



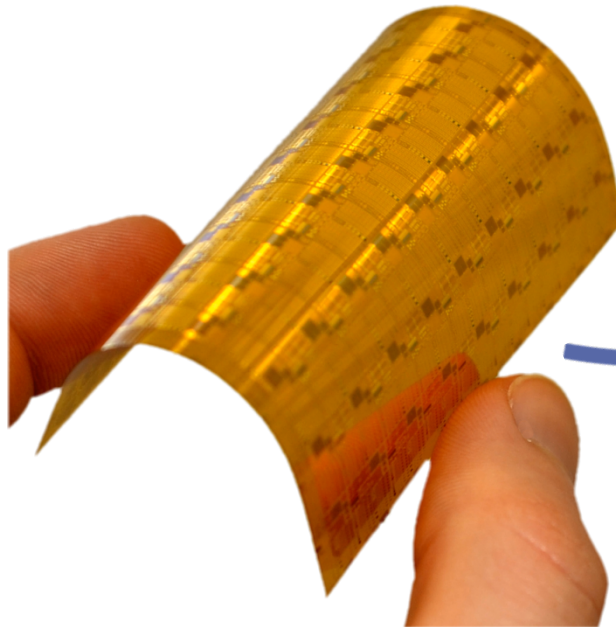
# Investigation of a-IGZO TFT gate material ductility

enabling flexible a-IGZO TFT s bendable to a radius of 1.7 mm

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43<sup>rd</sup> European Solid-State Device Research Conference

# I. Flexible electronics



**Flexible transistors**

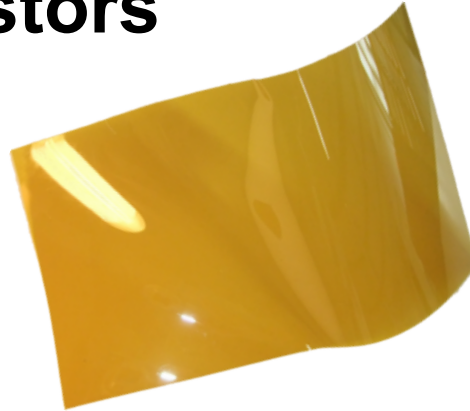


**New applications**

## II. Flexible transistors

### Flexible substrate

- Polyimide foil



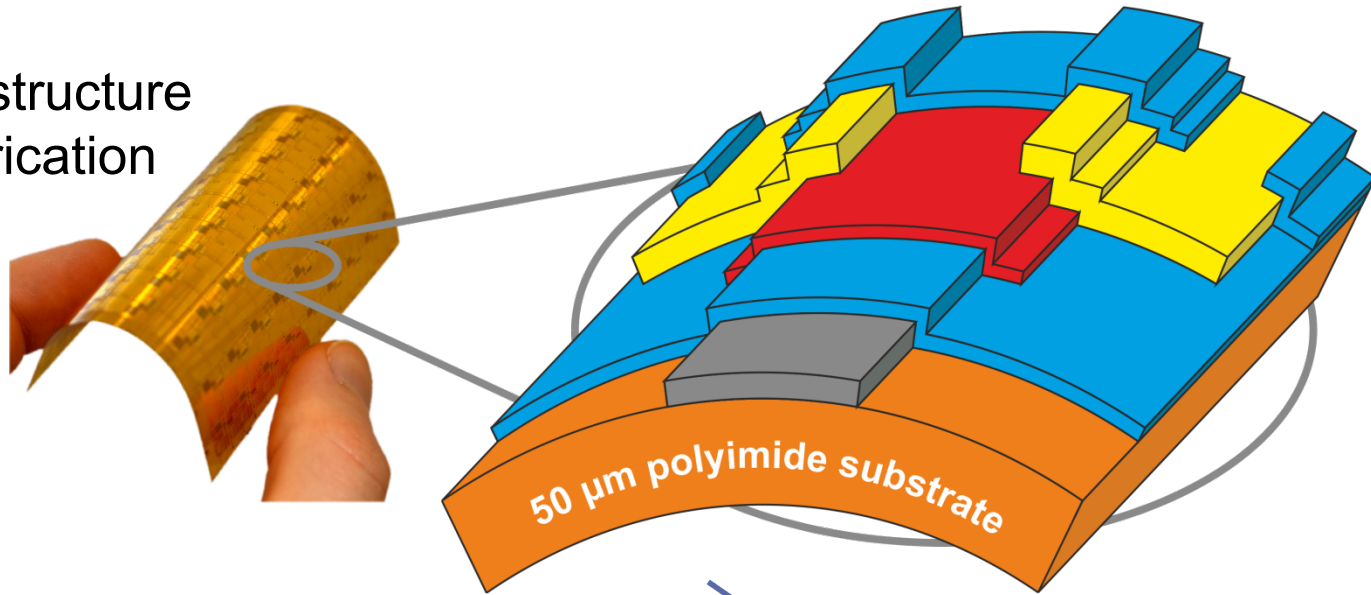
### Low temperature semiconductor fabrication techniques

### Compatible materials

- Semiconductor: Amorphous In-Ga-Zn-O (IGZO)
- Dielectric: Aluminum oxide  $\epsilon \approx 9.5$
- Contacts: Metals

## II. Flexible oxide semiconductor transistors

Device structure  
and fabrication

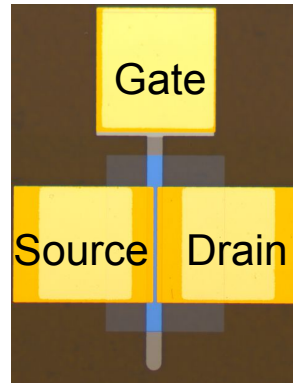


- 35 nm Cr gate contact → e-beam evaporation
- 25 nm Al<sub>2</sub>O<sub>3</sub> gate isolator / passivation → Atomic layer deposition
- 15 nm a-IGZO semiconductor → RF magnetron sputtering
- 10 nm Ti / 60 nm Au source- / drain contacts → e-beam evaporation



