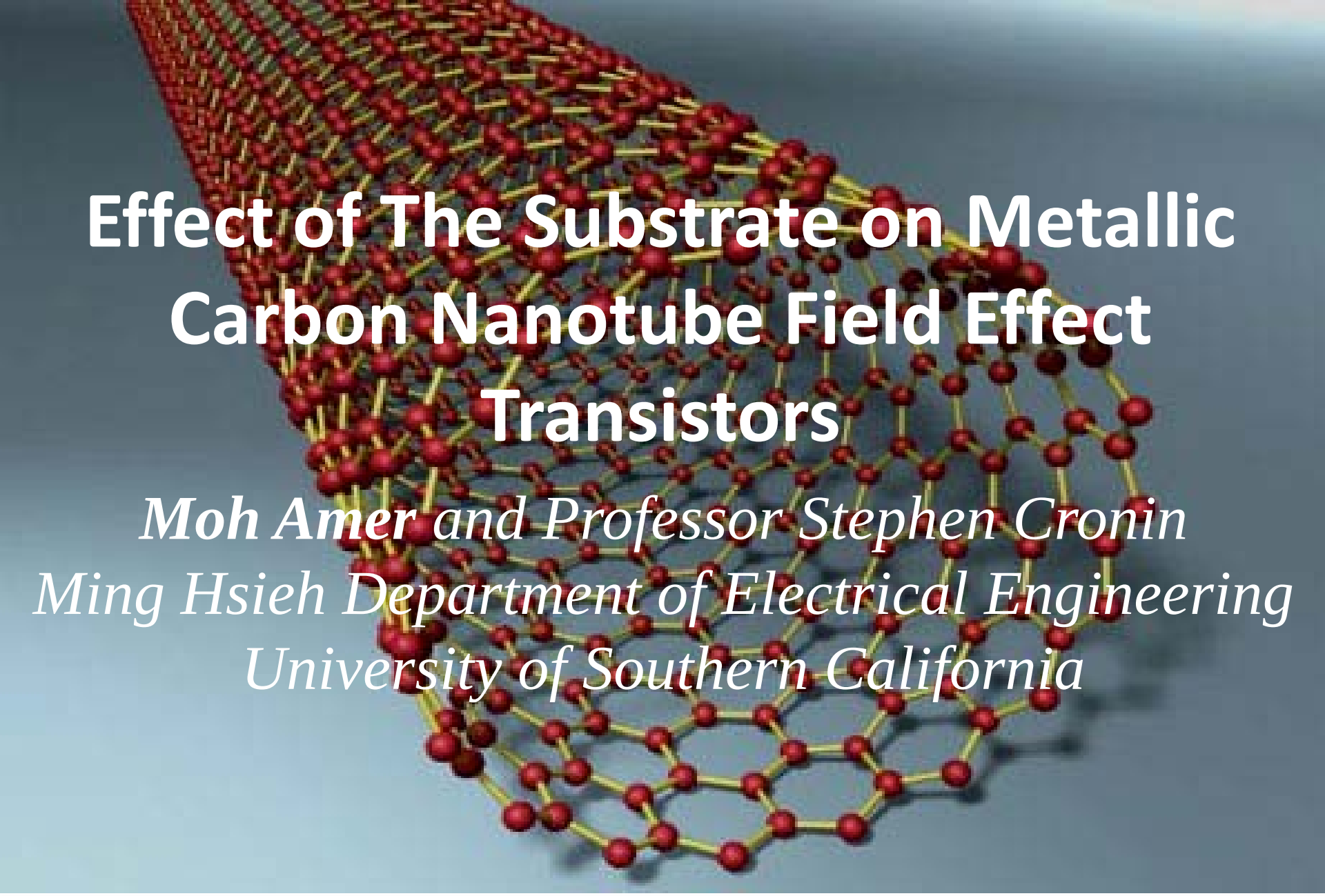
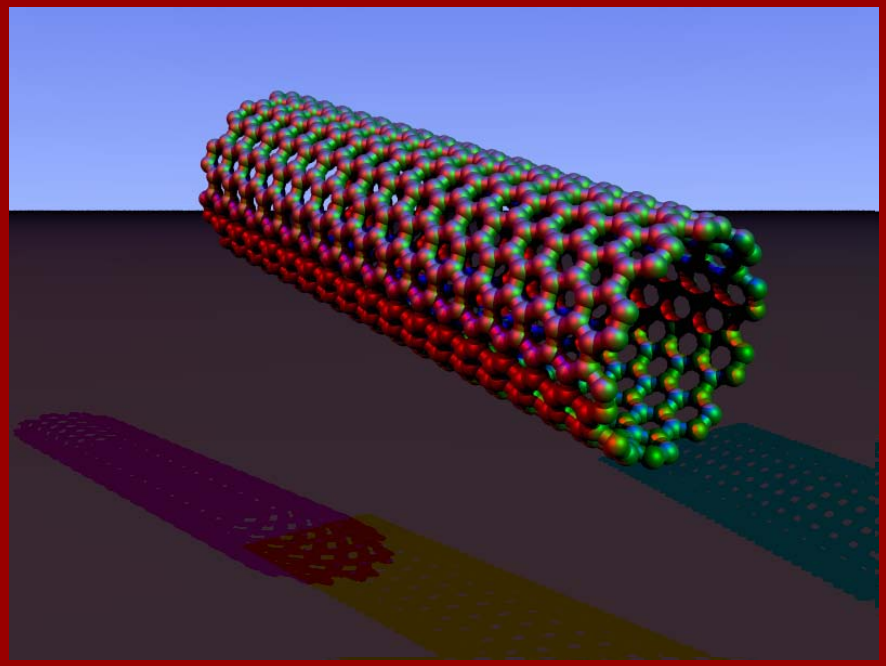
