

Integrated electrochemical gating of Carbon nanotube FETs for biosensing



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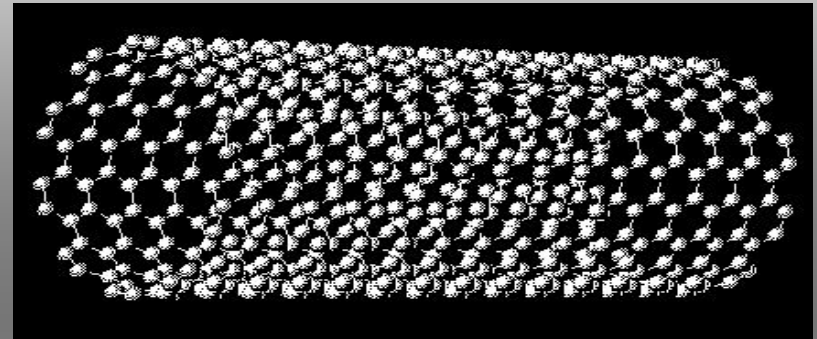


Motivation

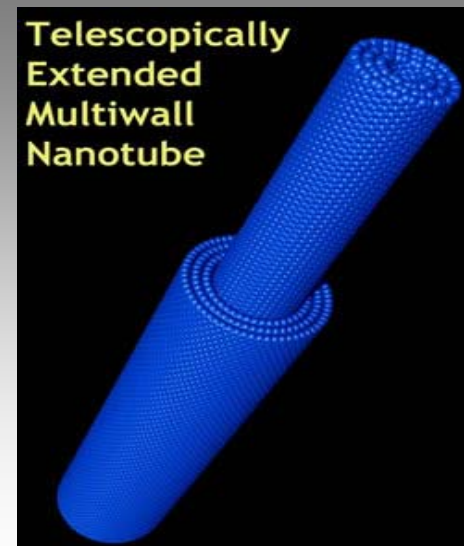
- Detection of the human thyroid hormone, *Triiodothyronine* (T3) via nanotube-FETs
- Improve nanotube sensors
 - Fabricate a convenient method of applying voltages to devices.

What are Carbon Nanotubes (CNTs)?

- One-dimensional nanoscale structures with unique set of properties.
- Two types of CNTs:
 - Single-Walled Nanotubes (SWNT)
 - Multi-Walled Nanotubes (MWNT)



