Applications of the Organic Thin Film Transistor: Biological Sensing and Fragile X Syndrome

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Background: Pentacene Thin Film Transistors

Same equations (approximately)

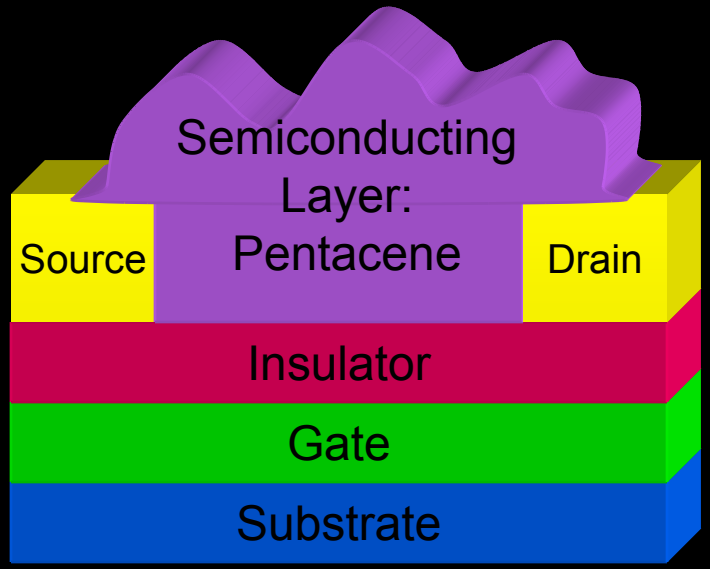
Linear

$$I_D = (\mu W C_i / L)*(V_G - V_T - V_D/2)*V_G$$

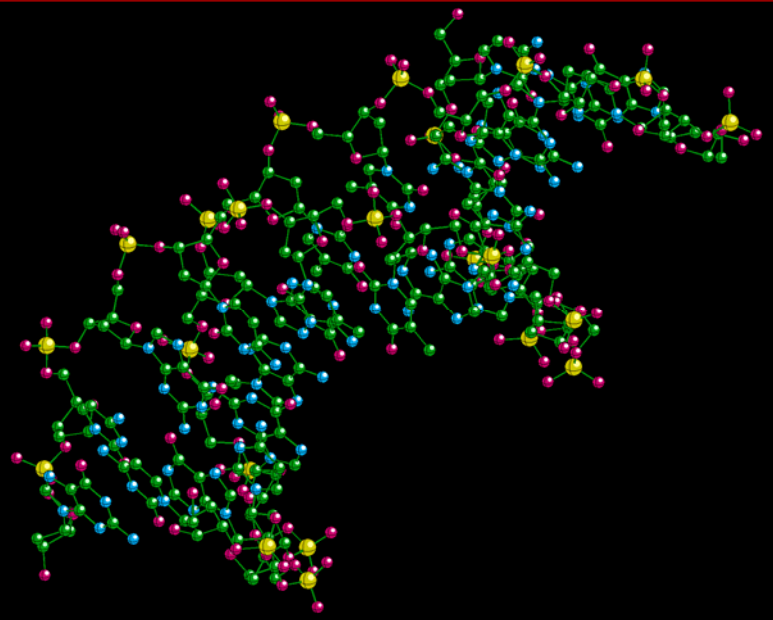
Saturation

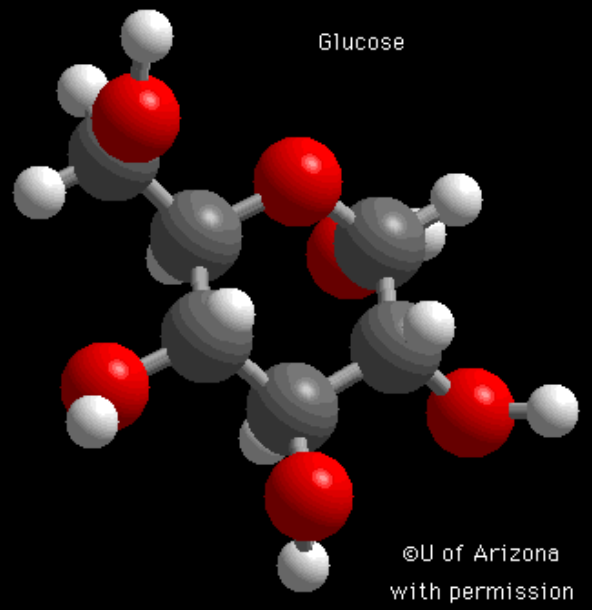
$$I_D = (\mu W C_i / 2L) * (V_G - V_T)^2$$