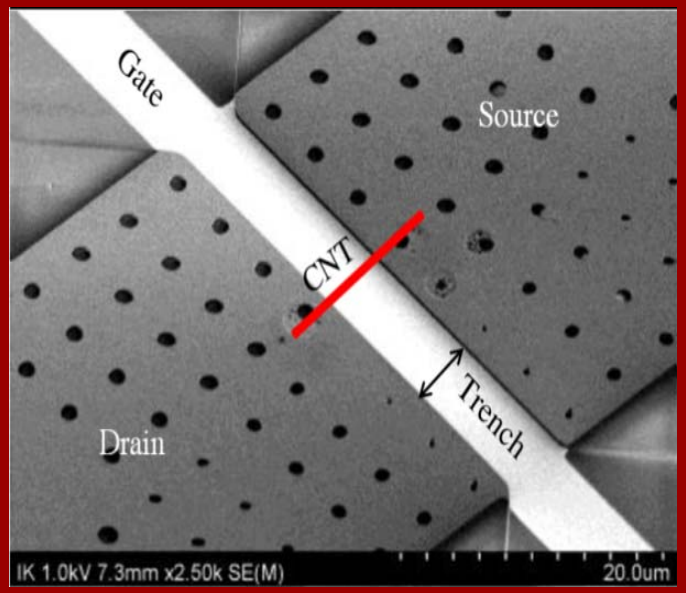


