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Electromigration Forces on Ions in Carbon Nanotubes

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Due to their unique structural, electronic, and optical properties carbon nanotubes (CNs) are promising candidates for future nanoelectronic devices. Recently, field-effect transistors (FETs) from single-wall CNs have been a research focus. In particular, ballistic transport has been demonstrated [1] and key transport parameters compare well with state-of-the-art silicon FETs.
In many cases improved CN-FET performance has been achieved by the use of dopants such as alkali metal atoms (see e.g. [2]). However, during transistor operation a current-induced, *electromigration*, force will be exerted on the alkali metal ions. Due to the low diffusion barriers the alkali ions may move along the CN which can influence the FET characteristics. On the other hand, electromigration forces can be used to intentionally transport atoms along a CN [3].
Here, we present self-consistent non-equilibrium Greens function calculations to treat a ballistic CN-FET within a tight-binding approximation. We use a cylindrically symmetric device and calculate the current-induced forces on ions located either inside or outside of the CN. We observe that the forces are especially large in the turn-on regime of the transistor, and much smaller in the off- and on-states. The electromigration forces are mainly due to momentum transfer from the charge carriers, i.e. due to the "wind" forces. The sign of the "effective valence" Z^* is independent of the actual charge sign, but can be reversed with gate voltage, providing a dramatic illustration of the quantum character of the wind force.

[1] A. Javey, J. Guo, Q. Wang *et al.*, Nature **424**, 654 (2003).
[2] M. Radosavljević, J. Appenzeller, and Ph. Avouris, Appl. Phys. Lett. **84**, 3693 (2004).
[3] B. C. Regan, S. Aloni, R. O. Ritchie, U. Dahmen, and A. Zettl, Nature **428**, 924 (2004).