C|D|T Cambridge Display Technology

Organic Semiconductors for Thin Film Transistors

Example application areas for printable thin film transistors

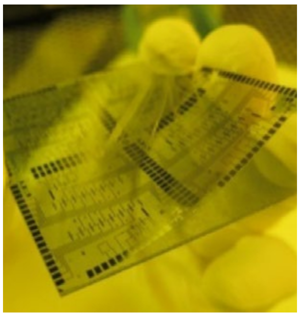
Hand-held Medical Devices

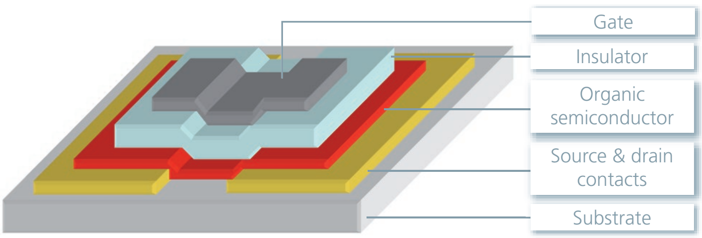
Wearable Devices

- **Sensors:** transistors as part of circuits to enable these applications
- **Circuits (digital and analogue):** logic gates, amplifiers, circuitry for sensor applications
- **Displays:** select and drive transistors for controlling pixel operation
- Solution processed transistors enable wider printed electronics applications to be envisaged through integration with existing printed devices. These include wearable devices optionally on flexible/curved substrates *(example concepts shown left)*

General properties of organic semiconductor materials:

- Soluble in typical organic solvents (such as xylene) for solution processing (e.g. inkjet or slot die coating)
- Low temperature processing compatible (<120° C), therefore inherently suitable for devices on plastic substrates such as commonly used PEN or PET
- Post printing annealing processes are not required for high mobility devices → simple process to integrate with other organic electronic devices





Example test cell device on plastic in a top gate configuration. Lithographically defined electrodes to 5μm channel length resolution

Performance features and material design aspects:

- Mobility as high as 2.5 cm^2/Vs. On/off current ratios $>10^5$ on plastic substrates
- Suitable for use with either gold or silver source and drain contacts
- Low voltage device platform developed for ≤10 V operation
- Example performance summary chart of one material is shown below.

OSC material: Example technical specifications performance	
Average saturation mobility (cm^2/Vs) at 10 µm	1.0 – 1.5 [bottom gate] 2.0 – 2.5 [top gate]
On/off current ratio	10^5
Phase property	Amorphous
Sub-threshold slope (V/decade)	0.6 (L=10µm, BG)

All device data taken from a top gate, bottom contact architecture on plastic films with gold source and drain contacts

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Barrier | Displays | OTFT | Insulator | Optical sensors | Lighting | Energy systems | Flex displays | OPV | Biosensors | Development partner

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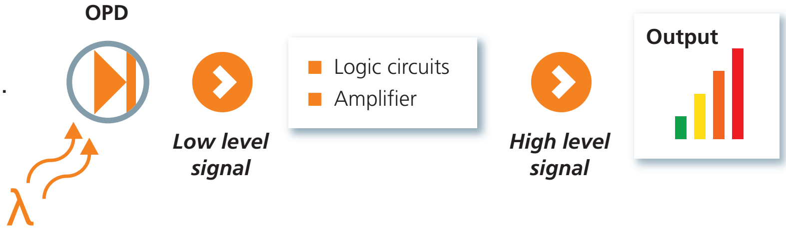
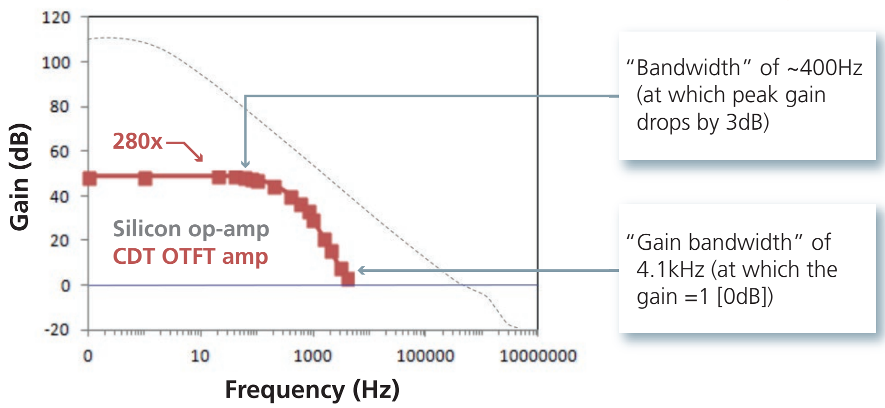
Application example: Printed OTFT circuits for integrated systems

Input signal:
OPD as detector element in optical sensor system e.g.
→ *Biosensor*
→ *Proximity sensor*



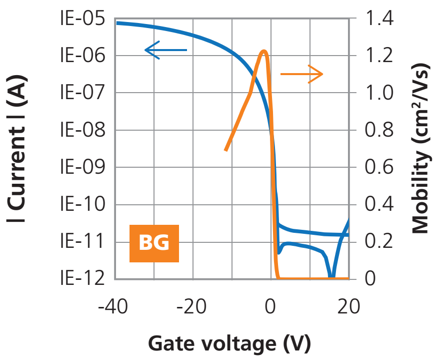
Output signal:
Increased voltage or current output

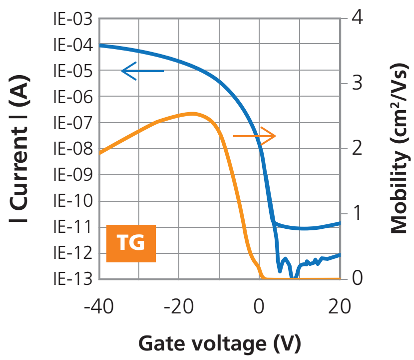
OTFT amplifier performance: Gain vs frequency



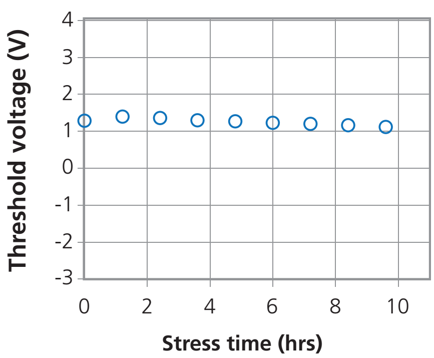
Printed OTFT device example data: Bottom gate (BG) and Top gate (TG) structures

Transfer characteristics





Threshold voltage stability



- Excellent mobility as high as 1 cm^2/Vs and 2.5 cm^2/Vs can be obtained at BG and TG structures, respectively
- Dielectric layer for BG is fabricated by using our original insulator material in PGMEA
- Threshold voltage shift extrapolated as a function of stress time is taken from transistors as a function of constant gate bias. Devices were subject to a constant gate bias of -20V for 9.6hours, measured periodically every 1.2 hours
- Inkjet and other printing methods can be applied due to the high solubility of OSC for common solvents and its amorphous nature.

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