Effect of The Substrate on Metallic Carbon Nanotube Field Effect Transistors

Moh Amer and Professor Stephen Cronin
Ming Hsieh Department of Electrical Engineering
University of Southern California

Carbon Nanotube





- A rolled sheet of graphene, one single layer of Graphite.
- Metallic or semiconductor.
- Diameter range between 1-3nm and length as high as centimeters.

Wang, *Nano Letters*, 9,9 (**2009**)

High On/Off Ratio of Semiconducting CNT FET Devices

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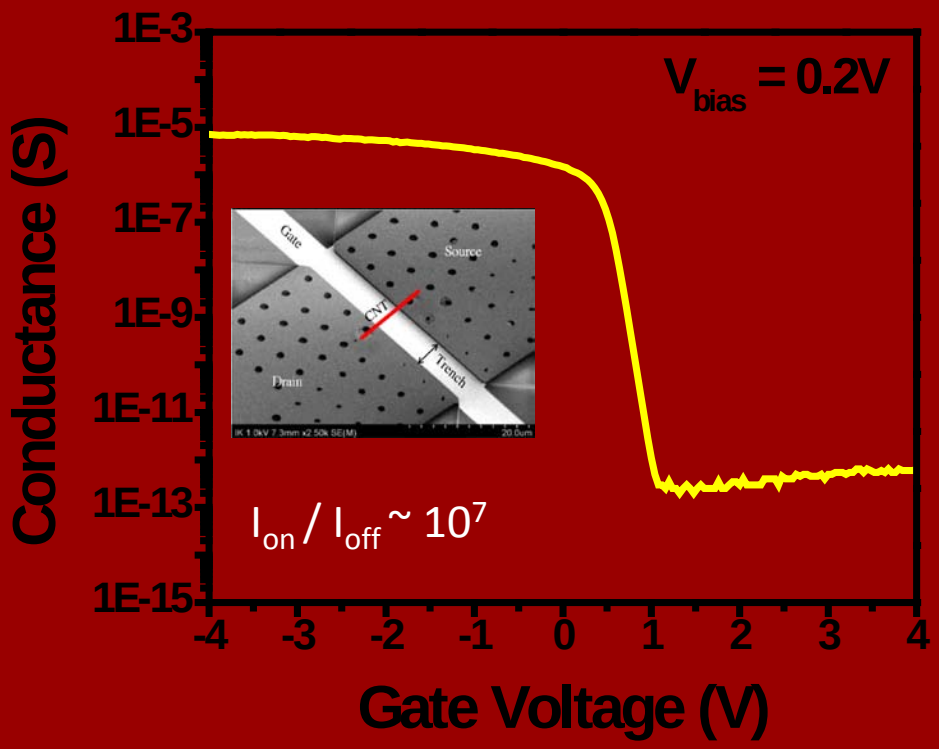

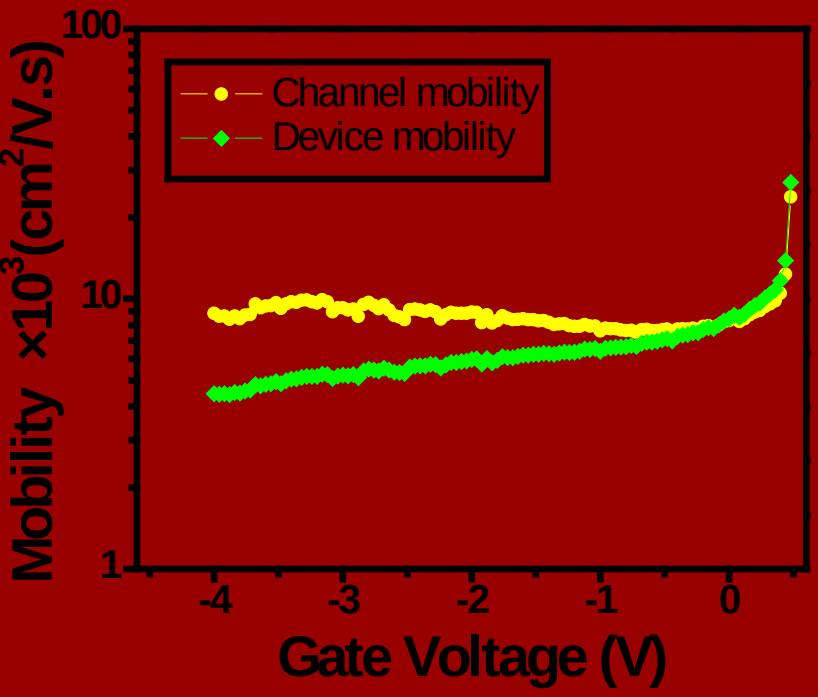

- Suspended semiconducting nanotubes exhibit I_{on}/I_{off} as high as 10^7 .
- 2 orders of magnitude larger than what has been reported previously on CNT-FETs and many order of magnitudes larger than MOS devices.
- Channel carrier mobility can reach 10,000 cm^2/ V.s.

