Ultraflexible Organic Devices for Biomedical Applications

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Outline

- Introduction
- Ultrathin OTFT, OPV & OLED
- Emerging applications
- Summary
Flexible Organic Electronics

OLED display
Sony

OLED lighting
OSRAM

Organic RFID tag
Poly IC

Organic Photovoltaic
Heliatek
Robotic
E-skin

E-skin System

Significant reduction of the number of wirings

1,000,000 = 1,000 \times 1,000 \text{ (active matrix)}

1,024 = 2^{10} \text{ (decoder & selector)}

1,000,000 wirings \rightarrow \sim 10+10

Power consumption of active matrix driving

Active matrix configuration shows power consumption much lower than passive matrix.

<table>
<thead>
<tr>
<th></th>
<th>Passive matrix (w/o TFT)</th>
<th>Active matrix (w/ TFT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 x 64</td>
<td>0.6mW</td>
<td>0.1mW</td>
</tr>
<tr>
<td>1k x 1k</td>
<td>130mW</td>
<td>1.3mW</td>
</tr>
</tbody>
</table>
Robots with sensitive skins will feel and even respond to a person’s warmth while shaking hands, consequently letting people feel that robots are warmer.
Ultraflexible organic devices
World’s thinnest and lightest OTFT (3g/m²)

Amazing robustness: Crumpling

Minimum bending radius $\sim 5\mu m$
Stretchable organic transistors
Crumpled organic integrated circuits

Bending radius

R\text{=}15 \ \mu m

R\text{=}20 \ \mu m

R\text{=}18 \ \mu m

R\text{<}10 \ \mu m

Cross-sectional TEM
World’s thinnest and lightest OPV

TV program on December, 2012
"Chikyu Astech - Solar Cell on Thin Film"
Stretchable OLED

Brightness: 100 cd/m²   Stretching >100%!

- Light-emitting device that fits 3D surfaces
- Light source health-monitoring sensors

Flexible Electronics for Biomedical Applications

In-vitro neural interface

S. Lacour, S. Wagner, Barclay MorrisonIII et al

Medical sensors & lighting

Intelligent balloon catheter

Epidermal electronic skin

J. Viventi, J. A. Rogers et al,

High-sensitive electronic skin


K. Takei, J. Ali

Chemical sensors


Neural interfaces


Holst Centre

http://www.holstcentre.com/

Artificial skin


Multifunctional wearable devices

Dae-Hyeong Kim,

Neural interfaces


Multifunctional wearable devices

Dae-Hyeong Kim,

Wearable electronics

IMEC: ECG patch sensor


ECG measurement result can be sent to doctors through Bluetooth and Internet.

http://www.youtube.com/watch?v=iv7Wlly_W0Q
John A Rogers’s Flex Devices

From Robotics to Human


Bionic Skins (2013)

T. Someya et al., PNAS 102, 12321 (2005).


Thickness: 1/1000

t=1~2 mm

�t=2μm
Surface electromyogram monitoring

Fuketa, et. al., IEEE/ISSCC2013 #6.4.

64 channel amp. array

Current source

Bias Amplifier

Source follower

EMG Electrode

Off-sheet

On-sheet

OUT0 OUT1 OUT7

Block00 Block01 Block07

Block10 Block11 Block17

Current source

Bias Amplifier

Source follower

EMG Electrode

Off-sheet

On-sheet

OUT0 OUT1 OUT7

Block00 Block01 Block07

Block10 Block11 Block17
Electromyogram measurement

For stress-free healthcare-monitoring and welfare IT

Fuketa, et. al., IEEE/ISSCC2013 #6.4.
Implantable organic amplifier

Flexible: $R < 10 \ \mu m$

Weight: $3 \ \text{g/m}^2$

Total thickness: $2.5 \ \mu m$
(w/ encapsulation)

Large-area coverage: $50 \times 50 \ \text{mm}^2$
Imperceptible electronics

Applications
Medical IT
Welfare IT
Digital Healthcare

Specifications
The lightest (3 g/m²)
The thinnest (2μm)

What
Electromyogram
Electrocardiogram
Body temperature
Heart rate
Blood pressure

Where
Everyday life
During exercise
At hospital
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SAM
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Ultrathin
Animal

Elastic conductors

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Animal Experiment
Artificial Hearts
Summary

The frontier of organic electronics

Today: OLED Display & Lighting
OPV

Tomorrow: Healthcare / Medical

Uniqueness of organic devices

Ultralight, Ultrathin ⇒ Minimum invasiveness
Flexible, Durable ⇒ High reliability &
High sensitivity

Emerging applications

Digital Healthcare
Medical IT
Welfare IT