We characterize the response of isolated single-wall (SWNT) and multi-wall (MWNT) carbon nanotubes and bundles to static electric fields using first-principles calculations and density-functional theory. The longitudinal polarizability of semiconducting SWNTs scales as the inverse square of the band gap (Figure 1). Because of the absence of depolarization effects in the longitudinal direction, nearby parallel tubes have very weak dielectric interaction, so in MWNTs and bundles the longitudinal polarizability is given by the sum of polarizabilities of the constituent tubes.

The transverse polarizability of SWNTs is insensitive to band gaps and chiralities and is proportional to the square of the radius (Figure 2). The electric field applied perpendicular to a SWNT is screened by a universal factor of about 4.5, independent of the nanotube’s radius. This property is inherited from the anomalous scale-invariant in-plane response of a sheet of graphene. The transverse response is thus intermediate between metallic and insulating. We construct a simple electrostatic model based on a scale-invariance relation that captures accurately the first-principles results for transverse response of SWNTs and MWNTs. Because of strong screening and radius dependence of polarizability, the outer few layers dominate the response in MWNTs.

Using the results of our calculations, we analyze the feasibility of separating semiconducting and metallic nanotubes using uniform and non-uniform static electric fields in vacuum and in solutions. We also find that the dielectric response of non-chiral SWNTs in both directions remains linear up to very high values of the applied field.

**REFERENCES**