SWNT



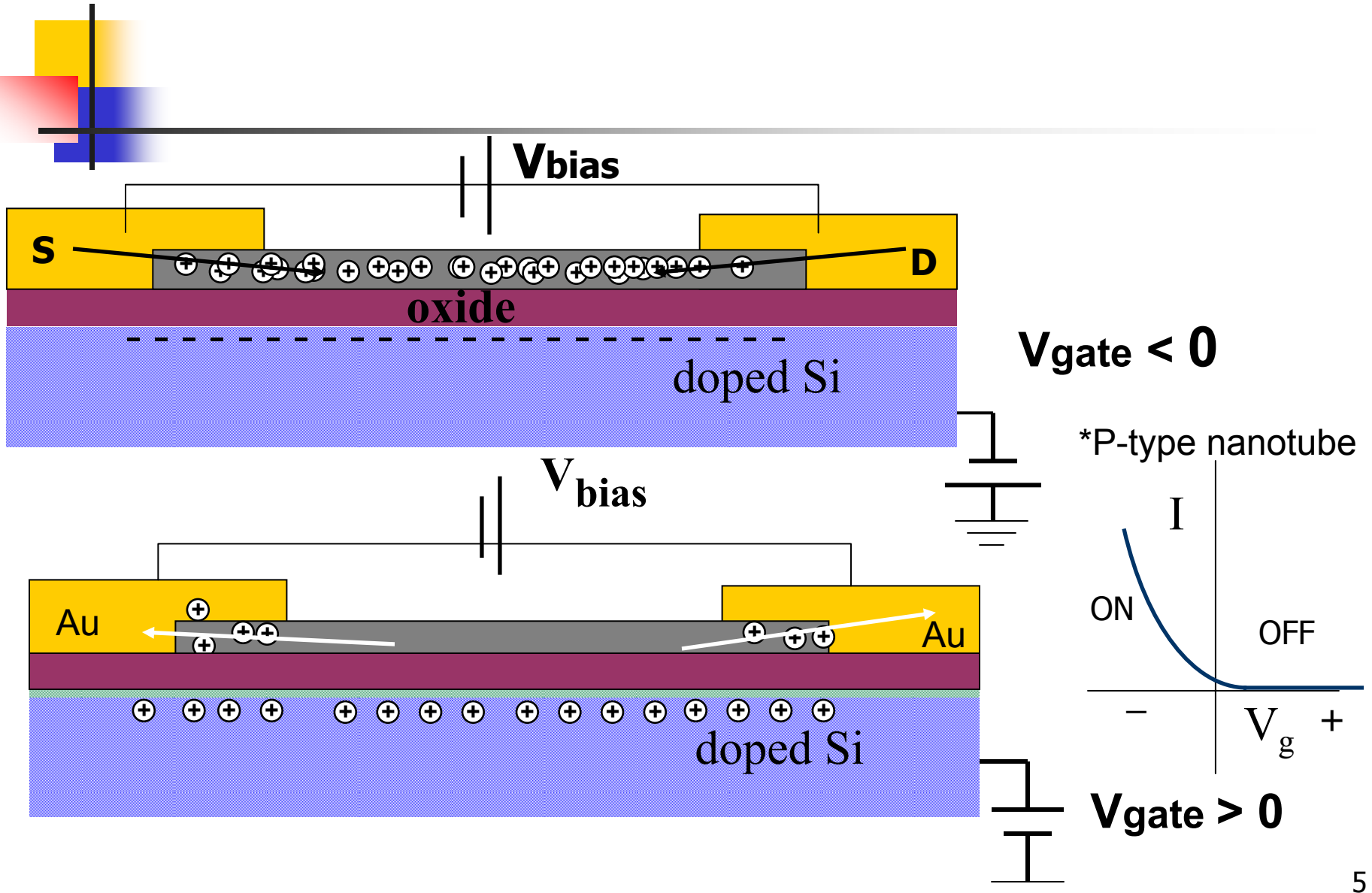
MWNT



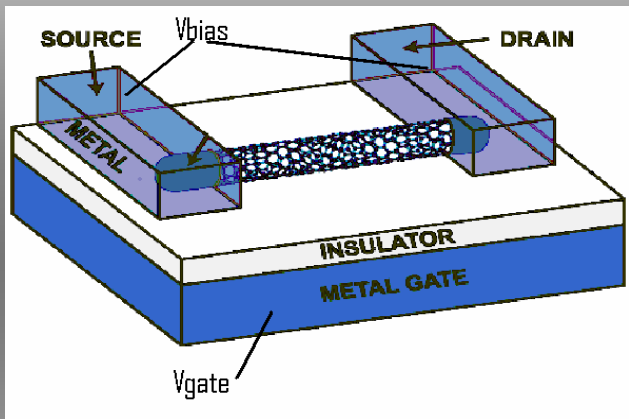
Properties of SWNTs

- **Semiconducting nanotubes**
 - Carrier mobility superior to the best known semiconductors, e.g. Si
- **Metallic nanotubes**
 - Conducts 1000x more current than an equivalent sized metal, E.g. Cu, Au
- **Size**
 - Diameter: 1-2 nm
 - Length: 100's of micro-meters
- **Sensitivity**
 - **Extremely sensitive to the presence of chemicals**