Reported mobilities (μ) have been as high as 1 cm^2/s



Biological Applications

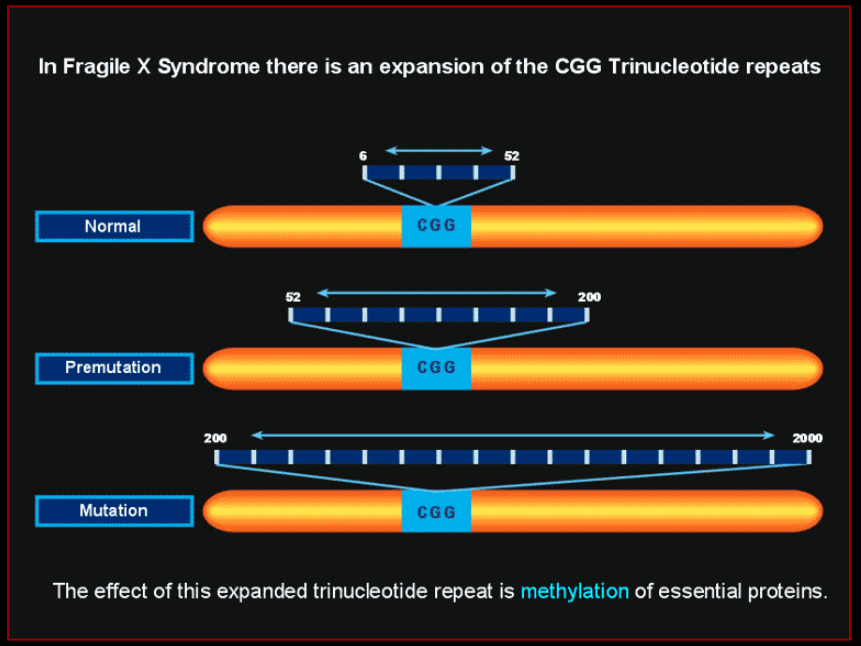




- Glucose
- dsDNA, ssDNA, hybridization detection

Background: Fragile X Syndrome

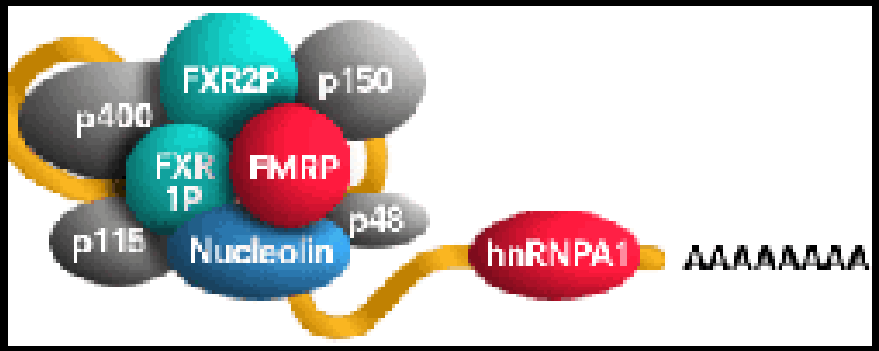
- Too many CGG repeats on FMR1 gene
- No Fragile X Mental Retardation Protein (FMRP, is an RNA-binding protein) produced
  - Mild to severe mental retardation
  - Exact role of the FMRP in development not known

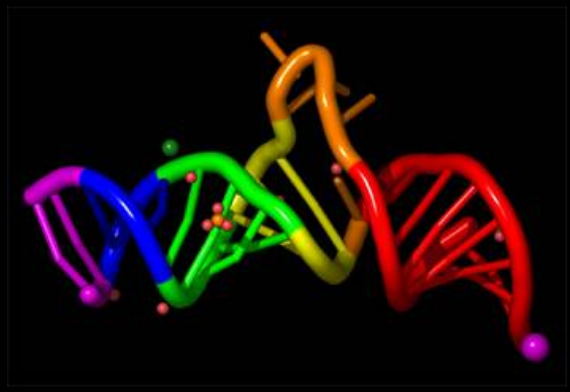


Fragile X Syndrome

General

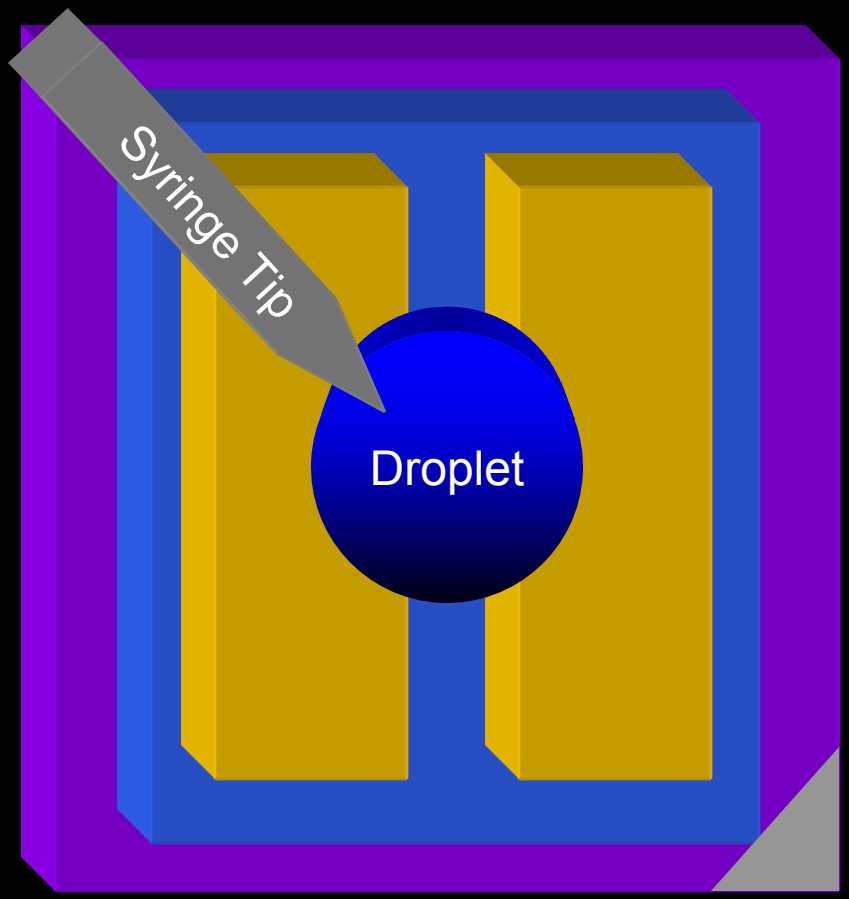
- Expose transistor to biologically relevant media and evaluate its ability as a sensor
- Test its ability to function in a biologically relevant environment
- Look at the behavior of the transistor in this environment, and see if the environment could be optimized so that the transistor is responding specifically to the targeted agents



