Functionalizing Carbon Nanotubes with Antibodies for the Detection of Prostate Cancer Biomarkers

James Resczenski
Johnson Group
SUNFEST
Prostate cancer is a growing public health issue. The current standard for detection has room for improvement. Prostate Specific Antigen (PSA) tests are unreliable, but osteopontin (OPN) is a new biomarker protein present in patients with prostate cancer.
Functionalized Carbon Nanotubes as Sensors

- Sensitive to low concentrations
- Antibody functionalization offers a high degree of selectivity
Carbon Nanotubes

- Members of the fullerene family
- Hexagonal lattice of sp² bonded carbon atoms
- Diameter of ~1 nm
Chemical Vapor Deposition

• The Si/SiO$_2$ wafers were cleaned using a plasma etcher.

• An iron nitrate catalyst was diluted in isopropanol

• The chips were heated to 900°C in argon, hydrogen, and methane gas
Photolithography

1. Film deposition
2. Photoresist application
3. Exposure
4. Development
5. Etching
6. Resist removal

Image courtesy of ahshonorschemistry.wikispaces.com
Photolithography
5 nm of titanium was then evaporated onto the face of the chips followed by 30 nm of palladium.

The excess metal was then removed using a 4-step wash.
Electrical measurements are taken by measuring the current through the pair of electrodes that are connected by a single nanotube as a voltage is applied to the back gate.

The back gate voltage changed steadily from 10 V to -10V allowing us to view the devices’ electric properties on a IVg curve, where current is plotted against the gate voltage.
The $sp^2$ bonds of the carbon nanotubes, makes them fairly inert. Therefore, somewhat reactive chemistry is required to initiate functionalization.

1) Diazonium
2) EDC
3) NHS
4) scFv
5) OPN
Antibody-Antigen binding is highly specific

Antibody protein segment attached to the CNT can attach to the target protein in vivo
Results

Devices showed a concentration-dependent response

Experimental detection limit of 1 pg/mL beats current ELISA diagnostic standard by factor of ~1000
Conclusions

- We were able to attach OPN antibodies to carbon nanotubes using the diazonium functionalization process.
- The functionalized devices able to detect OPN at 1 pg/ml; 1000x better than the current ELISA methods.
Acknowledgements

• Members of Johnson Group at UPenn
  • Prof. A.T. Charlie Johnson
  • Mitchell Lerner
  • Jennifer Dailey
  • Akshay Amin

• Members of Robinson Group at Fox Chase Cancer Center
  • Prof. Matt Robinson
  • Dr. Lisa Goldsmith
  • Jimson D’Souza
  • Tatiana Pazina

• Department of Defense PCRP #PC080542P1 and grant #W81XWH-09-1-0206

Thank you for your attention!