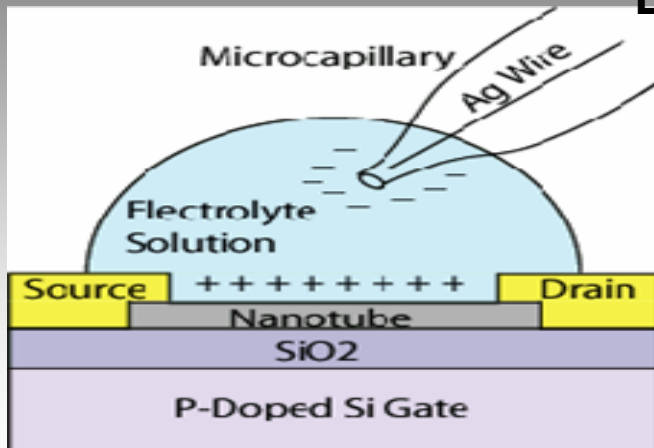
How nanotube-FETs work



Gating of nanotube-FETs



Backgate

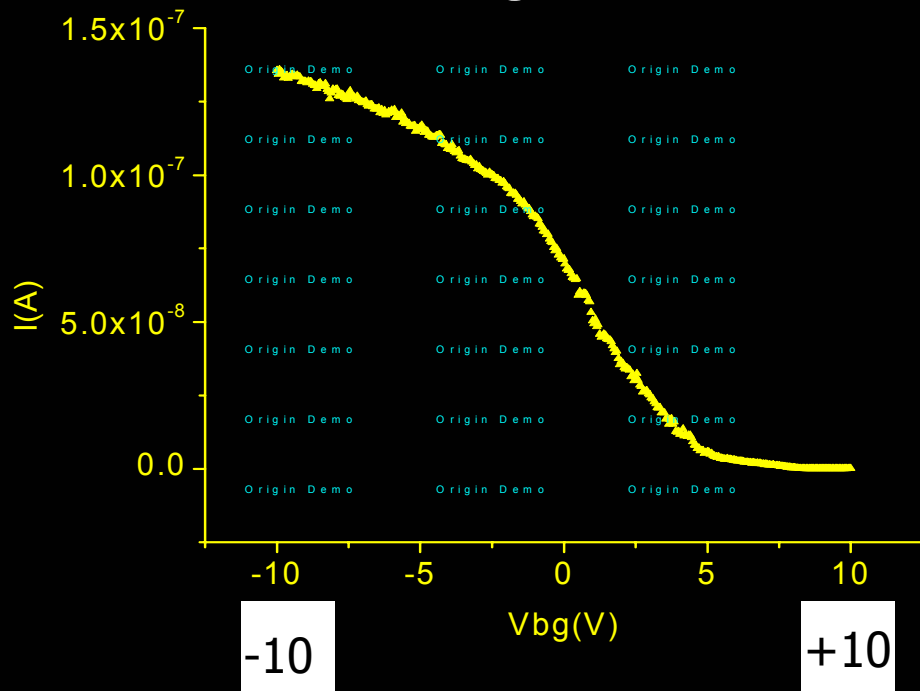


Electrolytic "tip" gate

- The goal is to achieve :
 - Strong nanotube-gate capacitance