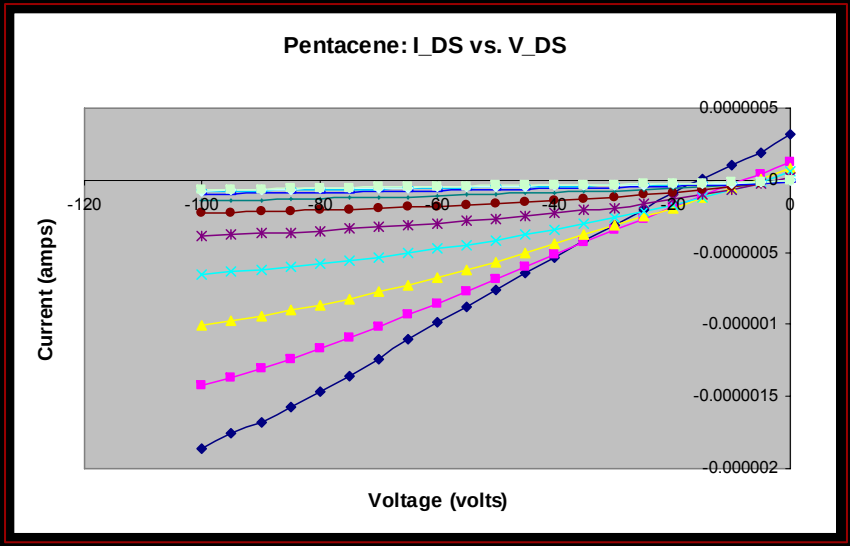


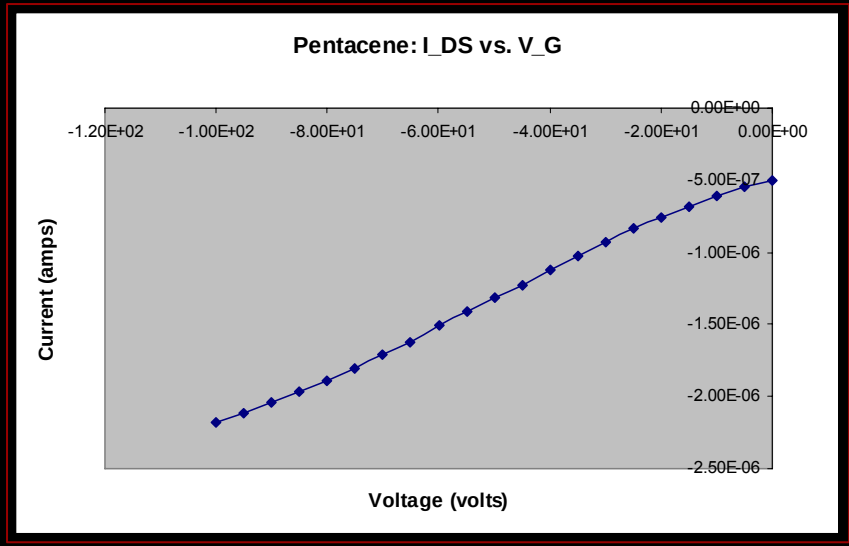
Exposing the Transistor

- ☑ Deionized, distilled water
- ☑ Moine buffer (salt solution with pH 7.4)
- ☑ BSA (bovine serum albumin)
- ☐ RNAsin (RNAse Inhibitor)
- ☑ tRNA
- ☑ FMRP
- ☑ FMR1 RNA
- ☑ All combined (BSA, no BSA)