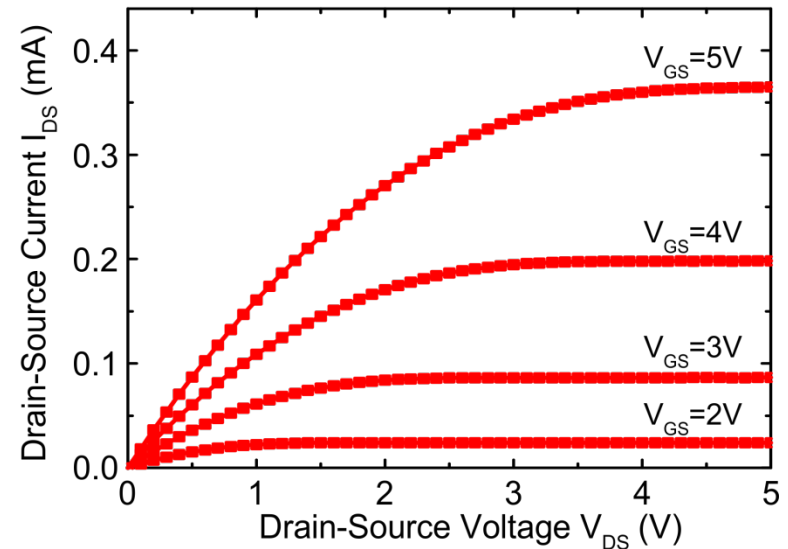
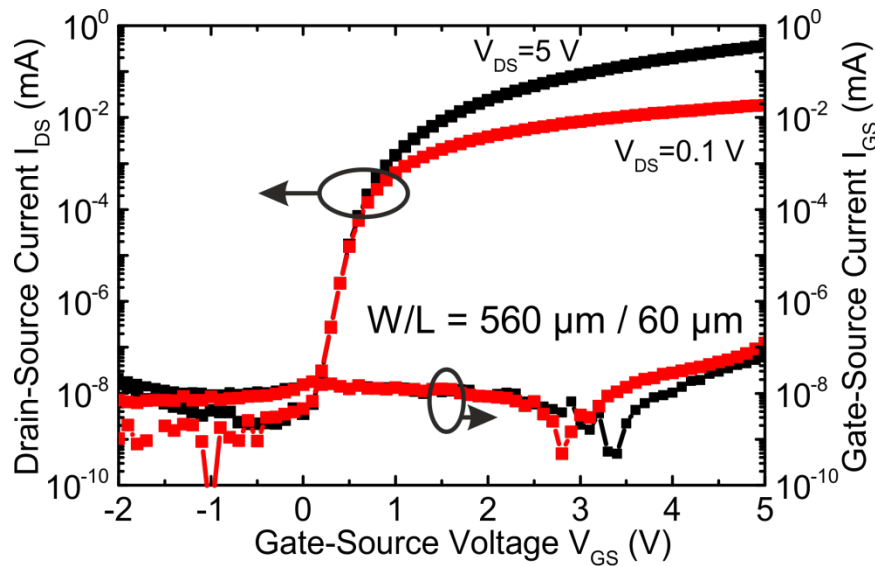
## II. Flexible oxide semiconductor transistors

Performance



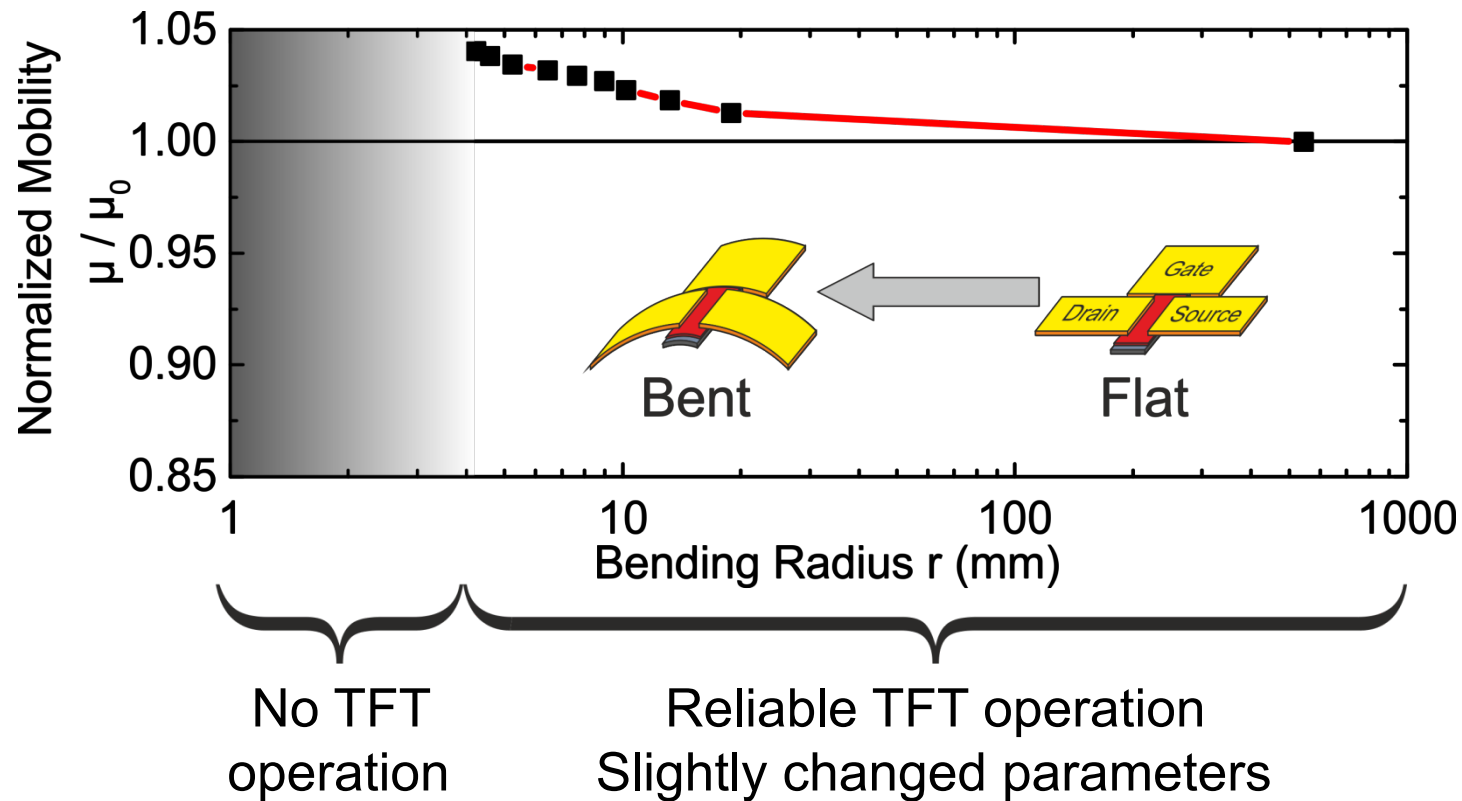
Parameter:

Mobility	15 cm <sup>2</sup> /Vs
Threshold voltage	1.1 V
Subthreshold swing	100 mV/dec.
On / off ratio	9·10 <sup>9</sup>



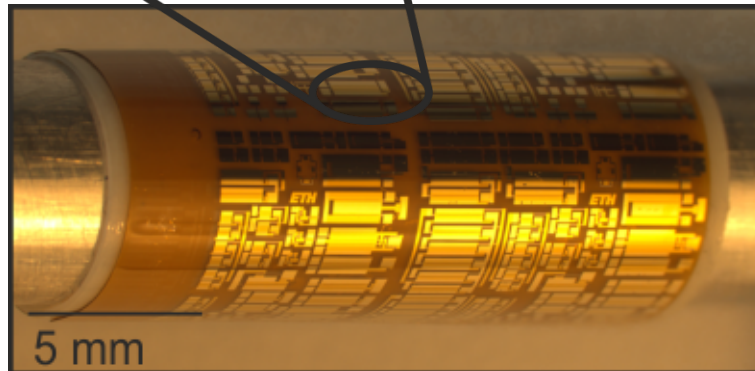
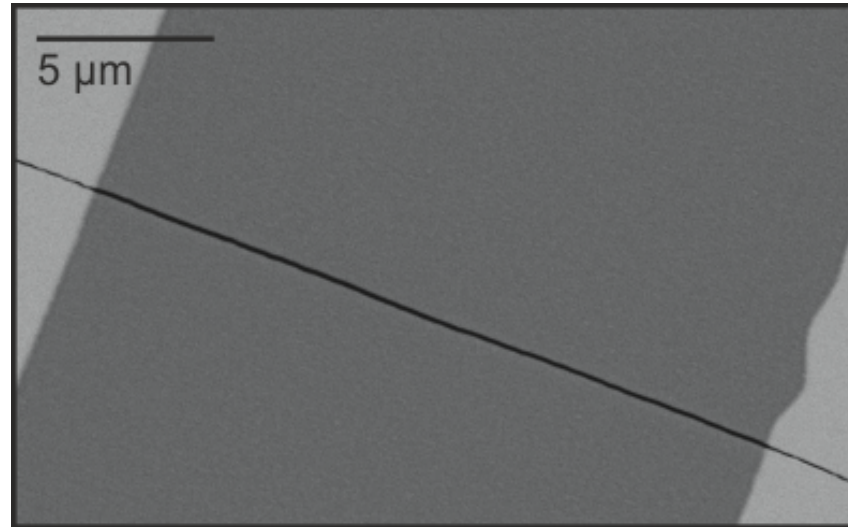
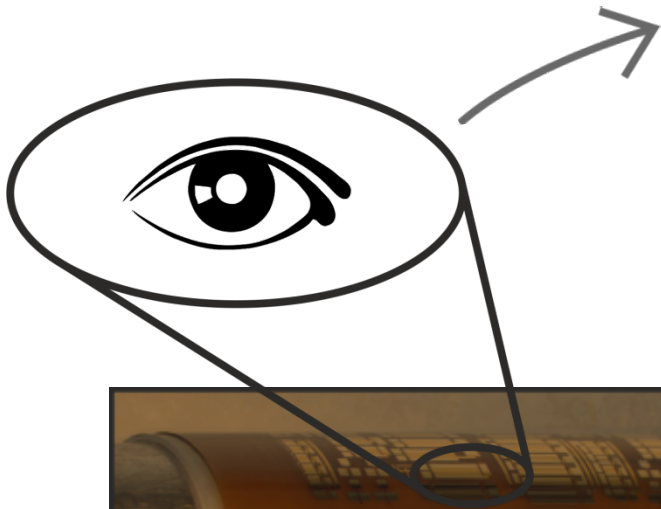
## II. Flexible oxide semiconductor transistors

Influence of bending



## II. Flexible oxide semiconductor transistors

Origin of device failure:



Crack formation

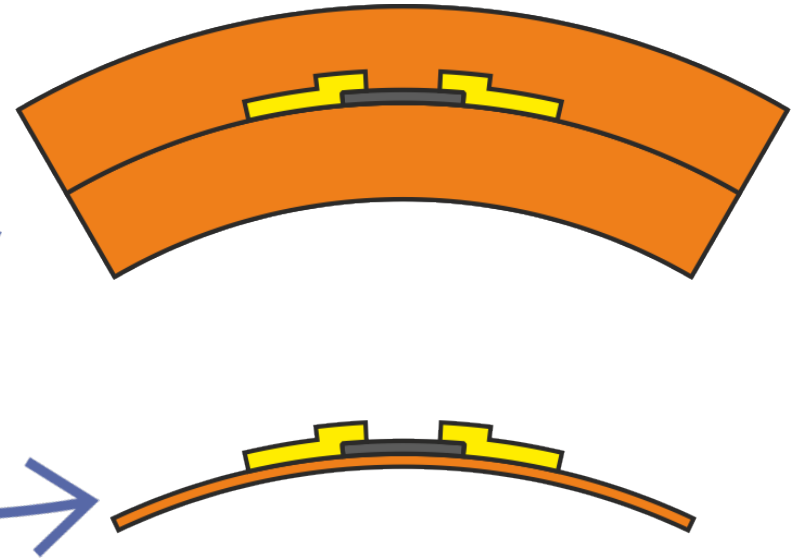


### III. Flexibility

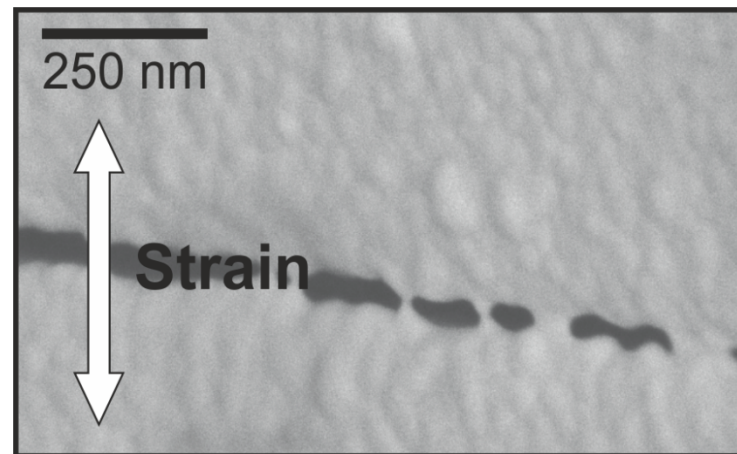
Increase of the device bendability

#### 1. Less strain

- Encapsulation
- Thinner substrate

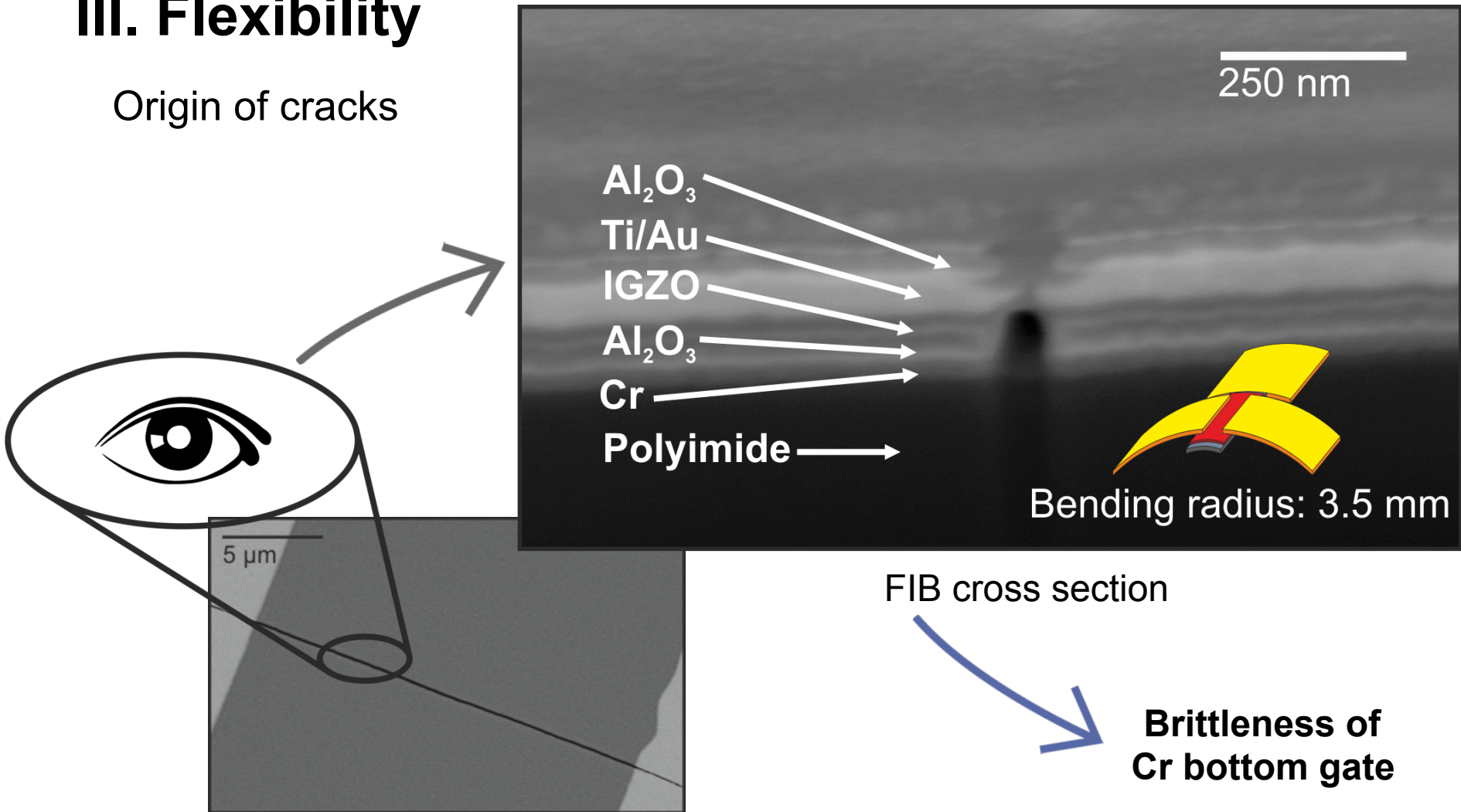


#### 2. Higher ductility



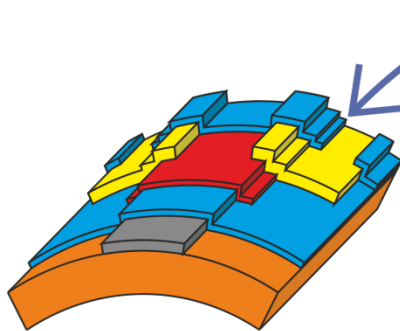
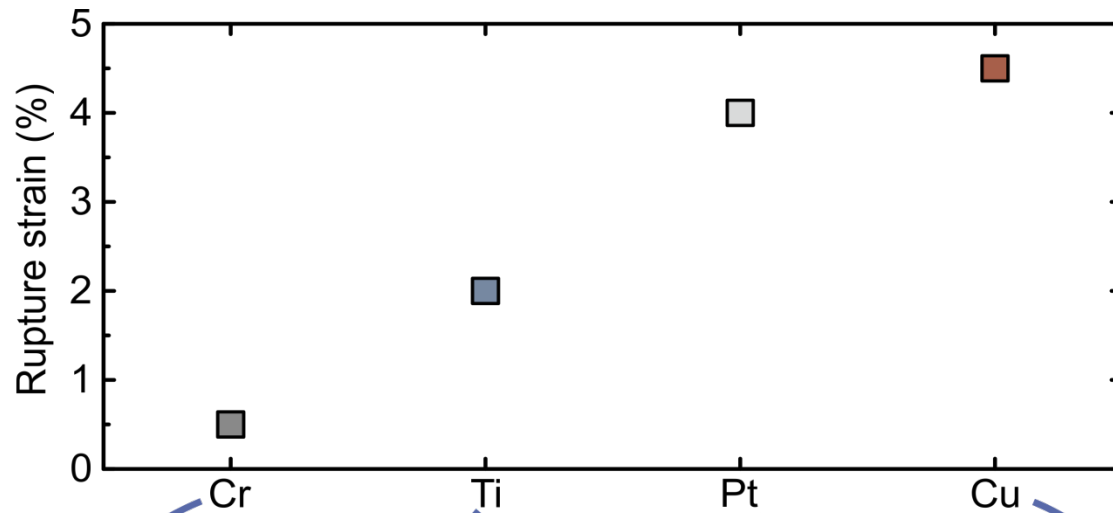
### III. Flexibility