 - Low device operating voltage
 - Steeper ON-OFF transition

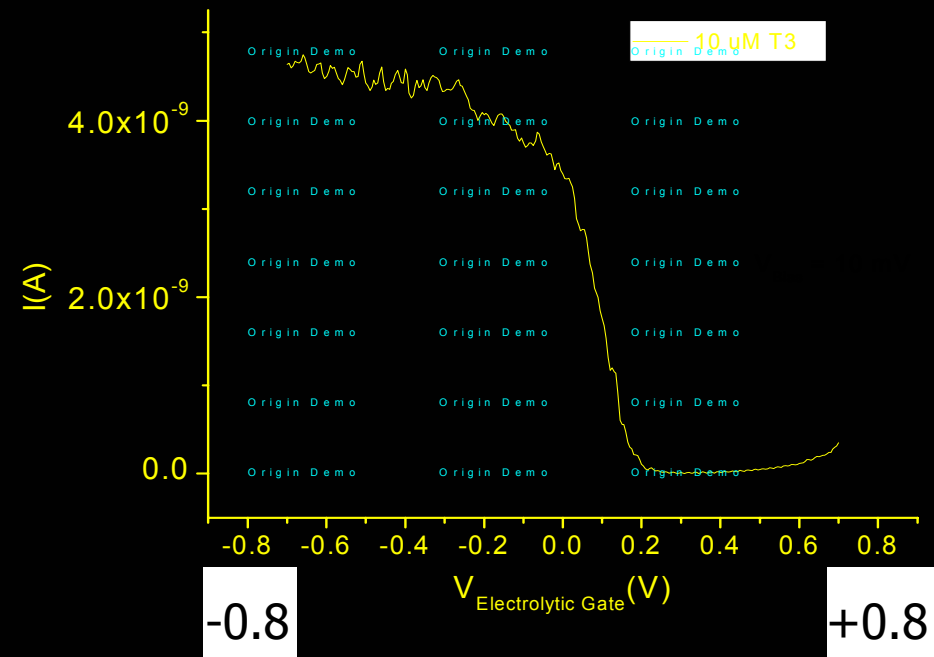
Backgate vs. Electrolytic gate

Backgate



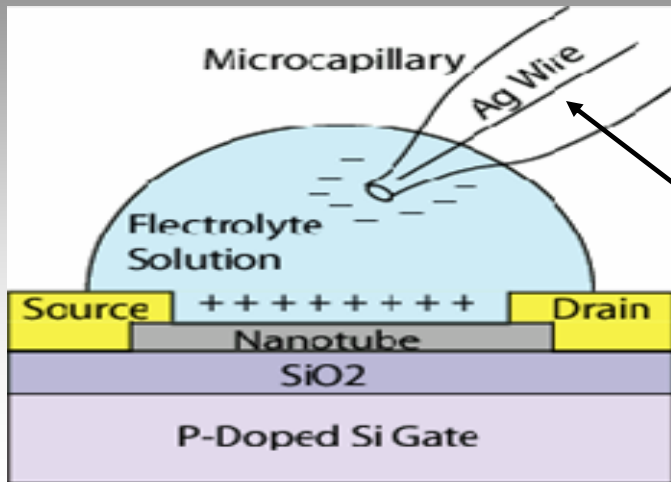
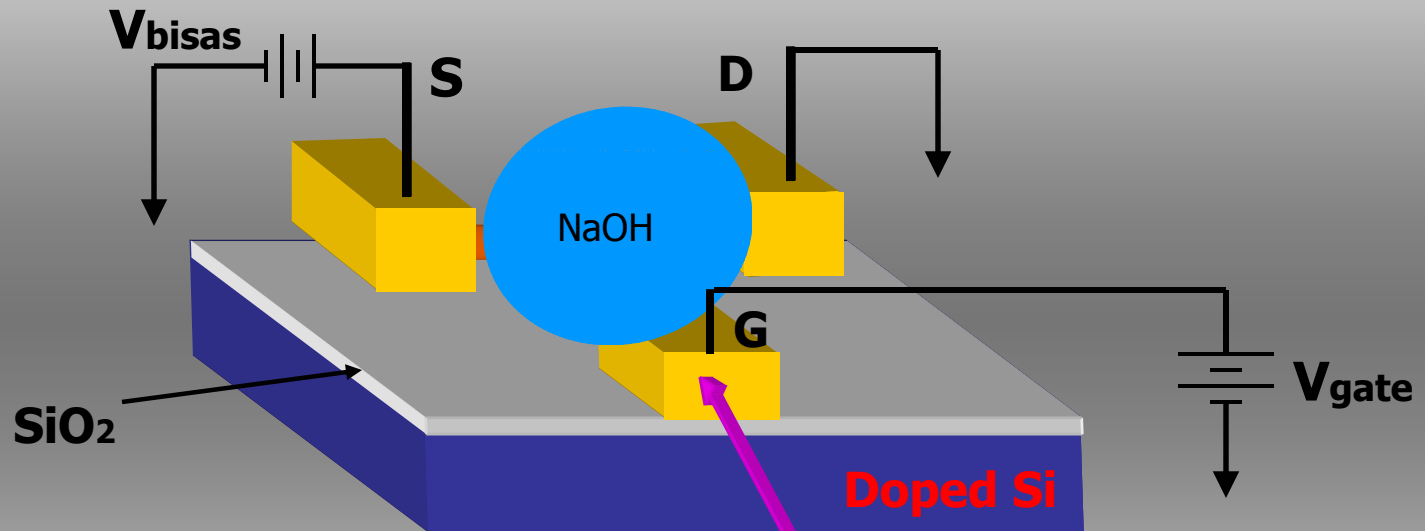
- Integrated gate

