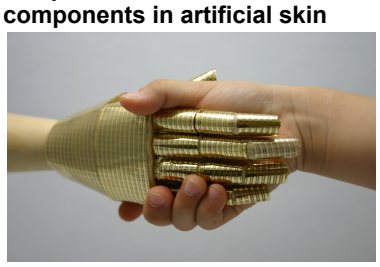
High senstivity organic temperature sensor

Research student: Xiaochen Ren

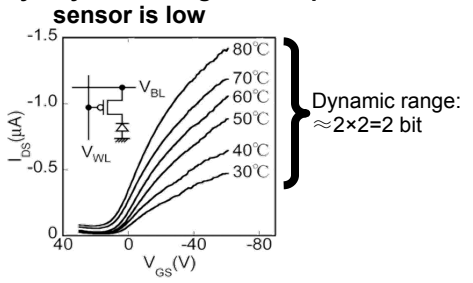
Background and objectives

Temperature sensor is one of the key components in artificial skin



T. Someya *et al.* IEDM 2003

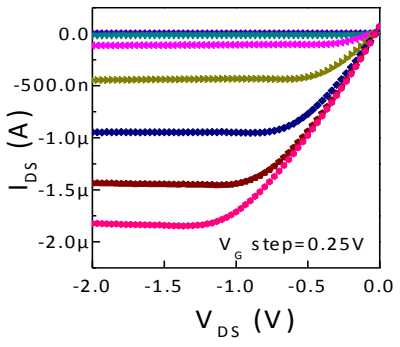
Dynamic range of temperature sensor is low

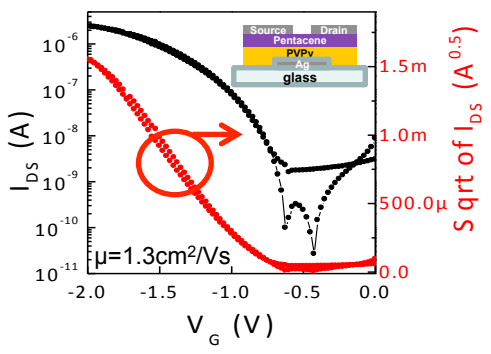


T. Someya et al. Proc. Natl. Acad. Sci. USA 2005, 102, 12321.

The dynamic range is hinted by the serially connected diode, to obtain lower current at room temperature, transistor need to be at off state.

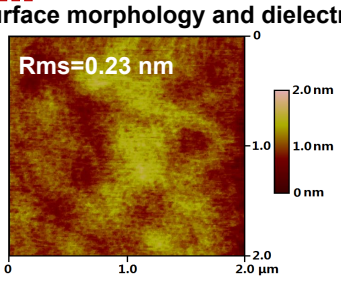
Polyvinylpyrrolidone (PVPy) based organic thin film transistor

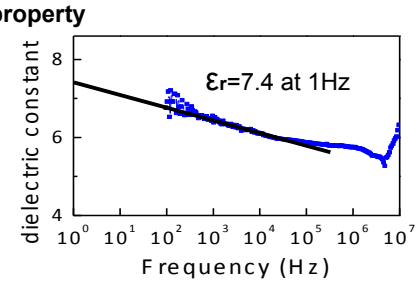




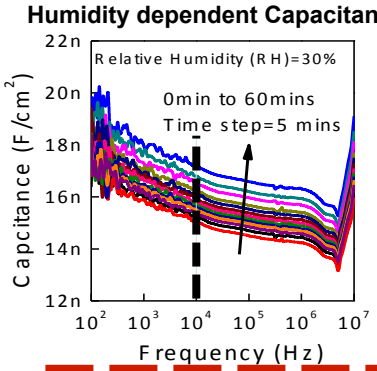
Characterization of spin coated PVPy thin film

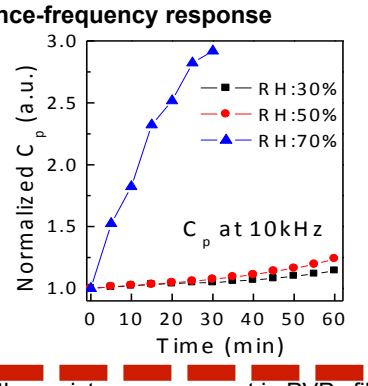
Surface morphology and dielectric property



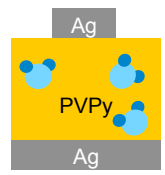


Humidity dependent Capacitance-frequency response



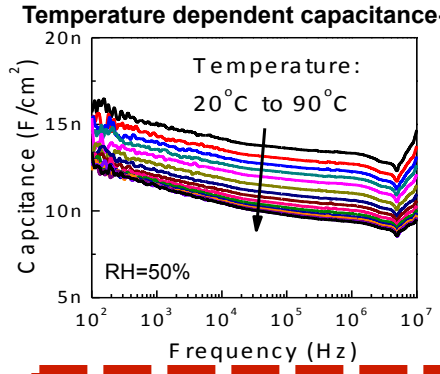


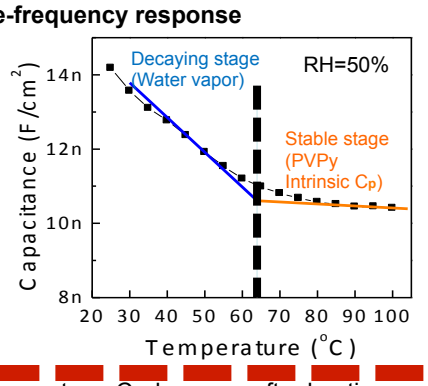
εr=80.4(20℃)



