FULLY ORGANIC INTEGRATED ARRAYS ON FLEXIBLE SUBSTRATES FOR X-RAY IMAGING
**Flexible Organic Imagers: Motivation**

- light-weight
- flexible
- robust
- compatible with x-ray scintillators
FLEXIBLE ORGANIC IMAGERS: MOTIVATION
Flexible Organic Imagery: Motivation

- organic photodetectors (OPD)
- integration of imagers
- imaging results
organic photodetectors (OPD)
PHOTODETECTOR MADE WITH MOLECULES

$C_{60}$ fullerene

SubPc (subphthalocyanine)
PHOTODETECTOR MADE WITH MOLECULES

organic active layer

C\textsubscript{60} fullerene

acceptor (n-type)

SubPc (subphthalocyanine)

donor (p-type)
HIGH ABSORPTION OF ULTRATHIN LAYERS

organic active layer
HIGH ABSORPTION OF ULTRATHIN LAYERS

organic active layer

SubPc absorption
C$_{60}$ absorption

scintillators

extinction coefficient [-]

wavelength [nm]
OPD SPECTRUM = SPECTRUM OF MOLECULES

SubPc: 20 nm thick
C$_{60}$: 30 nm thick
FROM ORGANIC THIN FILMS TO PHOTODETECTORS

Detector (0.1 μm)

Top contact
Organic active layer
Bottom contact

Glass substrate

Ag
BCP
30 nm C₆₀
20 nm SubPc
MoO₃
Au

Semi-transparent cathode
electron transport layer
acceptor
donor
hole transport layer
reflective anode
ORGANIC PHOTODETECTOR IN ACTION

detector
(0.1 µm)

- top contact
- organic active layer
- bottom contact

glass substrate

- Anode
- Donor
- Acceptor
- Cathode

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integration with organic ROIC on foil
PENTACENE-BASED OTFT ROIC

- gate dielectric
- readout (0.2 µm)
- foil (25 µm)
- flexible foil
- planarization
- gate metal
- S/D
- bottom contact
- pentacene

Pentacene-based OTFT ROIC diagram with layers labeled.
INTEGRATION OF OPD AND OTFT

detector (0.1 µm)

- top contact
- organic
- active layer
- bottom contact

foil (25 µm)

- gate dielectric
- planarization
- flexible foil

edge cover layer

pentacene

S/D

gate metal

readout (0.2 µm)
INTEGRATION OF OPD AND OTFT

detector (0.1 µm)

- top contact
- organic
- active layer
- bottom contact

foil (25 µm)

- gate dielectric
- pentacene
- S/D
- gate metal
- planarization
- flexible foil

edge cover layer

readout (0.2 µm)

- readout TFT

photodetector area

data/select lines

200 µm

70 µm

30 µm

200 µm
ENCAPSULATION: PROTECTION AGAINST O$_2$/H$_2$O

detector (0.1 µm)
- top contact
- organic active layer
- bottom contact
- gate dielectric

foil (25 µm)
- planarization
- flexible foil

edge cover layer
- pentacene
- S/D
- gate metal

readout (0.2 µm)

flex-bonding

encapsulation

flex-bonding

encapsulation
Readiness for Scintillator Integration

x-rays \( \lambda \approx 550 \text{ nm} \)

- Scintillator
- Gate dielectric
- Organic active layer
- Bottom contact
- Planarization
- Flexible foil
- Top contact
- Edge cover layer
- Pentacene
- S/D
- Gate metal
- Processing on foil → flexibility
  → light weight
  → unbreakable
  → upscalability
imaging results
CLEAR SIGNAL UNDER ILLUMINATION

![Graph showing the effect of illumination on current density](image)

- Dark: 110 counts
- 130 µW/cm²: 20 counts

**Axes:**
- Y-axis: Pixels [counts]
- X-axis: Current density [A/cm²]
CLEAR SIGNAL UNDER ILLUMINATION

![Graph showing the relationship between pixel counts, current density, and illumination levels.](image)

- **Axes**:
  - Y-axis: Pixels [counts]
  - X-axis: Current density [A/cm²]

- **Legend**:
  - **Dark**: Grey
  - **130 μW/cm²**: Green

- **Data Points**:
  - **200 μm pitch**
  - **1 mm pitch**
PHOTOCURRENT LINEAR FROM $\mu W/cm^2$

wavelength = 532 nm

![Graph showing current density vs. power for different pixel pitches.](image)
Imaging with 1 mm Pitch Imager

*Imager with shadow mask*

Flexible fanout

Shadow mask
IMAGING WITH 1 MM PITCH IMAGER

*imager with shadow mask*

*flexible fanout*

*shadow mask*

*resulting image*
IMAGING WITH 200 µm PITCH IMAGER

imager with shadow mask

flexible fanout

shadow mask

resulting image
CONCLUSIONS

• **OPD integrated with OTFT**

• **32x32 px imagers on foil**

• **imaging with shadow masks**
Outlook

• more aggressive pitch
• larger array sizes
• x-ray → visible