Origin of cracks

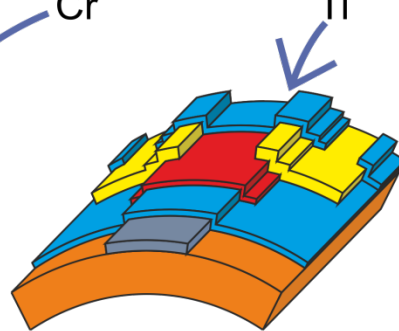


# III. Flexibility

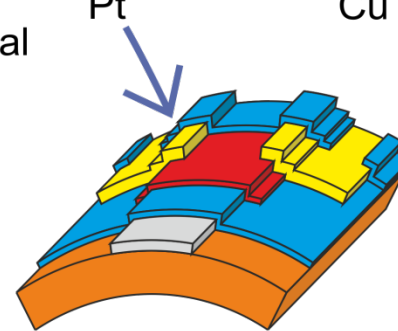
## Alternative gate metals



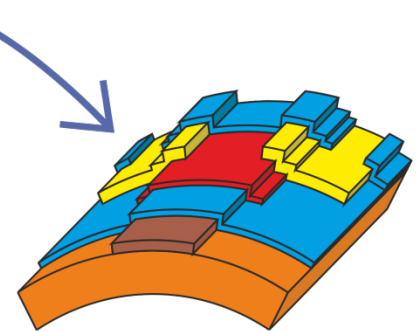
Cr gate



