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Response to "Comment on 'Intrinsic electron transport properties of carbon nanotube *Y* junctions'" [Appl. Phys. Lett. 83, 1674 (2003)]

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In a recent letter,[1] we reported on the *intrinsic* electronic transport properties of carbon nanotube *Y* junctions. By separating the intrinsic properties of the conductor and the effect of its contact to metallic leads, we showed that a symmetric *Y* junction does *not* display a potential rectifying behavior, i.e., asymmetric transmission curves. More precisely, our results demonstrated the critical role played by the contacts in the rectification process, an effect notably overlooked by the authors of the present comment.[2,3] The issue related to the importance of the applied bias potential profile in the rectifying behavior was clearly mentioned in our original work. In the following paragraphs, we offer a brief response to the comment of Andriotis *et al.*

Recent reports in the literature underline the dramatic role played by the interface between electrodes (leads) and the nanodevice (conductor).[4] For instance, it has recently been shown that the electrical properties of junctions between a semiconducting carbon nanotube and a metallic lead dominate the overall electrical characteristics of nanotube-based field-effect transistors.[5] In order to focus on the properties of the conductor itself (i.e., its *intrinsic* properties), one usually relies on modeling. Fortunately, theoretical methods conveniently offer the possibility to separate the effects of the intrinsic properties of the conductor from the effects of its connection to metallic leads. In our letter,[1] we remove the effect of the heterogeneous contact between carbon nanostructures and metallic leads by *seamlessly* connecting the conductor to the electron reservoirs by semi-infinite nanotube leads, which possess the same structure as the branches of the *Y* junction. By doing so, we automatically account for all the structural properties and the symmetry of the junction, while removing all spurious effects due to its finite size. As expected for an undoped semiconductor, no rectification is observed. This is no longer the case when the conductor is connected to reservoirs by metallic leads, in which case a quantum dot is formed and the spatial profile of the applied potential dictates the rectification behavior.

As shown in the original letter, this effect occurs even for a straight nanotube segment connected to metallic leads, which prompted us to state[1] "Rectifying behavior will be induced by asymmetric transmission curves, provided that an asymmetric potential profile breaks the geometrical symmetry of the device." An in-depth discussion of the latter issue is found in, e.g., Ref. 6. These results, in conjunction with a detailed analysis of the density of states at the contact, unambiguously prove that the potential rectifying behavior originates from the interface between the conductor and the metallic leads (and potentially an asymmetric bias potential) and therefore is *not* an intrinsic property of the device.[1] This is not surprising, since the dominant factors inducing rectification are asymmetries in the geometry of the central conductor and in the electrostatic potential spatial profile: if no voltage drop occurs across a conductor, asymmetries in the energy spectrum or the geometry of an isolated system *alone* do not produce an asymmetric $I-V$ curve.[6,7]

In order to focus on the properties of the system *itself*, we intentionally avoided presenting $I-V$ curves, since this implies a somewhat arbitrary choice of the potential drop and would in addition require a self-consistent nonequilibrium Green's function treatment for proper description. The results of Refs. 2 and 3 are not self-consistent, are obtained using an equilibrium Green's function, and it is unclear how the applied potential drops along the nanodevice. If its profile is symmetric, nonrectifying $I-V$ characteristics are expected.[6] It should be pointed out that rectification induced by an asymmetric potential profile was explicitly discussed in our Letter, but not in the prior work[3] by the authors of the comment. Finally, it is worth noting that the prototypical systems described earlier are significantly different from the experimentally studied *Y* junctions and the present theoretical work does not apply directly to the published experimental results,[8] where the branches of the *Y* junctions have substantially different diameters.

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In summary, the discussion in our letter[1] emphasizes two points neglected in Ref. 3: (1) the importance of understanding the separate roles of the intrinsic properties of a nanodevice *and* of its connection to external leads and (2) the key effect of the potential drop profile along the device. As explained in the present response, the comment did not identify any *incorrect* or *incomplete* treatment in our original work.

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