

Lateral Ion Modulated Transistor on Paper

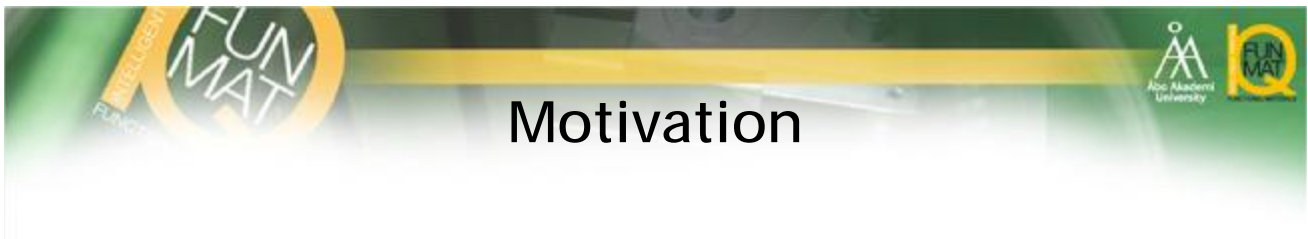
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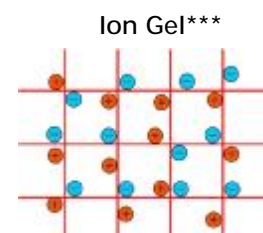
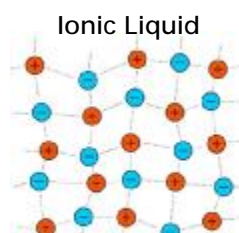
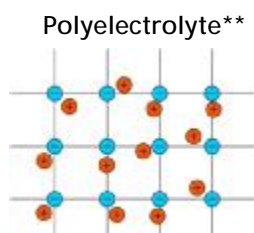
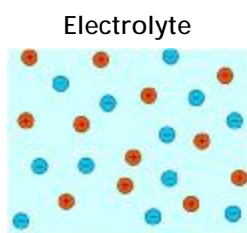
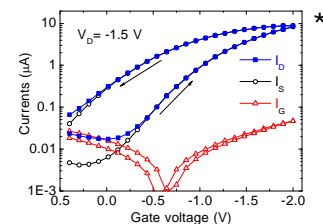
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Motivation

- Paper is rough substrate for electronics
- In stead of field effect- we can use potential driven device
 - Use ion conducting dielectric
 - Higher currents at low voltages
 - Less sensitive to substrate roughness