Electrolytic gate



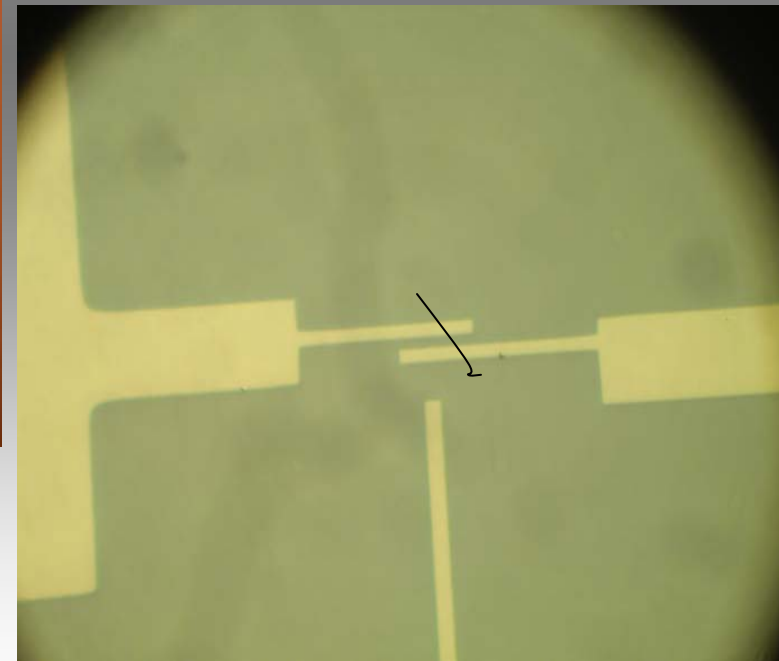
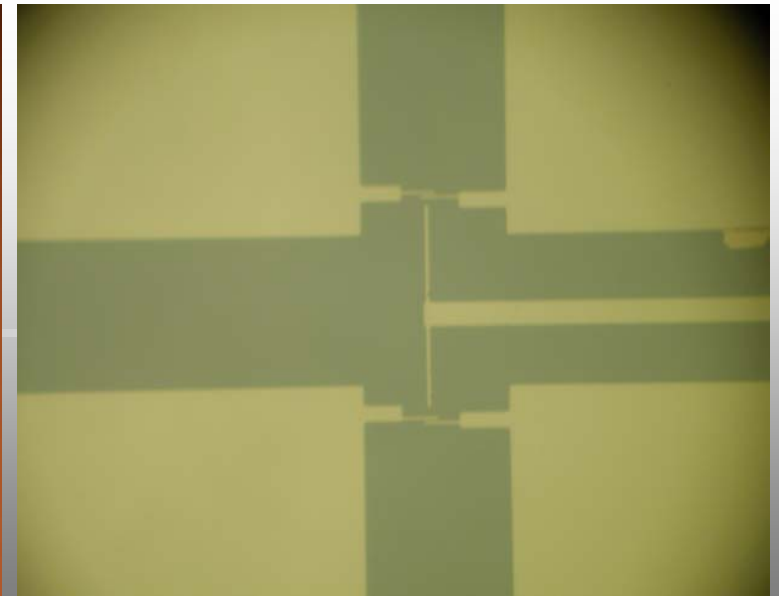
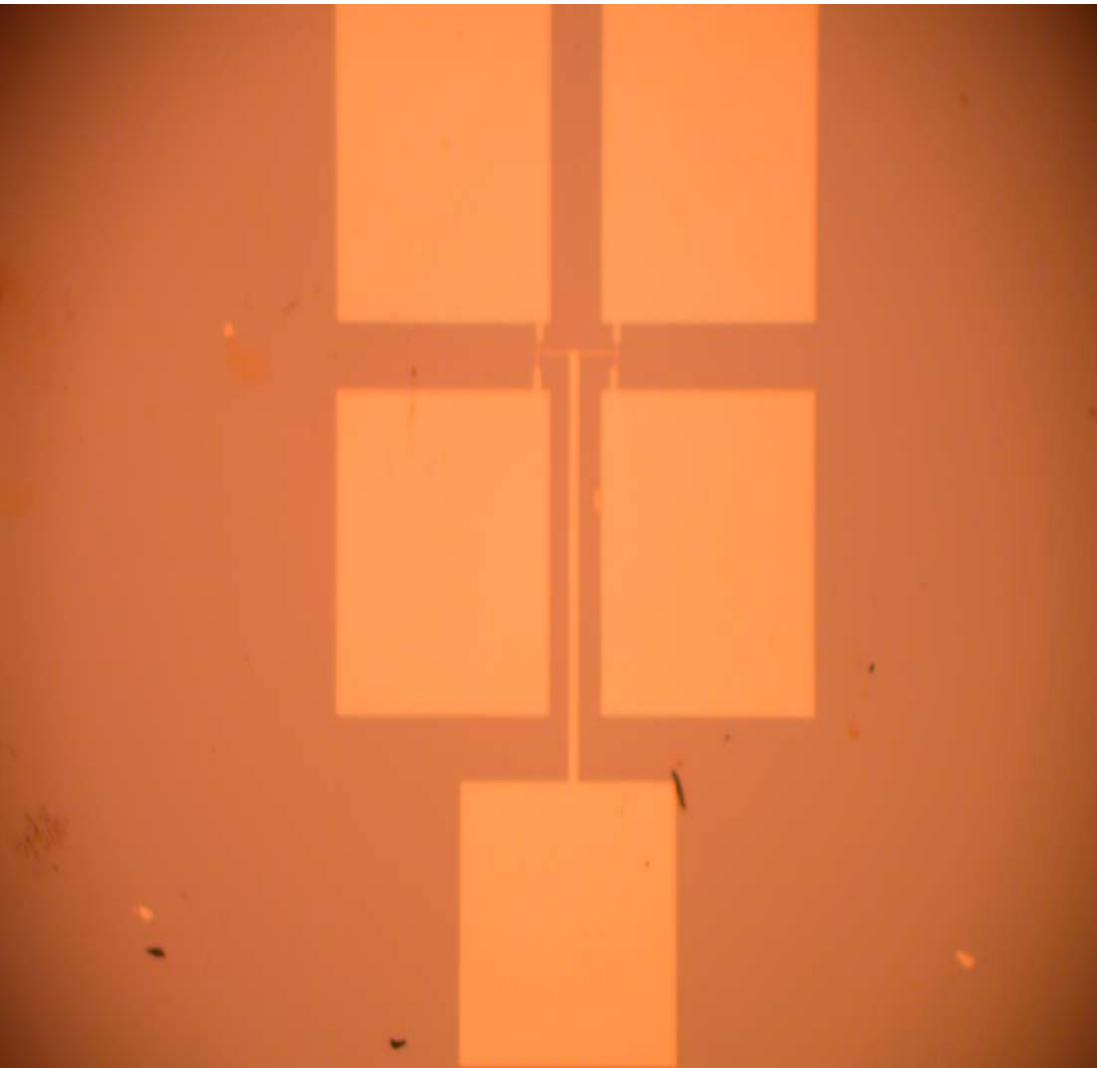
- Lower operating voltage
- Steeper slope (Fast switching)
- Needs integration