PVPy absorb water in the air, the moisture component in PVPy film increase the C_p due to the large dielectric constant of water

Temperature dependent capacitance-frequency response

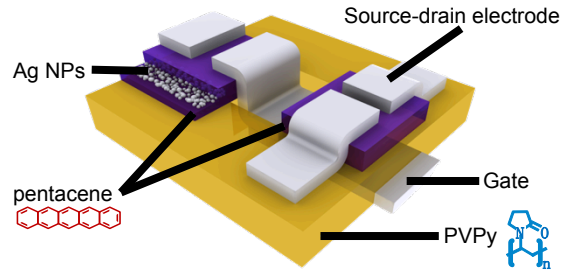


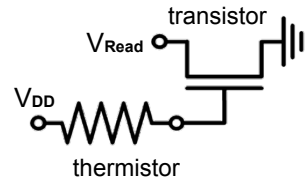


The moisture is vaporized at high temperature, C_p decrease after heating

Organic integrated temperature sensor

Device structure, one thermisor one transistor sensor

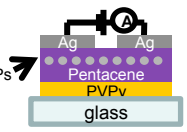




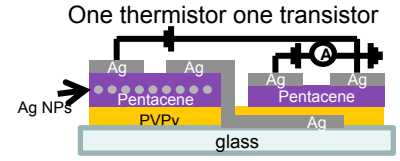
Temperature sensor performance

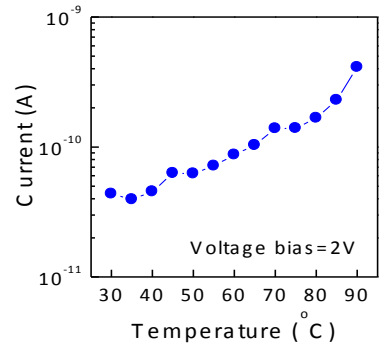
One thermistor

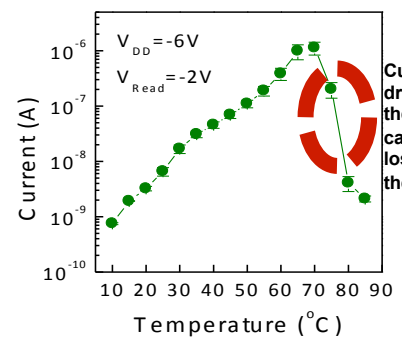
Ag Nps increase the temperature dependent conductivity variation of film: *Ref.1*



One thermistor one transistor







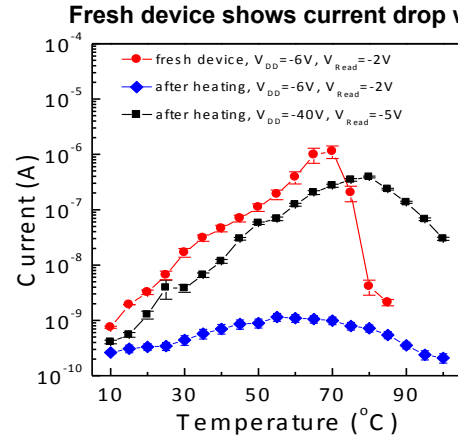
At low temperature, V_{DD}=-6V, $V_{resistor}$>V_G of transistor, transistor state: off

At high temperature, V_{DD}=-6V, $V_{resistor}$<<V_G of transistor, transistor state: on

The actual gate voltage of transistor is controlled by the resistor, the large on/off ratio of transistor brings large sensitivity of the sensor

Capacitance loss during the heating

Fresh device shows current drop when T>70℃



The drop of current is due to the capacitance loss during the heating, transistor need larger gate voltage to turn on, therefore it can be enhanced by increasing the V_{DD}

The heated device, when V_{DD} is increasing from -6V to -40V, the sensing performance is recovered.

Sensing dynamic range: 2^{11}>1300>2^{10}=10 bit !!!

Conclusion

PVPy can be use as a polymer dielectric for organic thin film transistor due to its high dielectric constant and smooth surface. The PVPy based 1R1T temperature sensor shows the sensing dynamic range can be up to 10 bits. During the measurements, heating leads to the lost of capacitance in the dielectric and therefore the operating voltage increases. The high dynamic range temperature sensor provide high resolution sensing ability which is capable for artificial skin application and the simple fabrication process could be potentially used for flexible and large area devices.

References

[1] X.C. Ren *et al.* Appl. Phys. Lett. **99**, 043303 (2011).
[2] T. Seketani *et al.* Adv. Mater. **22**, 2228–2246 (2010).
[3] J. Park *et al.* Mol. Cryst. Liq. Cryst. Vol. 531 (2010).