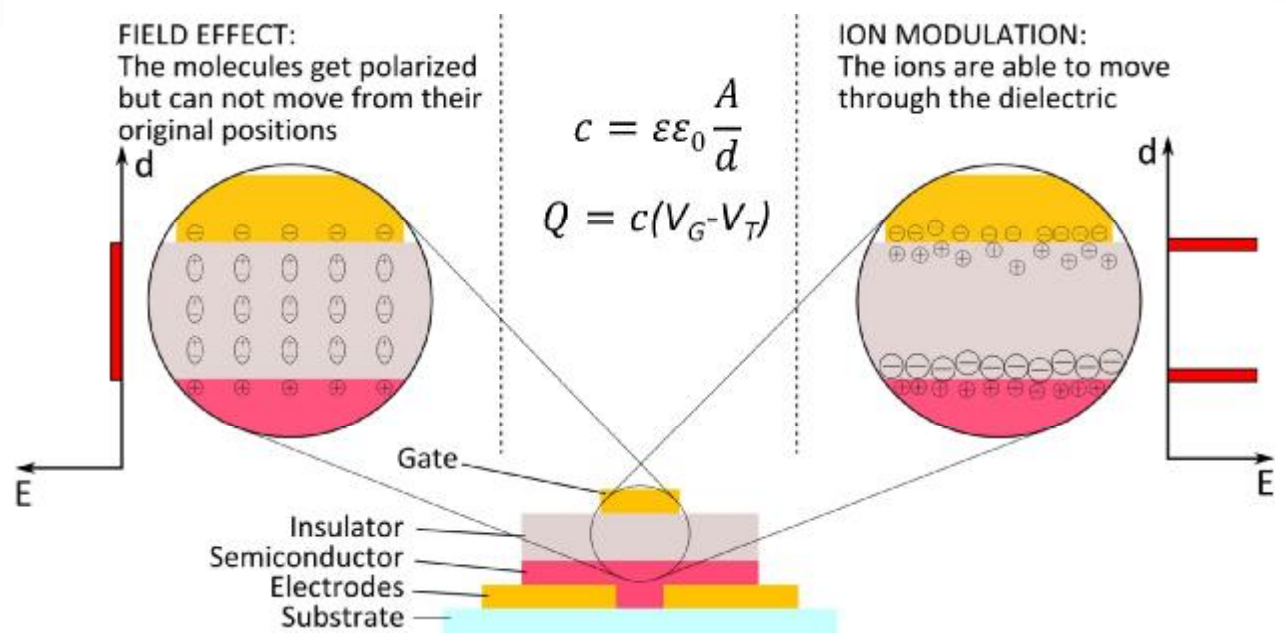


*R. Bollström et al. *Org. Electron.* 2009, 10, 1020

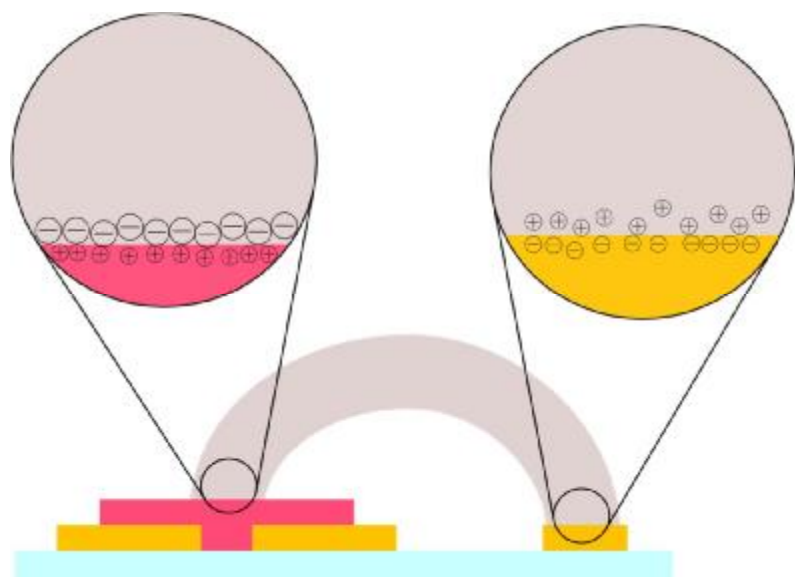
***J. AM. CHEM. SOC. 9 VOL. 127, NO. 13, 2005