Control: Unexposed Transistor



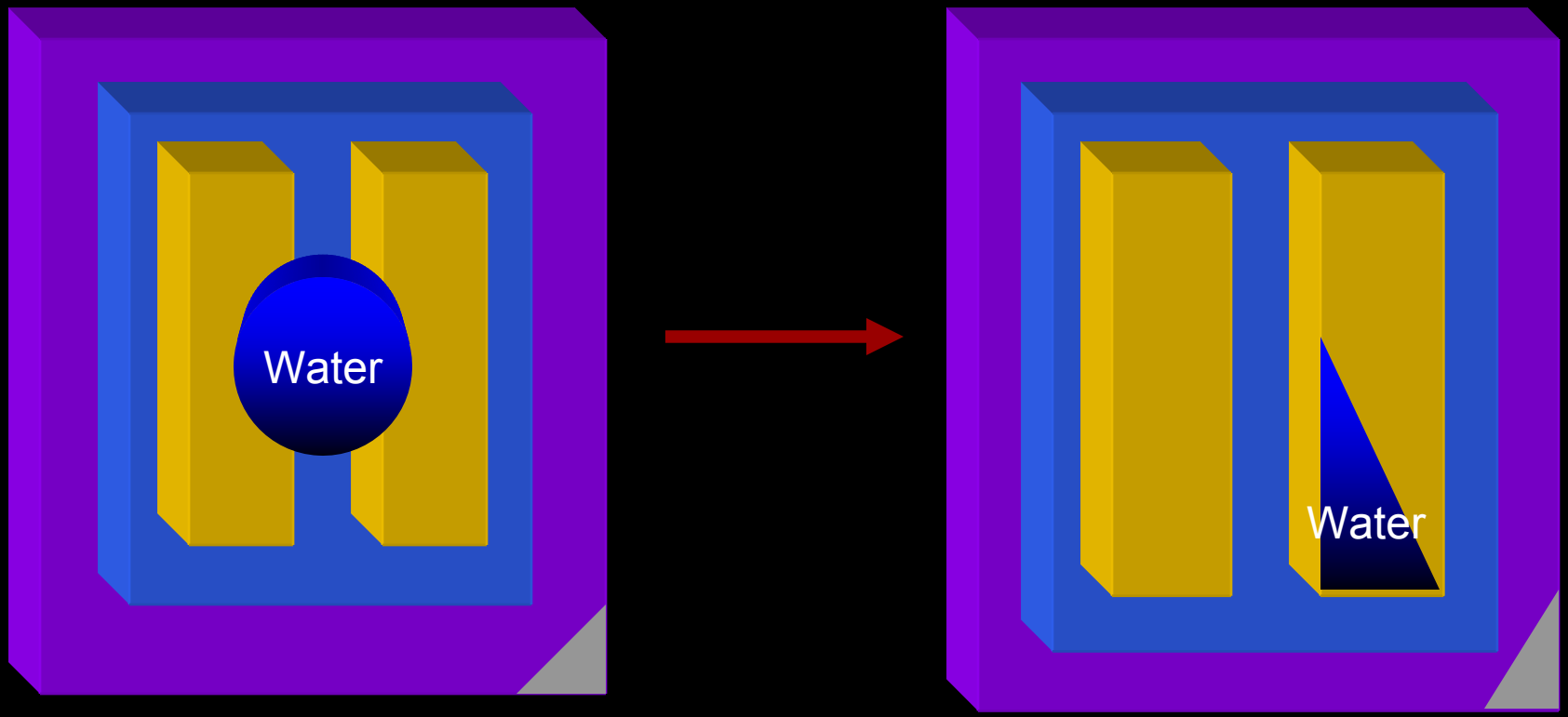


W = 1500 µm; L = 95 µm

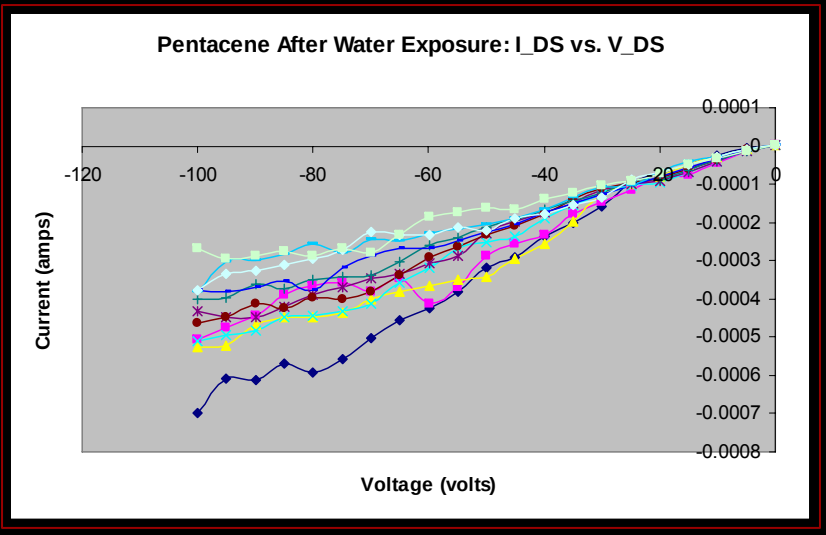
$\mu = 1.56 * 10^{-3}\ cm^2/s$

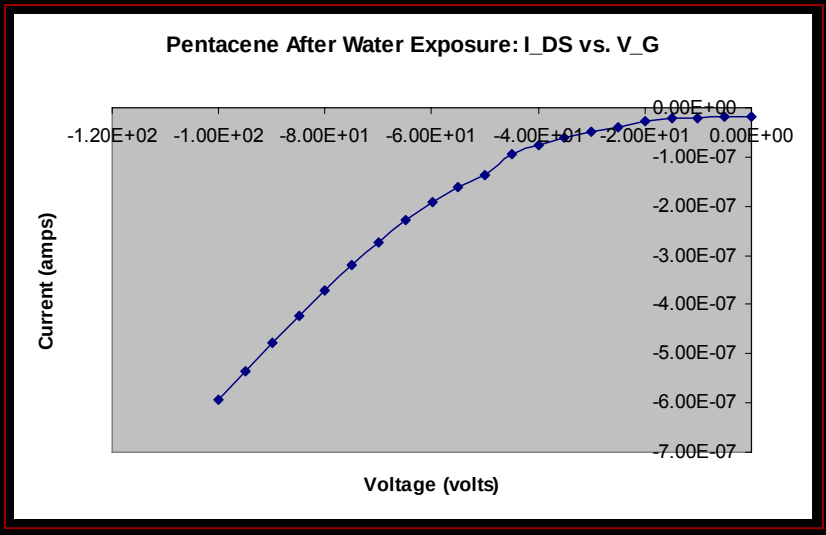
$V_T = 7.46 * 10^{1}$ volts

Distilled, Deionized Water



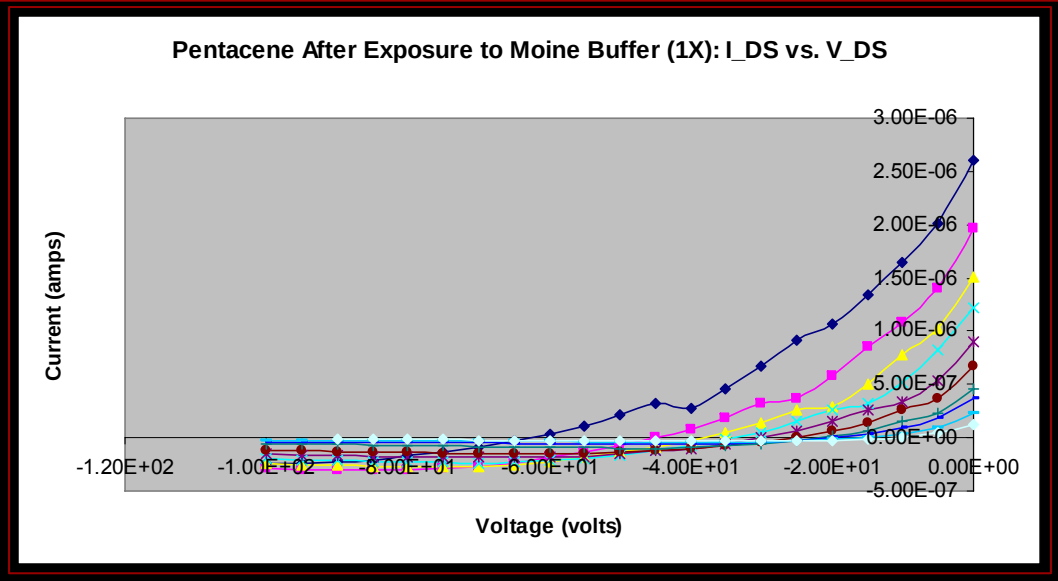
After Water Exposure





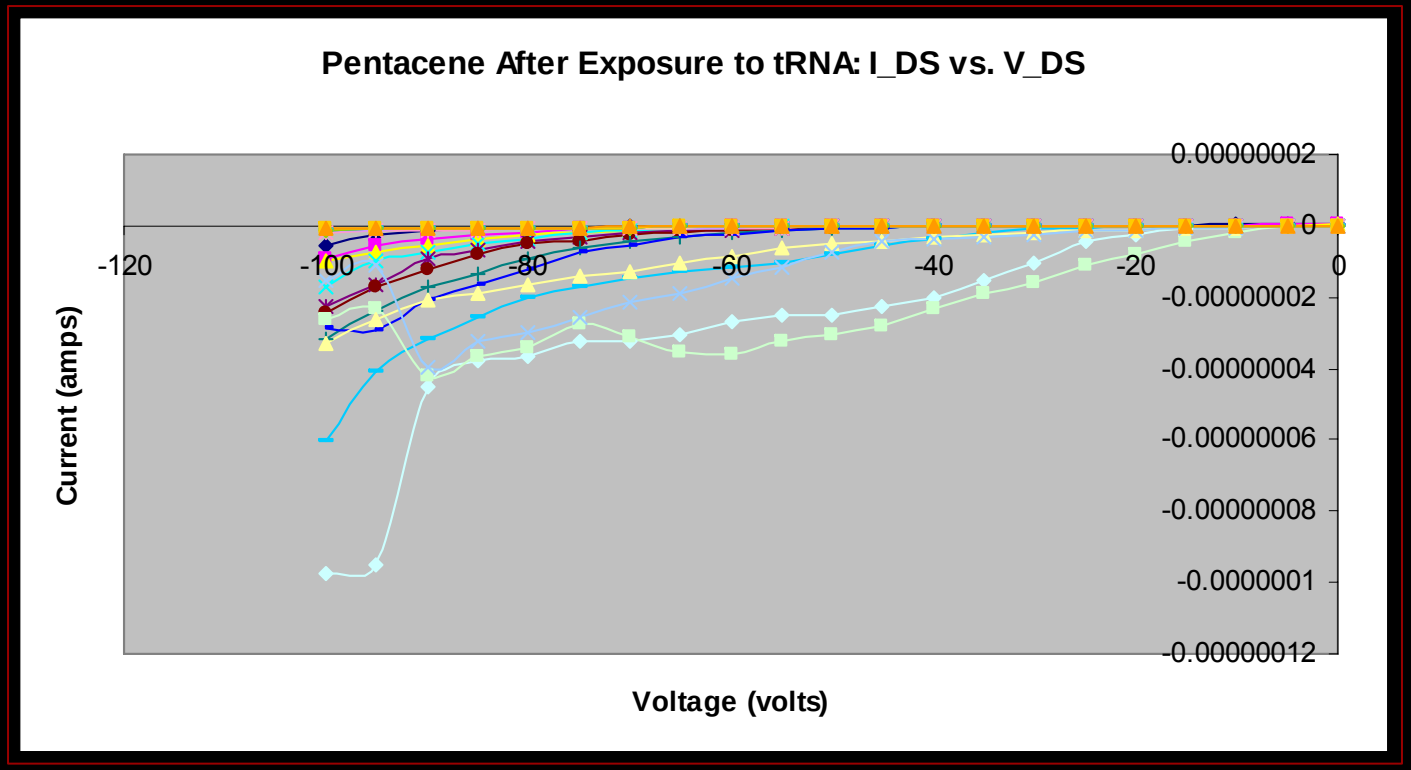