New integrated gating design



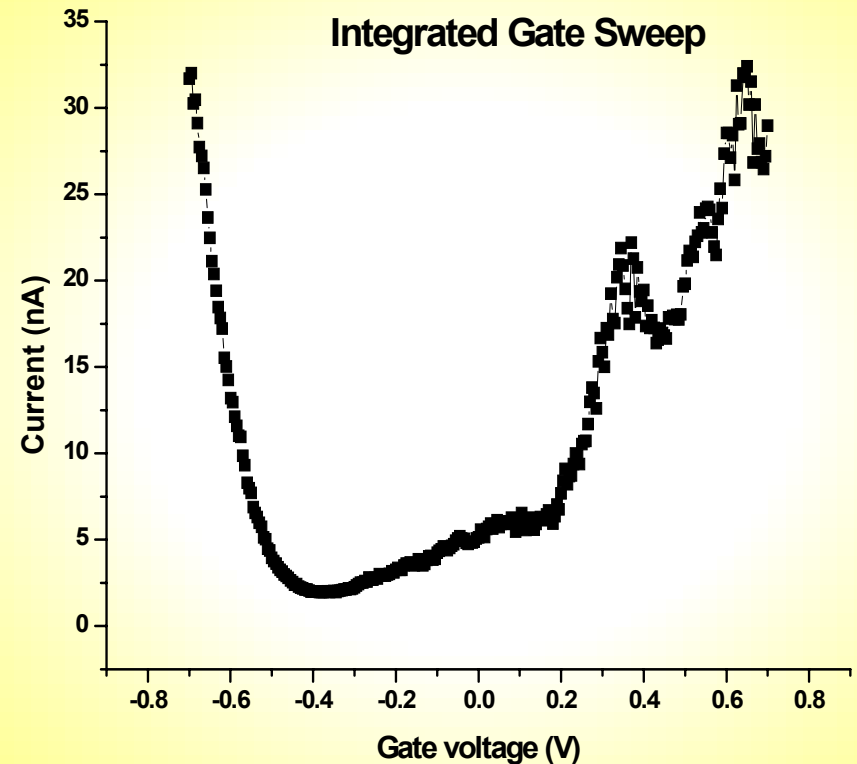
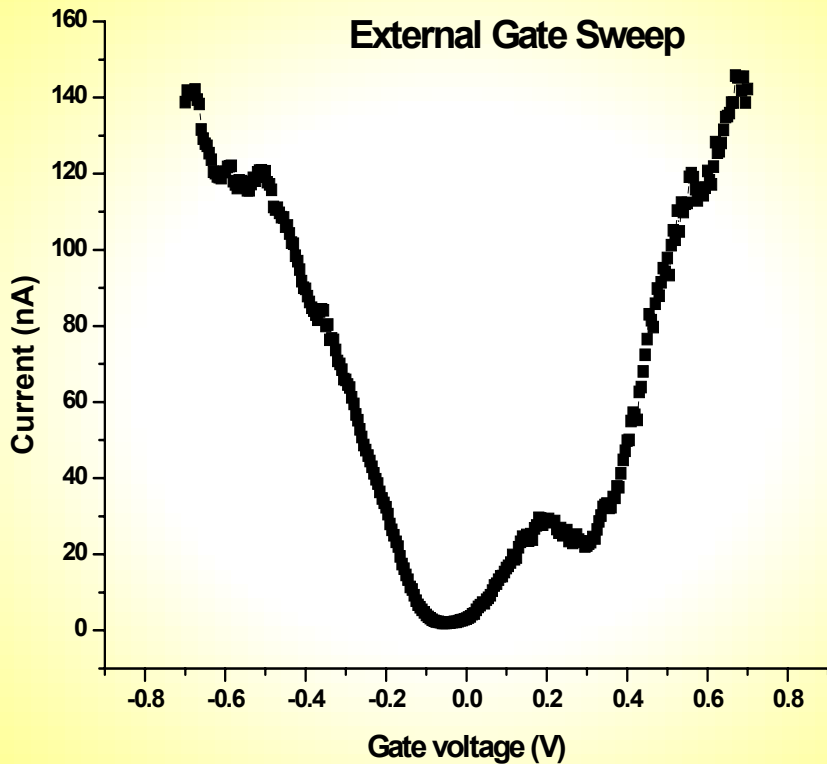
External gate