Ti gate



Pt gate

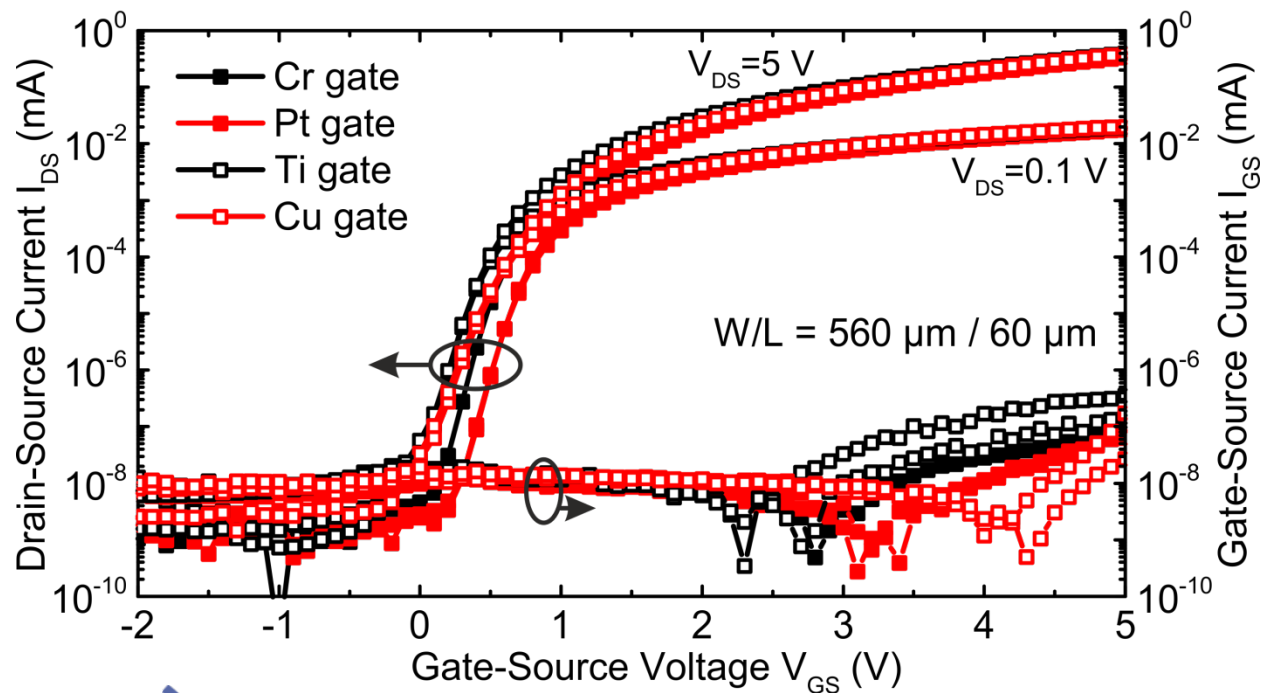


Cu gate



## IV. Influence of gate metal

Electrical performance

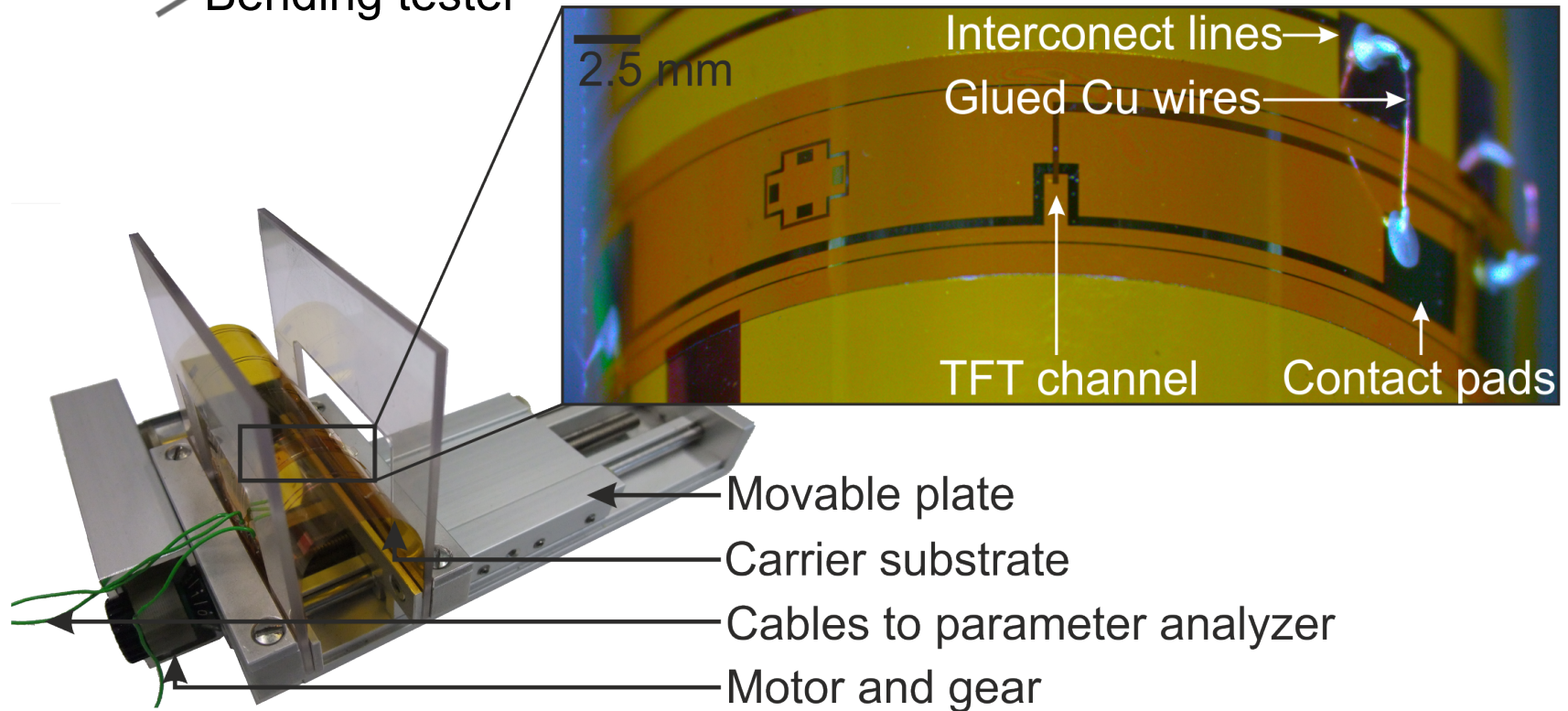


Similar electrical performance