**M. Berggren, *Adv. Mater.* 2007, 19,97

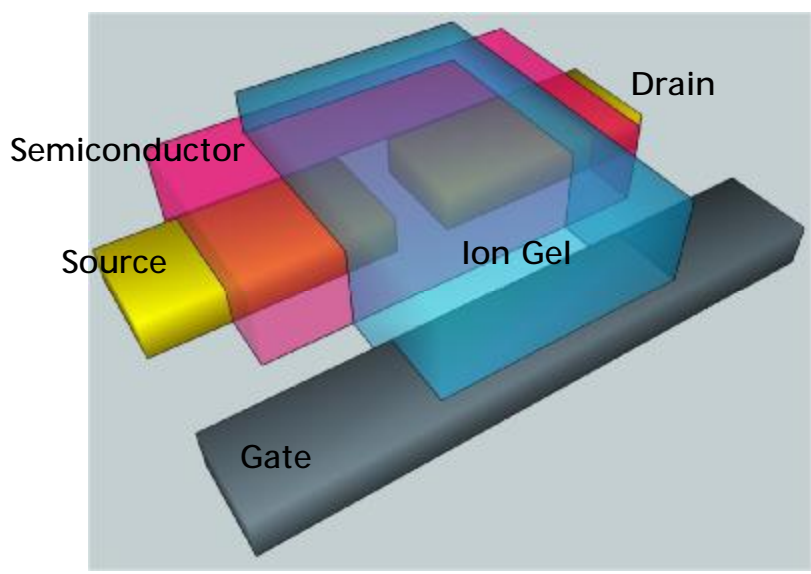
Field Effect vs. Ion Modulation



Ion Modulation

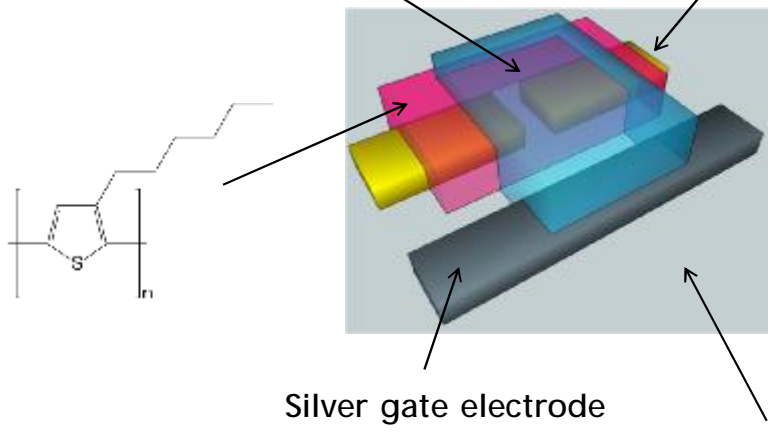
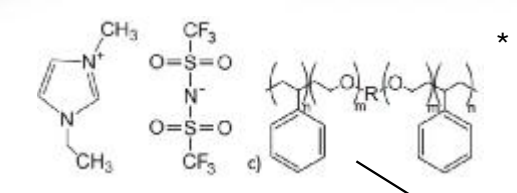


Lateral structure

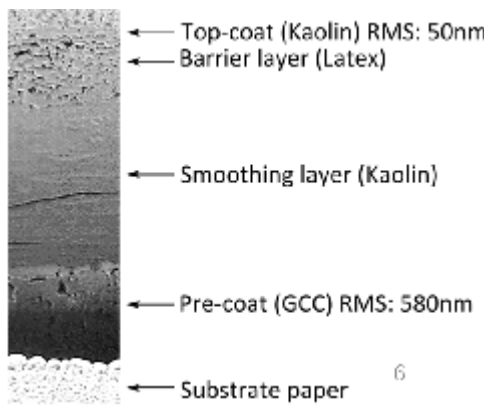


- Advantages:
- Fewer fabrication steps
 - Less sensitivity to roughness
 - No alignment issues
 - Avoid problem with printing gate on top of insulator
 - Insulator can be liquid
 - Favorable for sensor application
- Disadvantages:
- Speed

Materials



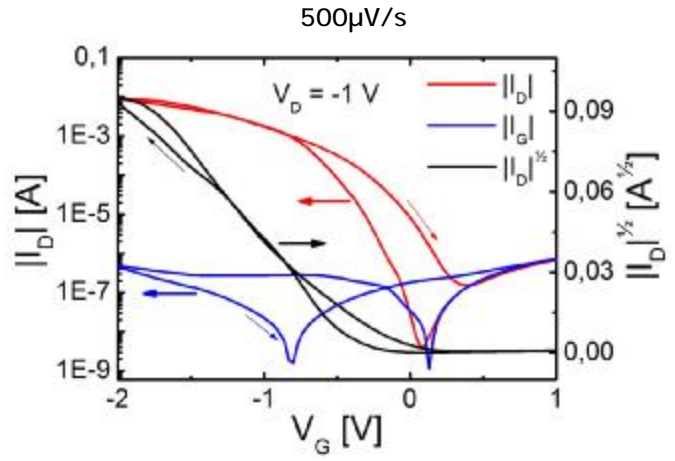
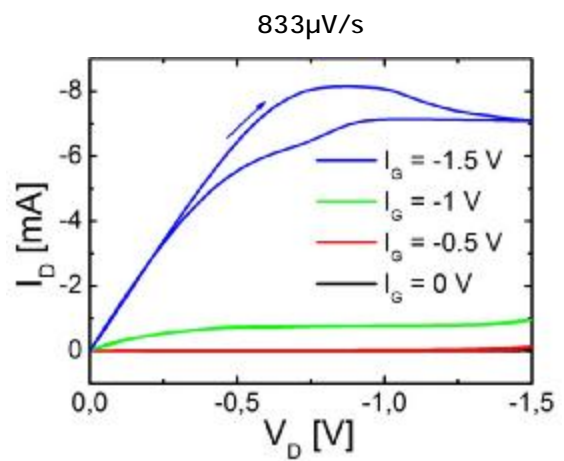
Gold source and drain electrodes