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Suspended and on Substrate Supported Metallic CNT-FETs

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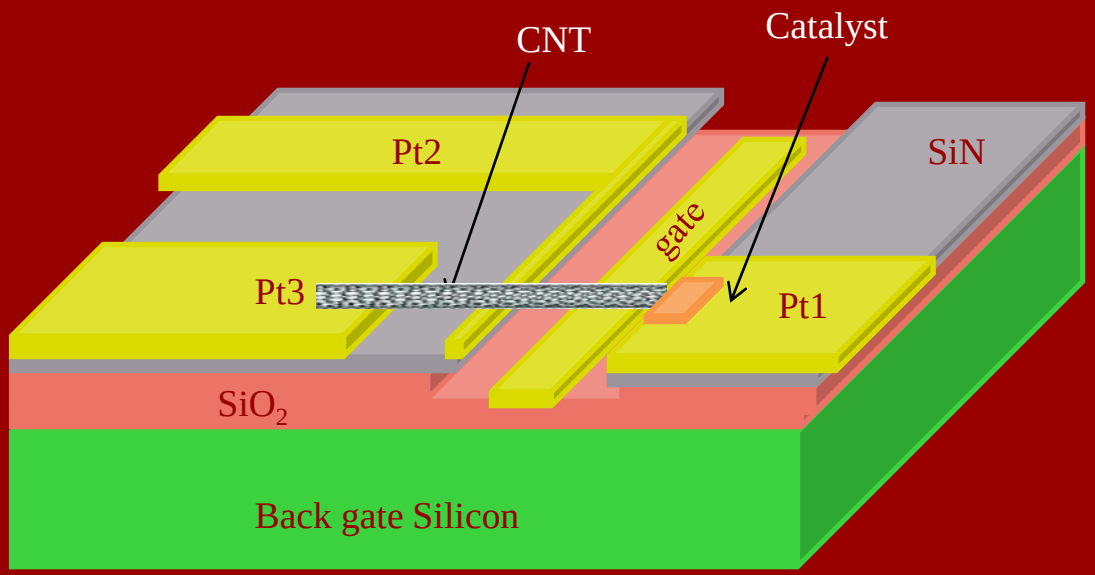

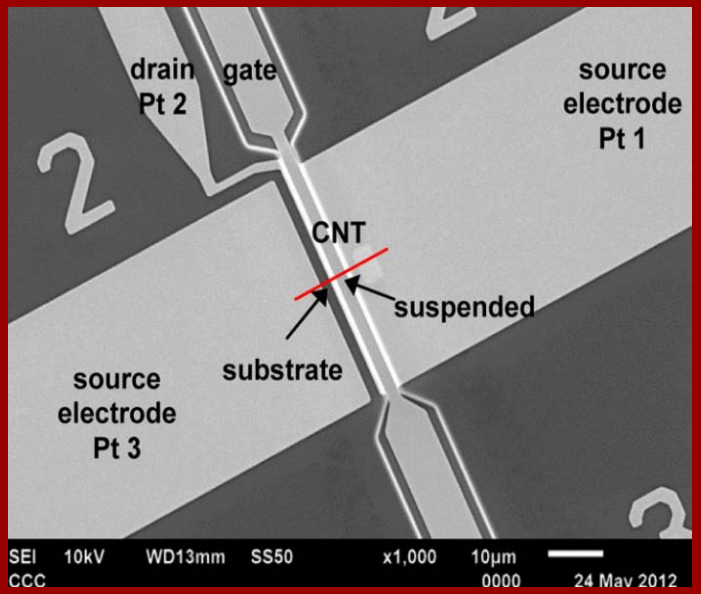

- Compare the changes in the current-voltage characteristics for optimal transistor performance.
- Nanotube devices are fabricated with a suspended portion and on substrate portion.