## IV. Influence of gate metal

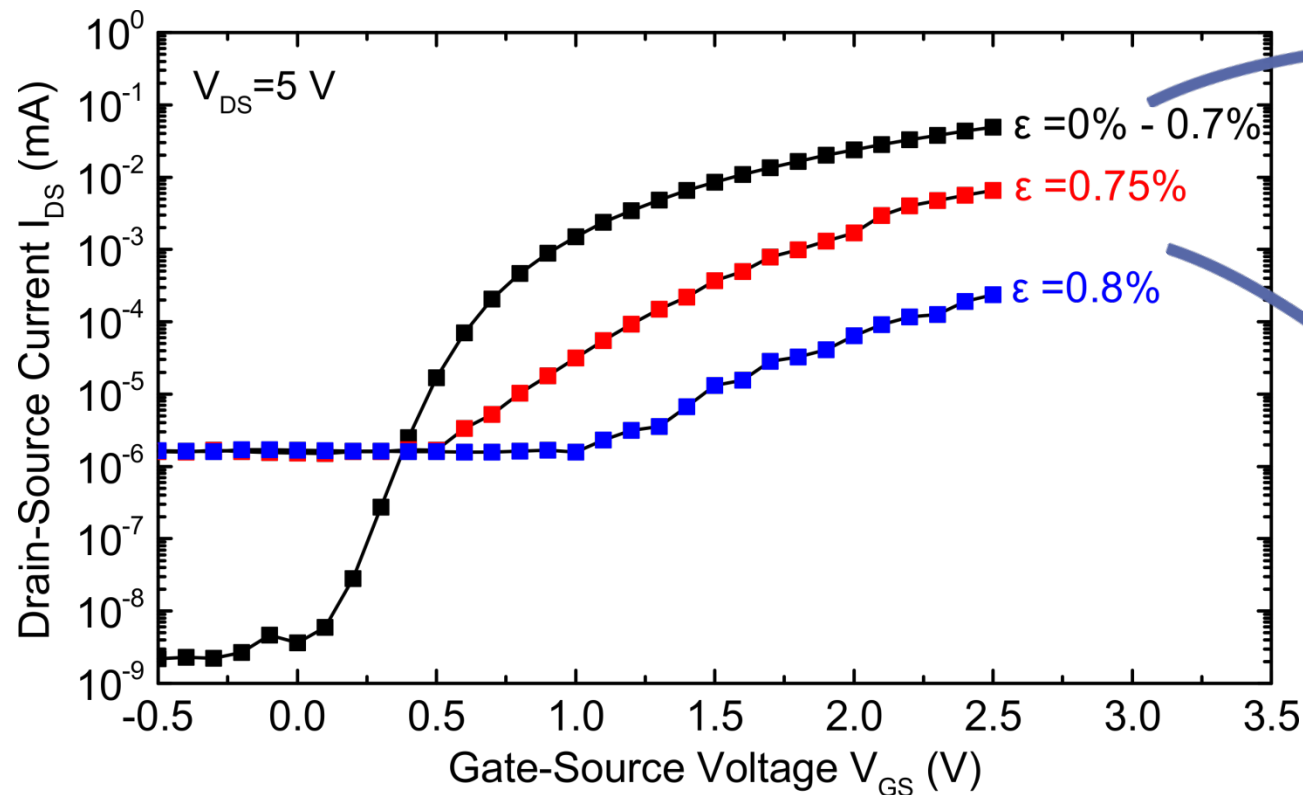
Bending performance

→ Bending tester



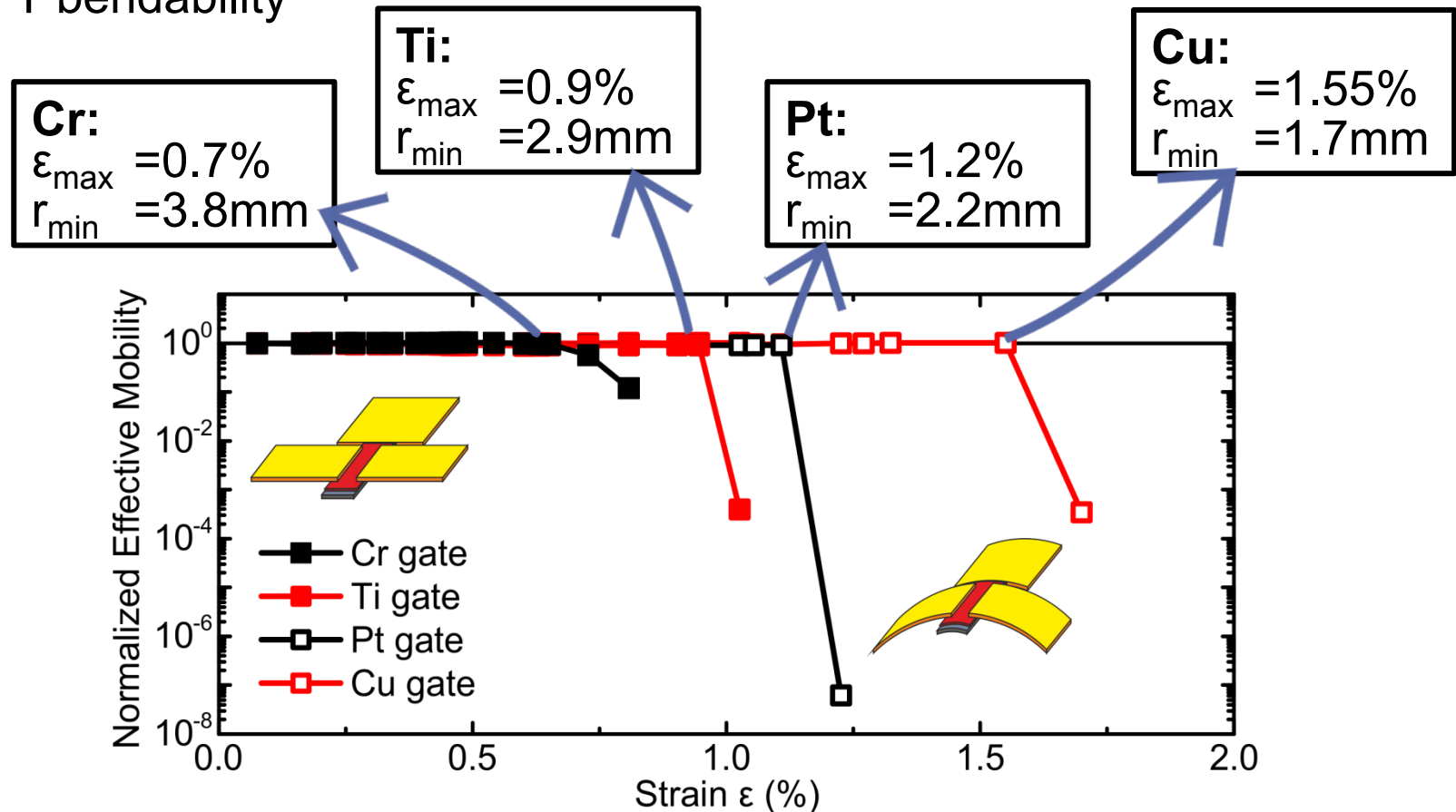
## IV. Influence of gate metal – Bendability

