the one-mode energy region shrinks, but the transmission features remain qualitatively unchanged. We observe that the figure of merit is enhanced when the chemical potential matches a Fano anti-resonance (see the peaks at about 60 and 72 meV in the lower right panel Fig. 1). We have found that such resonances can always be induced by a side-gate voltage applied between the two arms of the ring, even in symmetric rings.

References

[1] J. Munárriz, F. Domínguez-Adame, and A. V. Malyshev, Nanotech. **22**, 365201 (2011).

[2] J. Munárriz, F. Domínguez-Adame, P. A. Orellana, and A. V. Malyshev, Nanotech. **23**, 205202 (2012).

Figures

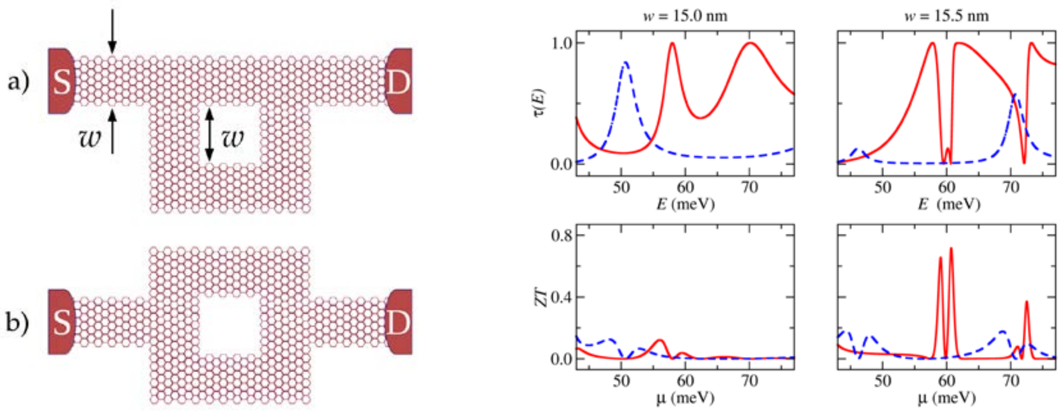

Figure 1: LEFT: Schematics of the device connected a) asymmetrically and b) symmetrically to leads. RIGHT: Transmission and figure of merit for symmetric (dashed lines) and asymmetric (solid lines) rings. Left and right panels correspond to *w*=15.0 nm and *w*=15.5 nm, respectively.