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Amer, *et al. Nano Letters*, *2*, 9,(**2012**)

IV_{ds} and IV_{gs} of suspended and on Substrate Regions

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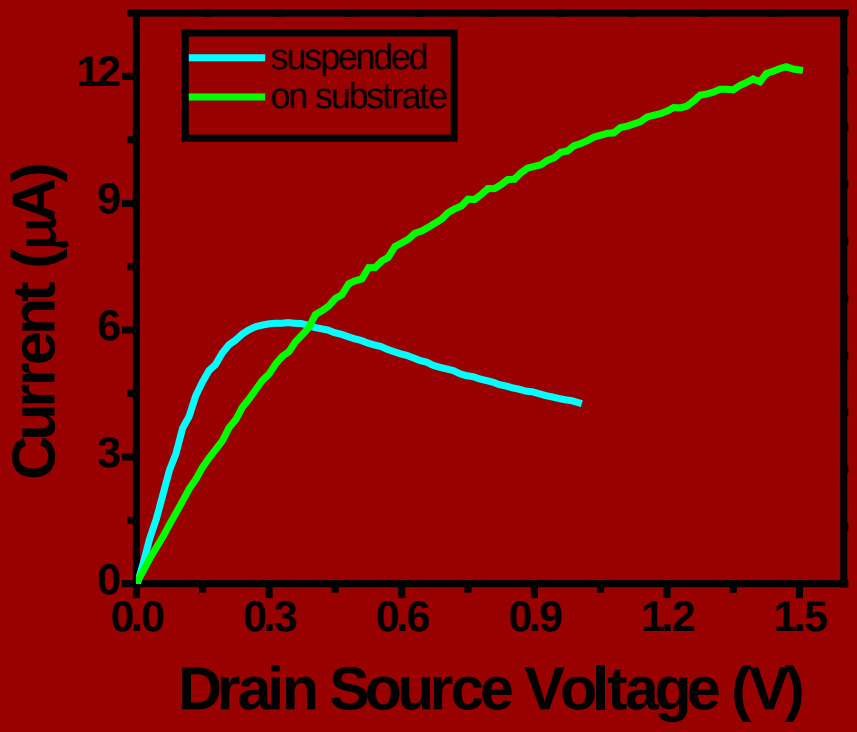

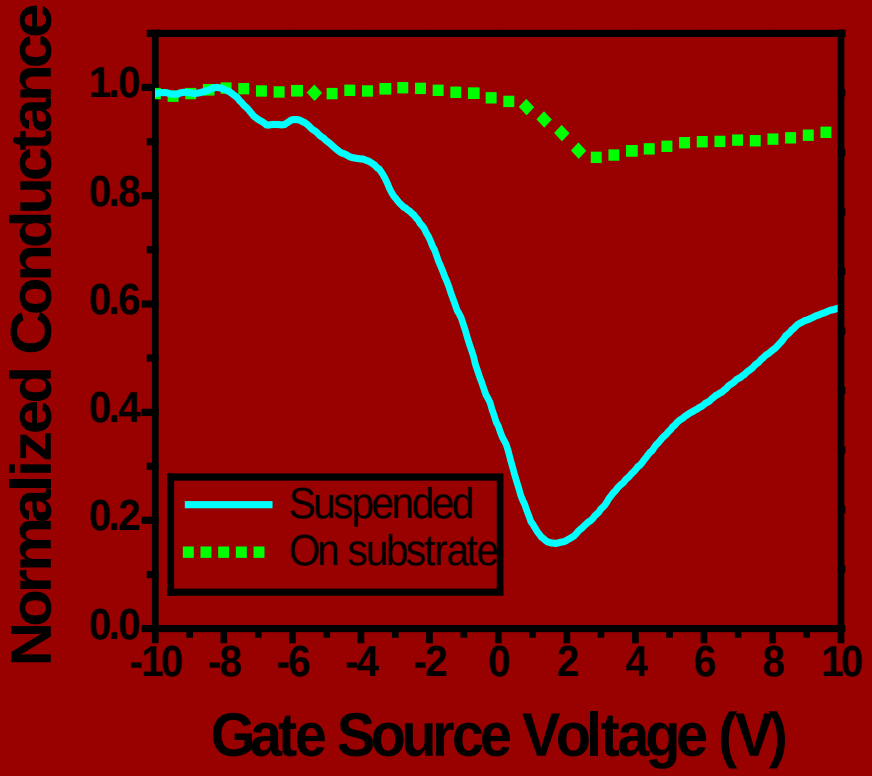

- When metallic nanotubes are suspended, a large band gap is observed. Conductance varies by 84%.
- the on substrate conductance varies by 11% due to a significant reduction in the band gap caused by supporting the nanotube.

