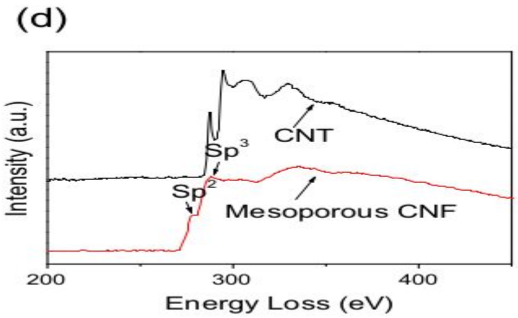
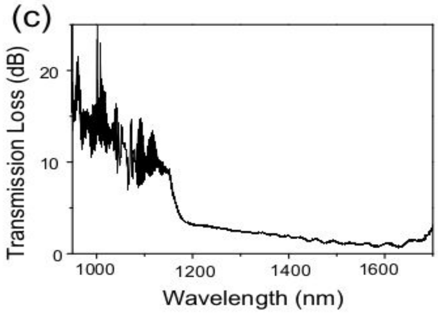
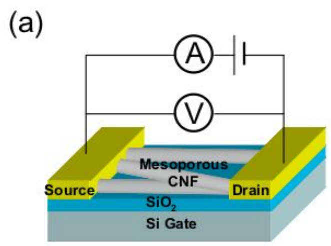
Electrical Properties of Carbon Nanofibers (An 1-D nanomaterial)

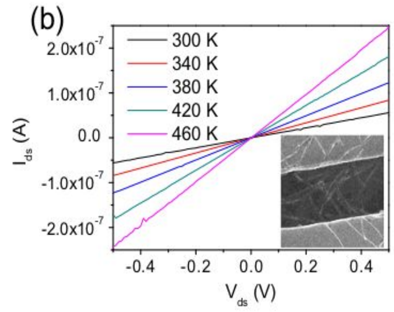
1. **Energy band gap**: Carbon nanofibers are semiconducting and it is clearly visible from the graph(c) attached below. At 1150 nm, adsorption is observed here, revealing the band gap is about 1.07 ev. Now from graph d (EELS spectra) for CNF, it represents its amorphous characteristics . Also, Carbon nanofibres consist of a homogenous mixture of sp2 and sp3 sites (also visible by the spectra graph d) that ultimately signifies that it is a weak semiconductor.

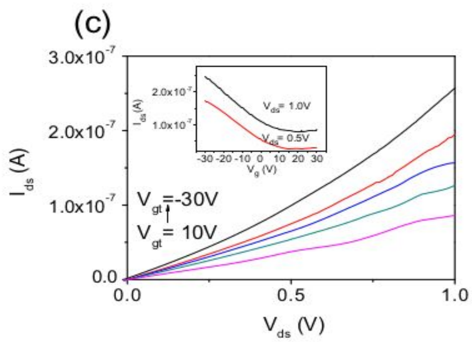




2. **Conductive Properties:** The setup to measure and verify most of the electrical properties of nanofibers are shown in fig (a) where ammeter and voltmeter are set up for readings and a battery is connected for generating electric field. As in fig (b), in the range of 300K to 460K, the resistivity (Vds/Ids) decreases with increase in temperature due to which it possesses semiconductors behaviour. In fig (c), by potting Ids vs Vds graph (at const temp), it can be precisely said that as gate potential increases, conductance decreases monotonically, hence FETs of nanofibers are p-channel FETs.



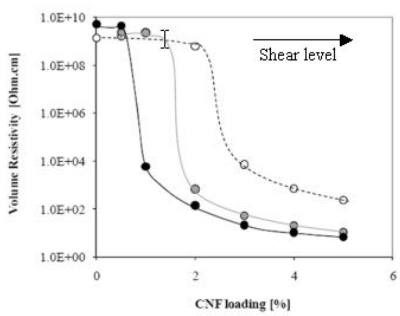




3. **Mobility, charge carriers concentration and bulk concentration:**

The projected value of carriers concentration (n) is estimated to be equal to 4.6 x 10^8 cm^-1 from which the bulk concentration comes out to be 1.5 x 10^18 cm^-3. Now from the inset of the graph (c) above (Ids vs Vds) and the value of carriers concentration, the value of mobility i.e Vd/|E|, where Vd is the drift velocity (Vd = I/neA, I is current, A is area of cross section, n is charge concentration and e is the charge of electron) and E is applied electric field (which is controlled by the potential we are applying) comes out to be μ = 10 cm^2/V at Vg = 0V.

4. **Electrical Conductivity(σ) :** Intrinsic (unloaded) CNF has an electrical conductivity of 5 x 10^{-5} Ω.cm at room temperature (found by σ =1/ρ and ρ = R.A/l, where R is resistance, A is area of cross section of the sample and I is the current) obtained by normalising the values of σ for various values of I and V in circuit show above (fig (a)). By loading the CNFs the properties like resistivity and conductivity can be enhanced accordingly which the graph below depicts.



5. **Idea of Diffusion Length in Nanofibers :** Since Carbon Nanofibers are still in preliminary stage so the lifetime of carriers and diffusion length are not clearly quoted in the research papers available but as the value of mobility is obtained, we can get the idea about these. Since D=μκT/e where D is diffusion coefficient, T is absolute temperature and k is Boltzmann's constant, D is directly proportional to μ which is 10 cm^2/V and it is also known that diffusion length L is √(Dτ) where τ is lifetime of carrier, so L∝ √D.