*Cho J. et al. *Nat. Mater.* 2008, 7, 900

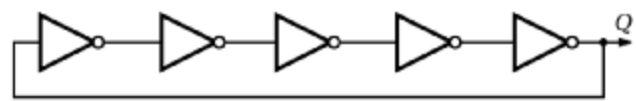
Transistor Characteristics

- Output and transfer curves measured in air
- Still works as transistor after two weeks storage in air

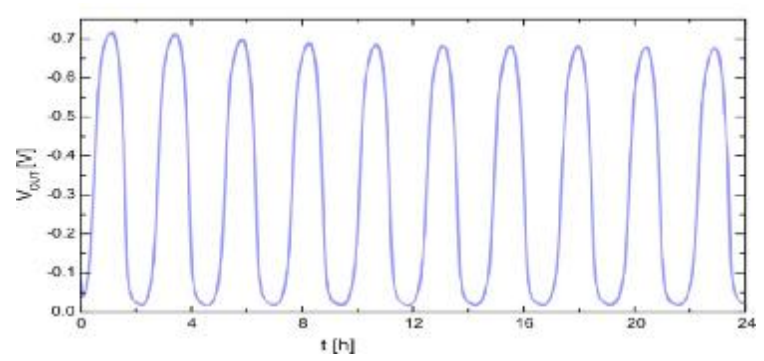
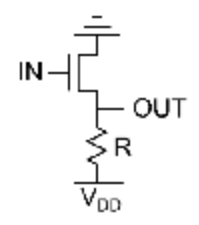


Ring oscillator

- We have built an electric circuit using our paper transistors
 - A ring oscillator with 5 inverters



$R = 205 \text{ k}\Omega$
 $V_{DD} = -0.8 \text{ V}$



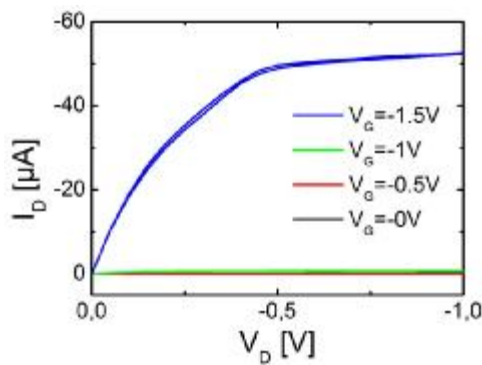
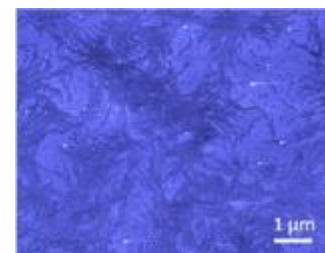
Improving the speed

- The volume of the semiconductor dictates speed (electrochemistry)
- Solutions:
 - Reduce device dimensions:
 - Print the whole device
 - Make the semiconductor thinner

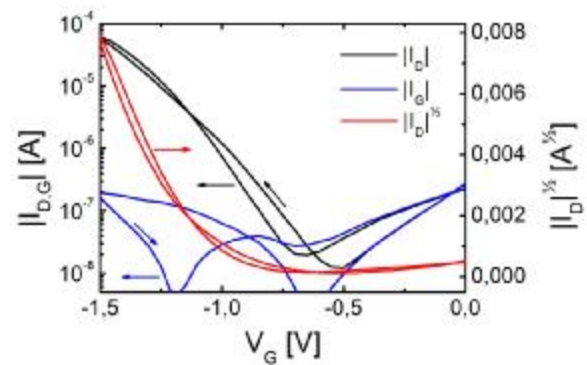
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Thinner semiconductor

- Use semiconductor/insulator blend (P3HT/PLLA) to get spontaneous vertical phase separation