- V_T without exposure = -45.0 volts
- V_T with exposure = -7.14 volts

After Moine Buffer (1X) Exposure



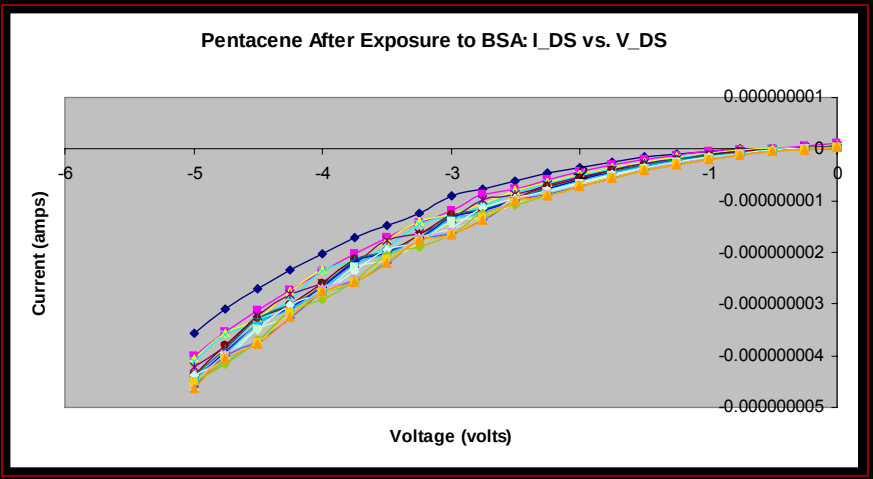
- Large amount of leakage current observed
- Drop showed little tolerance for any applied voltage, most likely due to salt concentration in electric field
- A short between the probes was most likely caused