Integrated gate



Actual transistor chip

External vs. Integrated gate



Similar switching behavior

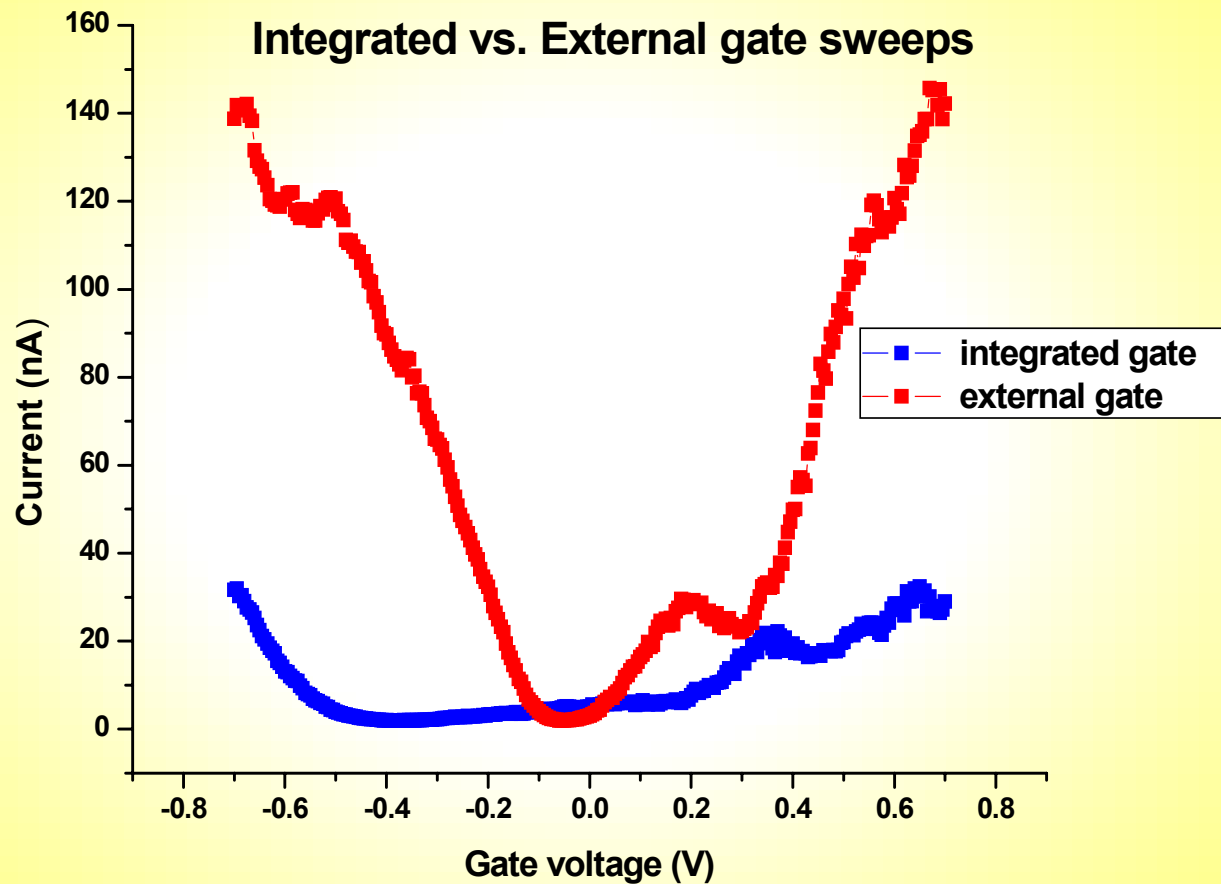
Results

- External gate

- Larger current drive

- Explanation...

- Thickness of silver wire





Future Directions...

- Improve the performance of the integrated gate
 - Conduct more tests
 - Try thicker gate electrode
- Integrate into actual devices