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Amer, *et al. Nano Letters*, *2,* 9,(**2012**)

Extracted Fermi Energy

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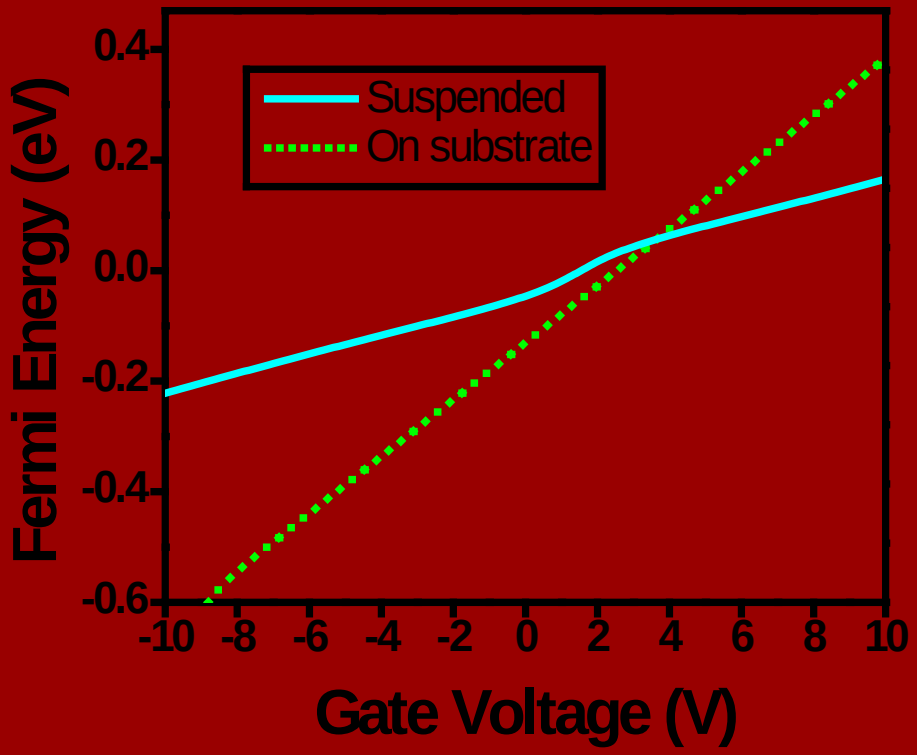

Trapped Charges alter the performance of the nanotube channel by screening out the small band gap

- Fitting the data to the Landauer model (Conductance model) yield band gap energies of 100 meV and 5 meV for the suspended and on Substrate segments, respectively.
- Non linear behavior of the Fermi energy for the suspended segment.
- Almost linear behavior of the Fermi energy for the on-substrate segment.

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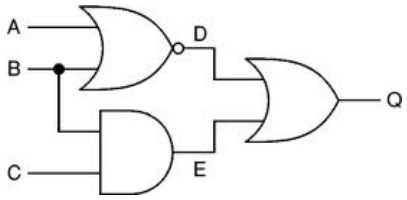
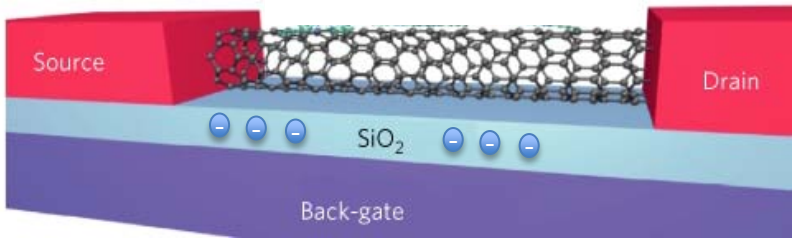
Amer, *et al. Nano Letters*, *2,* 9,(**2012**)

In Conclusion

- Suspended carbon Nanotubes offer many advantages in electronics due to their high Current on-off states and their high carrier mobility.
- Contrary to popular belief, metallic nanotubes do exhibit a small band gap that can be implemented in a THz or far infrared photodector.
- Trapped charges can screen out the observation of the band gap for metallic nanotubes.





Thank You

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