After Exposure to tRNA



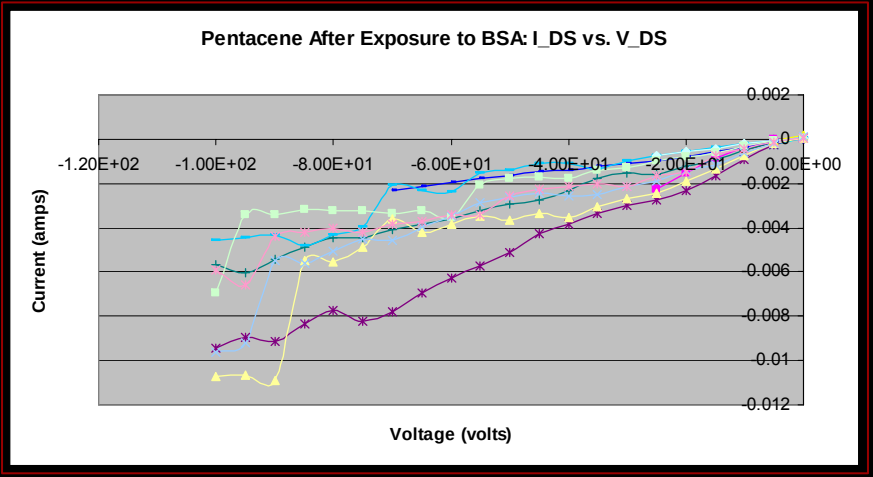
After Exposure to BSA

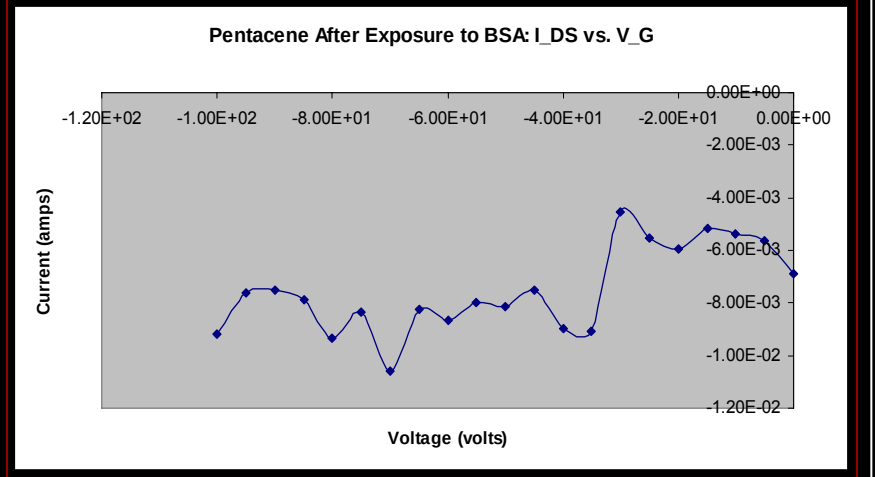
LOWER



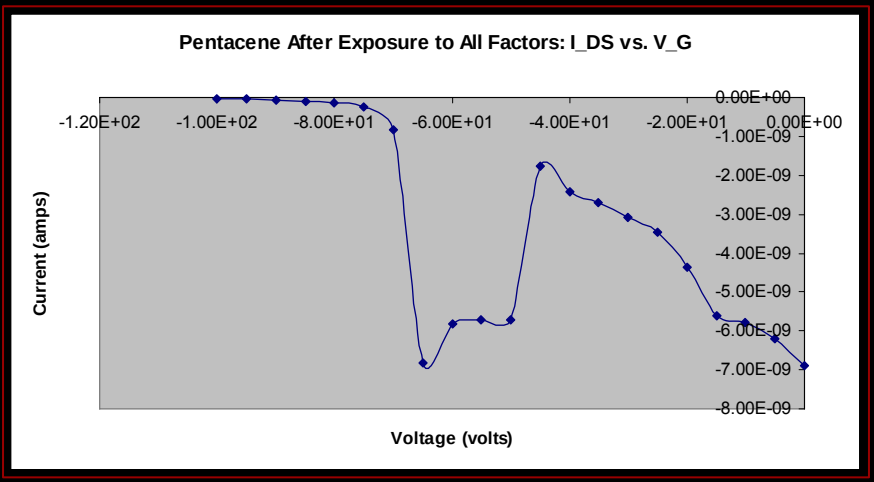
- Higher voltage graph slightly inconclusive
- For I_DS vs. V_G graph, very little dependence on the gate voltage shown

