Calculation of pull in voltages for carbon-nanotube-based nanomechanical switches

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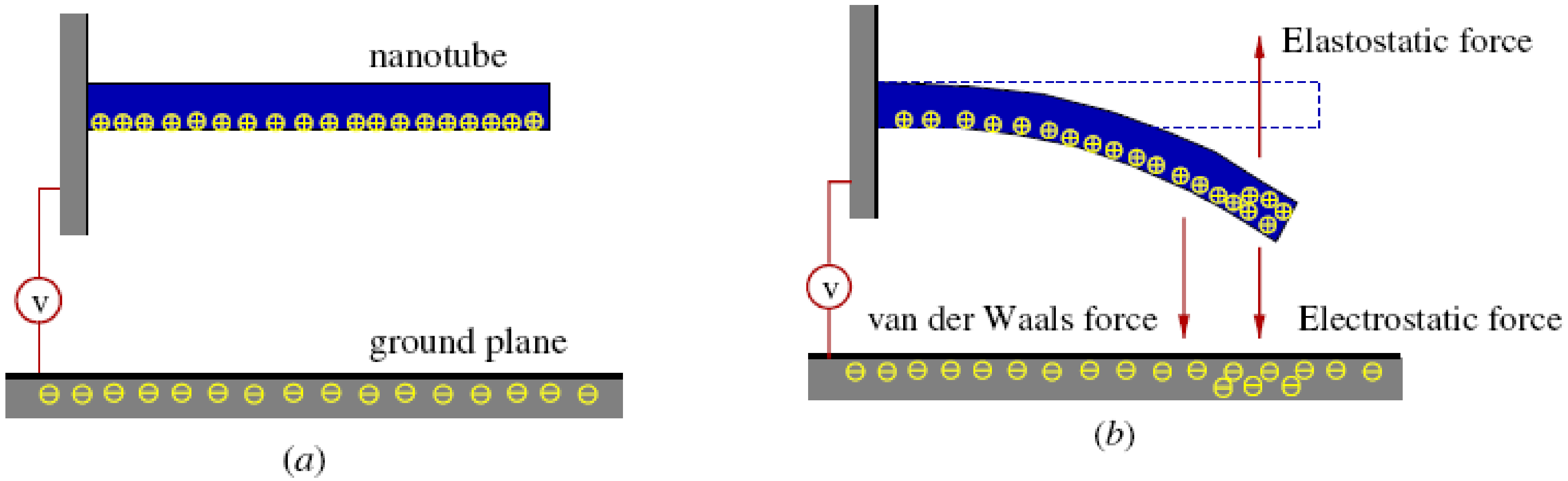
- Nanoelectromechanical(NEM) switches are three order of magnitude less than microelectromechanical(MEM) switches
- NEM switches- high frequency operation and fast switching in communication networks.
- Carbon nanotube have excellent electronic and mechanical properties.
- Vander walls interaction plays important role in nanoscale.



Force balance for nanotube over a round plane (a) position of a tube when V=0 (b) at V≠0

SWITCH ON: nano tube touches ground plane
SWITCH OFF: nano tube and plane are separated

Van der walls interaction: Lennard-Jones potentential gives attractive interaction between two atoms.

$$\phi_{ij} = -\frac{\mathcal{C}_6}{r_{ij}^6}$$

Total Lennard-Jones potential:

$$E_{\mathrm{vdW}}(r) = \int_{\mathcal{V}_1} \int_{\mathcal{V}_2} \frac{n_1 n_2 \mathcal{C}_6}{r^6(\mathcal{V}_1, \mathcal{V}_2)} \, \mathrm{d}\mathcal{V}_1 \, \mathrm{d}\mathcal{V}_2$$

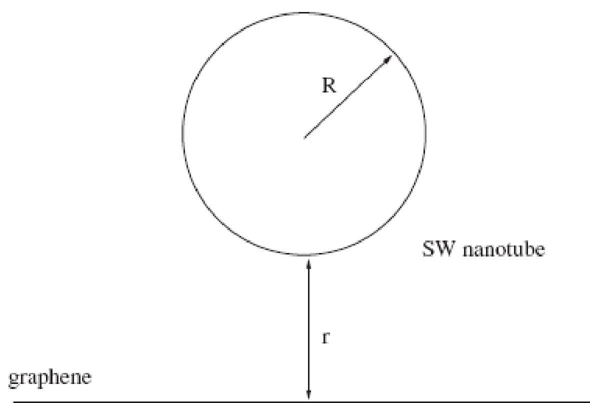


Figure 2. Single-shell continuum geometry: an SWNT over a graphene ground plane.

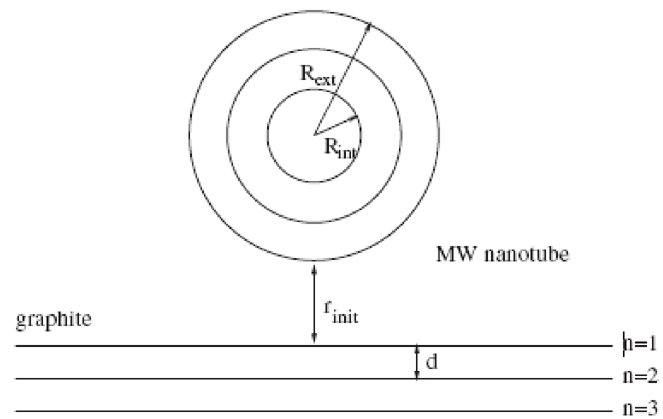


Figure 3. Multiple-shell continuum geometry: an MWNT over a graphite ground plane.

Energy per unit length:

$$\frac{E_{\mathrm{vdW}}}{L} = \frac{\mathcal{C}_6 \sigma^2 \pi^2 R(R+r)(3R^2 + 2(r+R)^2)}{2((r+R)^2 - R^2)^{7/2}}$$

- Elastostatic domain:

$$EI\frac{\mathrm{d}^4 r}{\mathrm{d}x^4} = q$$

• Coupling the electrostatic , vanderwaals and elastostatic domains into single equation

$$EI\frac{\mathrm{d}^4 r}{\mathrm{d}x^4} = q_{\mathrm{elec}} + q_{\mathrm{vdW}}.$$