100 mV/s

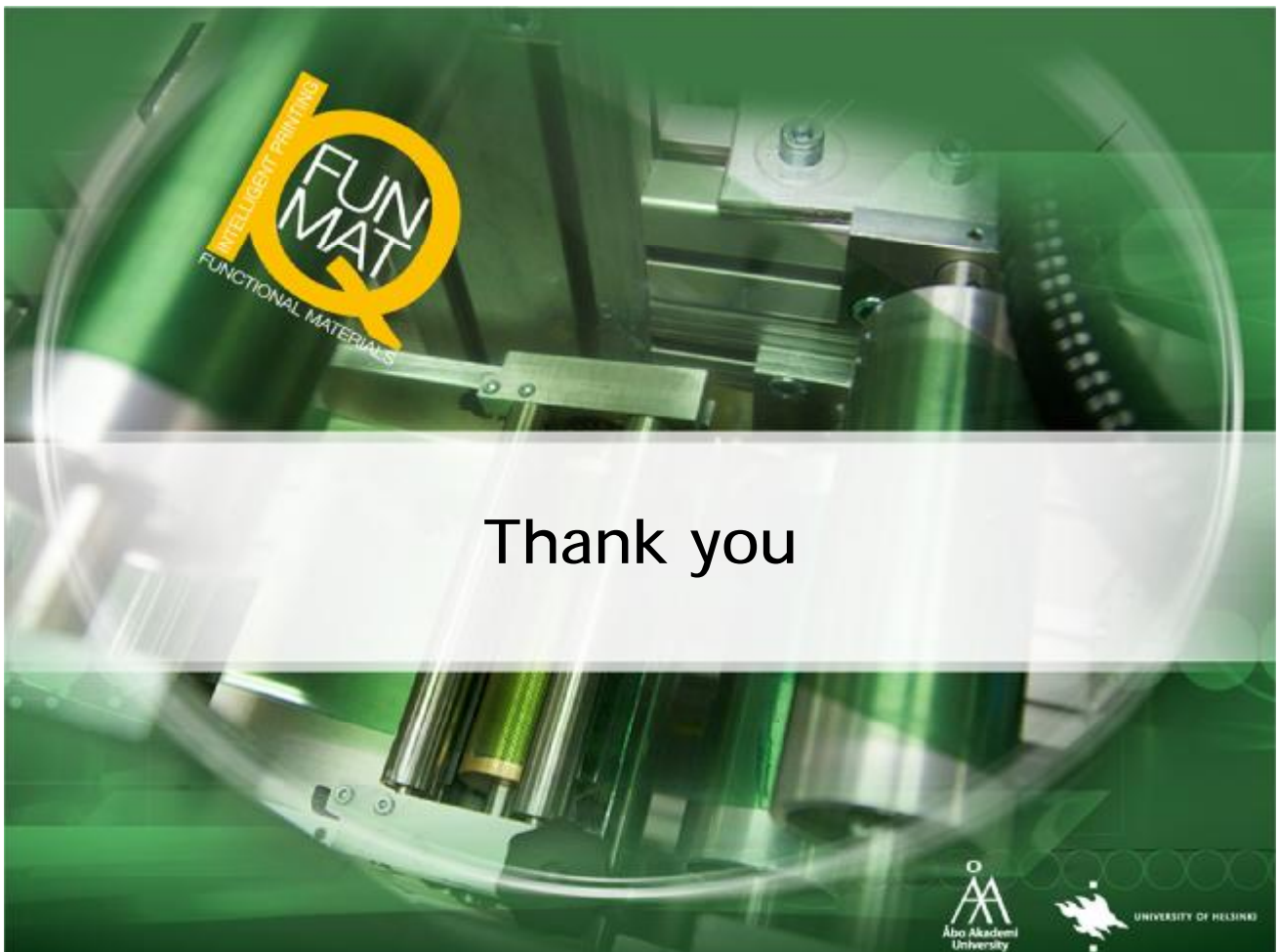


Conclusions

- We have created a low-voltage organic transistor on paper that works in air
- We have built a basic electronic component

Work in progress:

- Improving the speed by:
 - Printing the whole device
 - Using vertical phase separation to make thinner SC film



Thank you