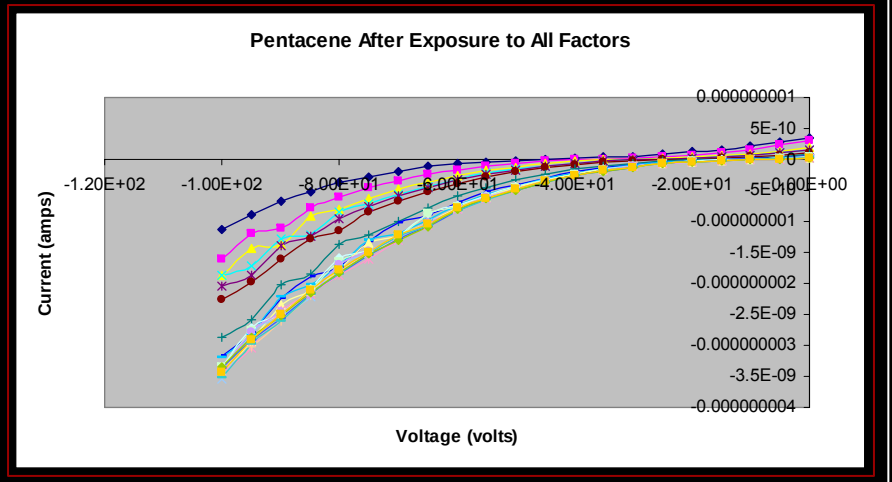
HIGHER





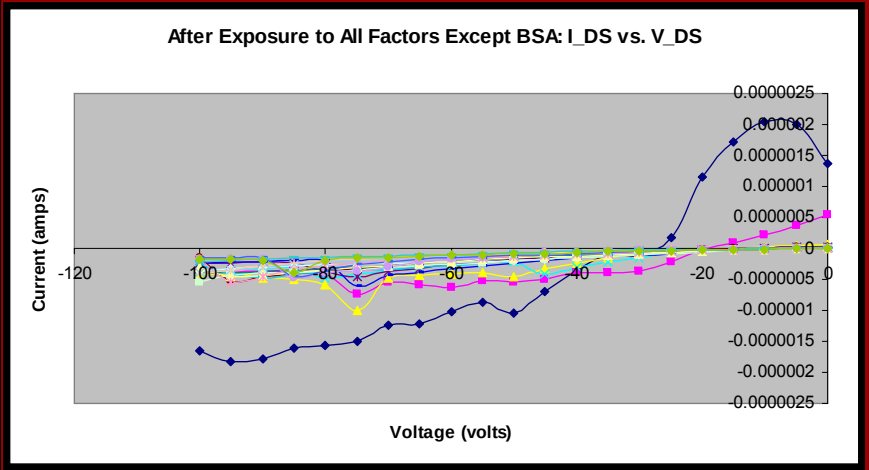
All Combined, with BSA

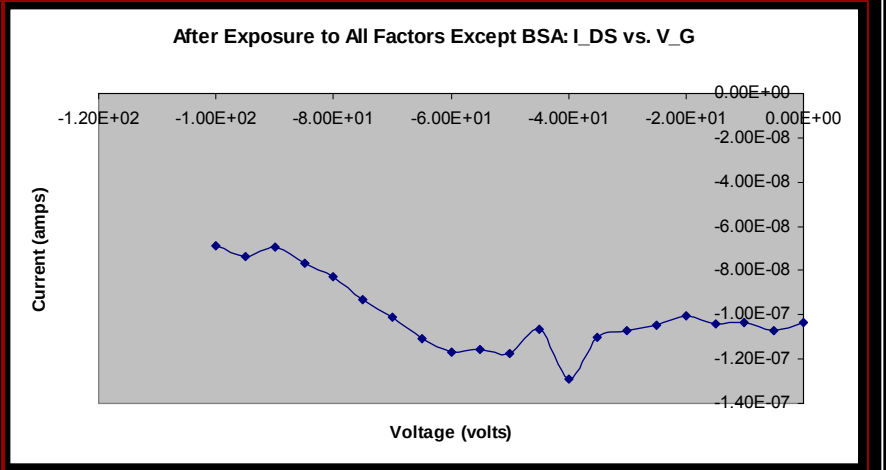




- Drop dispersed
  - Movement towards electrode
  - General spreading
- Resembles BSA Graphs

All Combined, No BSA





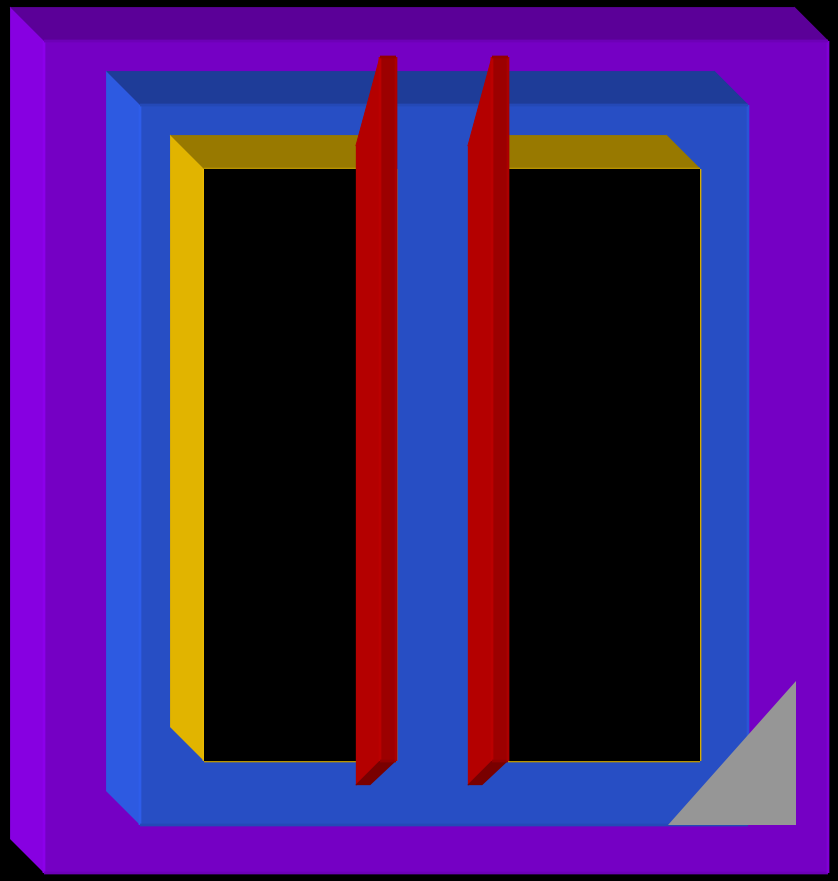
- Not much activity on the part of the transistor, current levels pushed to a relatively low level
- Drop did not disperse

