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ACTIVATION MECHANISM FOR CHARGE INJECTION IN INDIVIDUAL SINGLE-WALLED CARBON NANOTUBES

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Producing low-resistance contacts to carbon nanotubes in a reproducible manner is a crucial challenge towards the development of efficient nanotube-based electronics. A full understanding of the mechanisms responsible of charge injection through the contacts is necessary to steadily minimize their resistance. While the physics of junctions is very well-understood in the case of bulk materials, the geometry of low-dimensional structures such as nanotubes makes it a very different case, in which it is already known that the transmission of charges differs than the one for planar junctions [1].

Herein we present our recent results revealing a better identification of the mechanisms implied in carrier injection at carbon nanotube/metal contacts. We performed a thorough study of the electrical characteristics of individual single-walled nanotubes, arranged in field-effect transistors with Ti/Pd metallic top contacts. Measurements acquired over a wide range of temperature (77-400K) and for various gate and drain-source bias were used to investigate the transmission of carriers through the Schottky barrier formed at the interface between the metal and the nanotube.

Careful analysis of the temperature dependence of electrical characteristics revealed an injection behavior following an activation mechanism, instead of the expected Richardson relation for thermionic emission generalized to 1D semiconductors [2]. We discuss the interpretation underlying this mechanism, such as the contribution of intermediate localized states at the interface. The effective charge injection barrier was also extracted from the data (Fig.1). The height of this barrier was observed to decrease exponentially as a function of drain-source bias, which is consistent with an increasing tunneling component due to barrier thinning. Finally, barrier heights were measured for several individual quasi-metallic and semiconducting nanotubes, with values respectively close to the band gap of both species.

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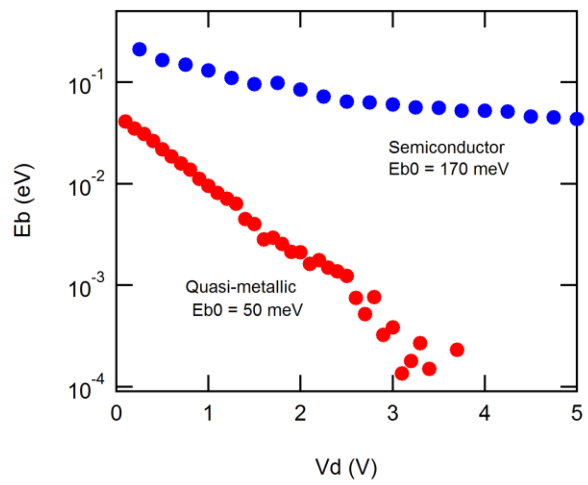

Fig.1 – Effective charge injection energy barrier (Eb) based on an Arrhenius activation mechanism, for a semiconducting and a quasi-metallic nanotube as a function of drain-source bias (Vd).

REFERENCES

[1] F. Léonard & A. A. Talin. Nature nanotechnology, 6, 773 (2011); and others.

[2] M. F. O'Dwyer, R. A. Lewis & C. Zhang. Microelectronics Journal 39, 597 (2008)