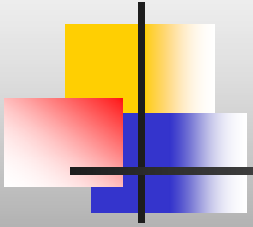
Acknowledgements

Deirdre Smith

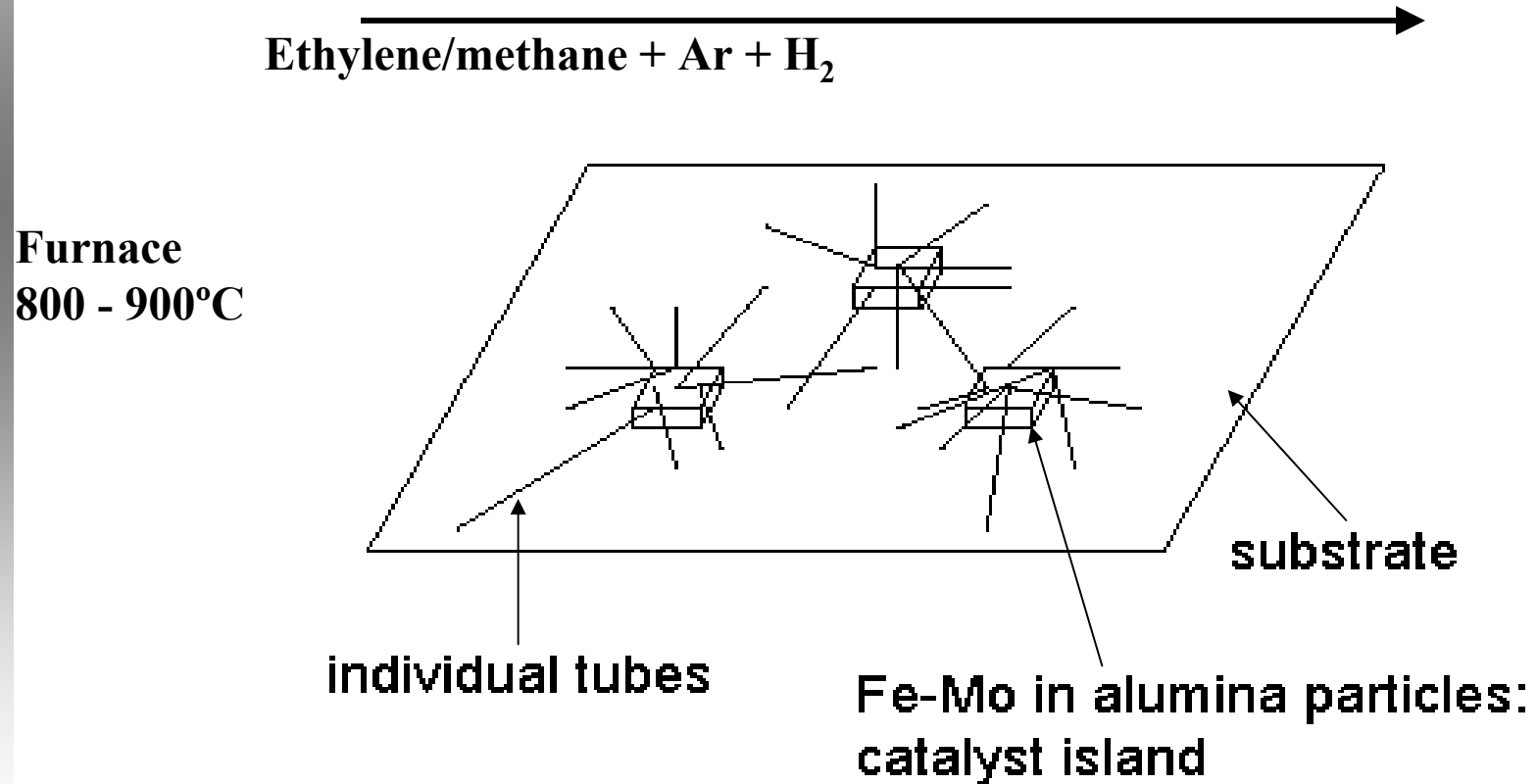
Mike Stern

Dr. Charlie Johnson

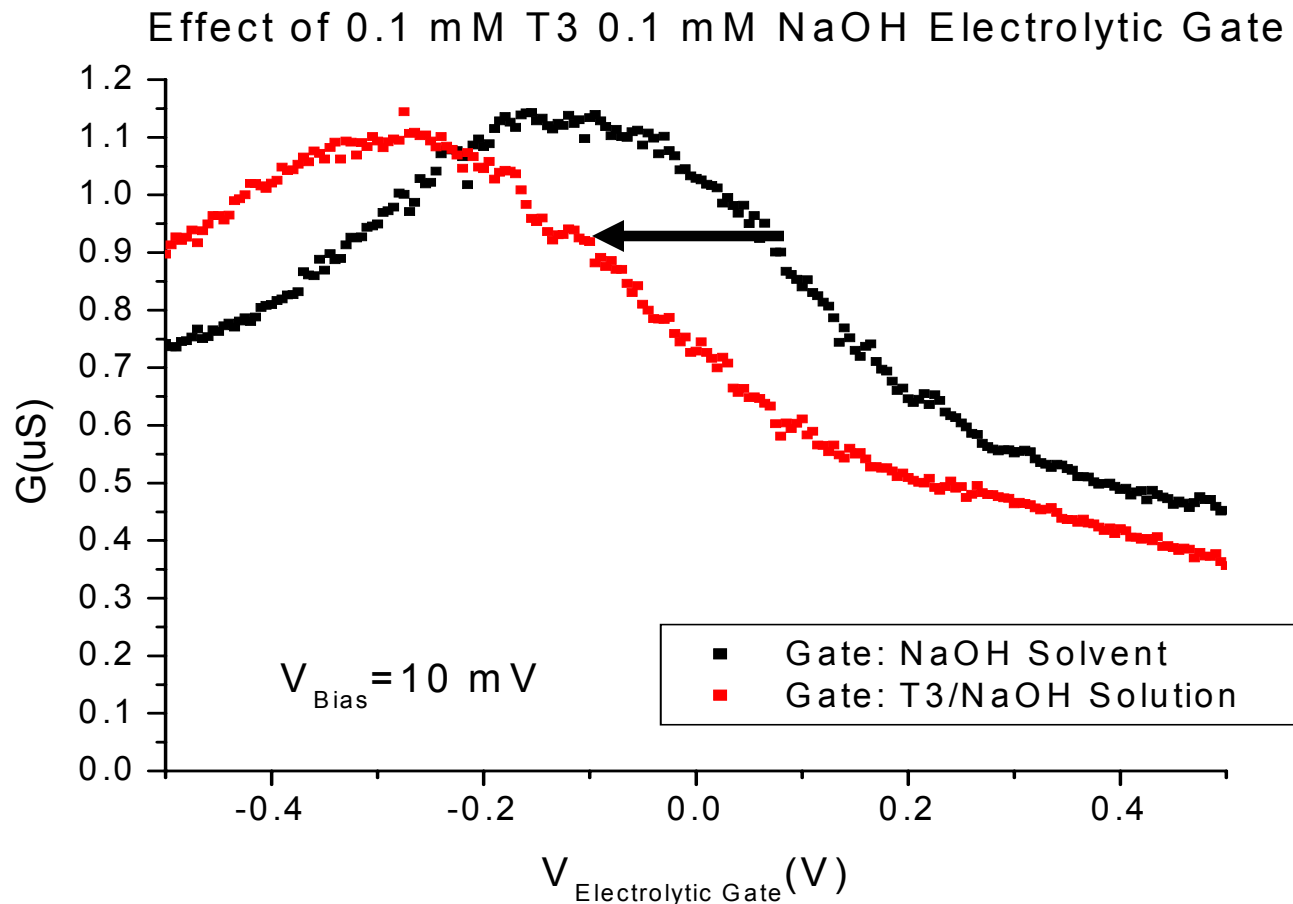
SUNFEST Program



I. Growing Nanotubes



Detection of T3



Home made apparatus