Conclusions

- BSA is known to coat the surfaces it comes into contact with – it is possible that when combined with all the other factors, it dominated the response
- However, this effect could also be due to water
- The transistor did show degrees of degradation upon exposure to these agents

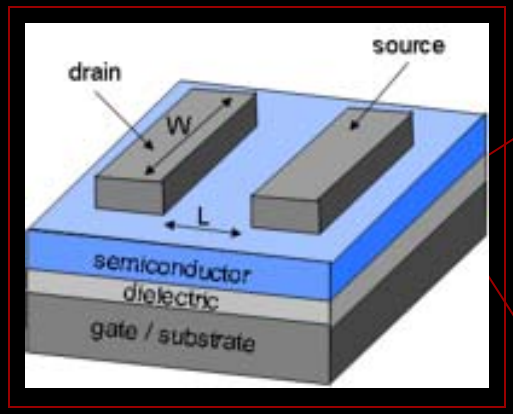
Conclusions and Suggestions

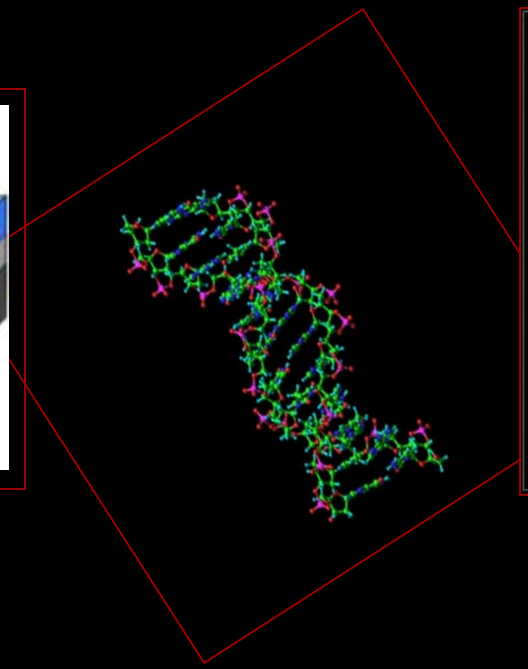
- A microfluidic channel should be used to contain the liquid within the channel and distribute it evenly around the channel
- The source and drain should be protected, possibly with fluorinated polymer
- All transistors should have long channels and be the same size to minimize variance according to size
- Repetition, isolate effects of FMRP and FMR1 RNA

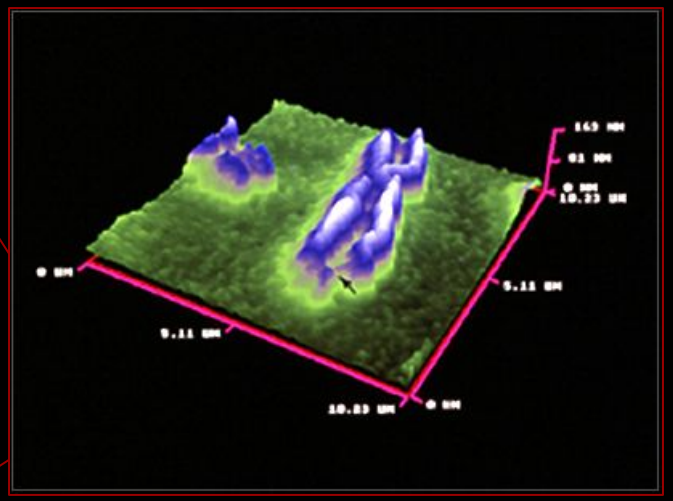


Continuing Research

- In the long run, we want to try to find out more about the function of the FMRP
- Affinity α importance of function

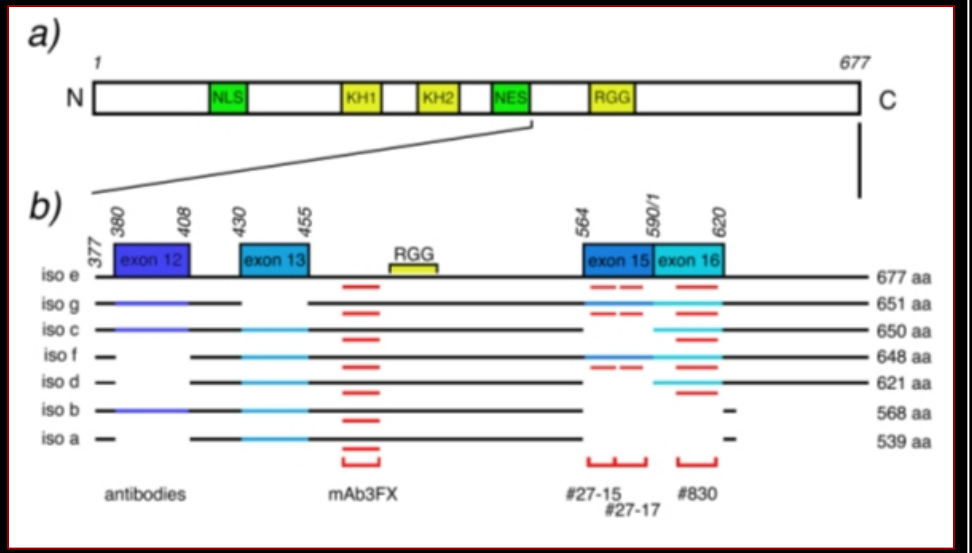






Continuing Research

- The transistor will be exposed to mixtures of varied FMRP and target RNA along with other components
- In particular, for the FMRP, the KH1, KH2, and RGG domains are the ones that will be cut out or kept
- Hopefully some combinations will cause a similar reaction, or some trend can be discerned based on affinity and the target RNA
- This will hopefully be able to contribute to research on Fragile X Syndrome



Acknowledgements

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