Transfer characteristic degeneration



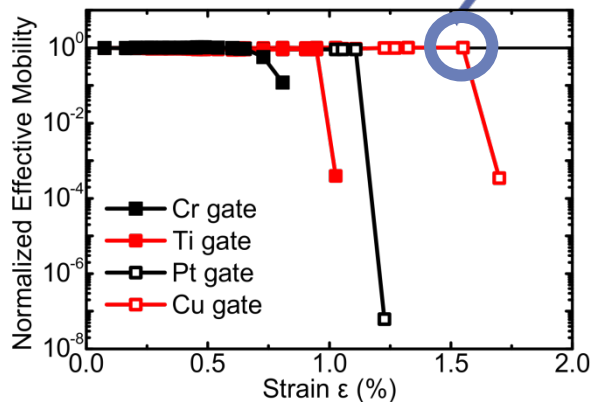
## IV. Influence of gate metal

TFT bendability

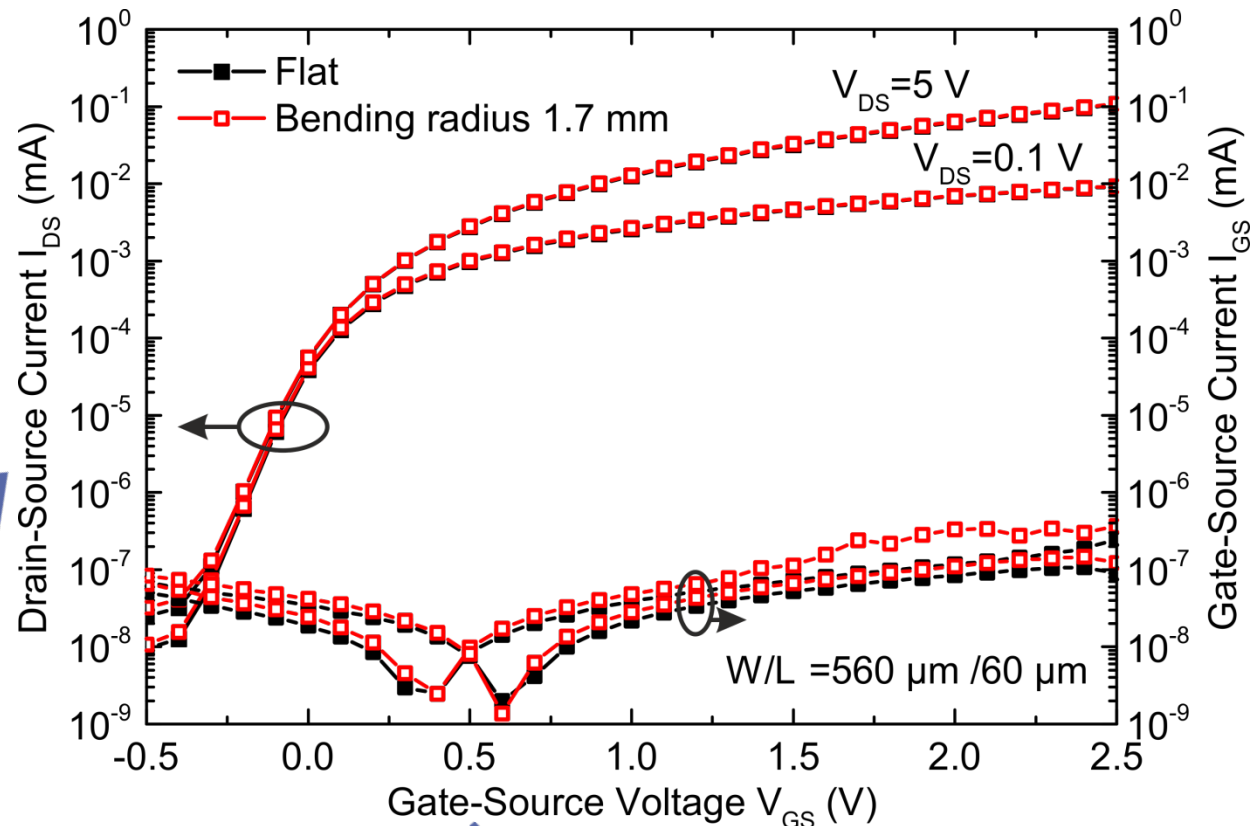


## IV. Influence of gate metal

Bending radius:  
1.7 mm



Electronics Laboratory



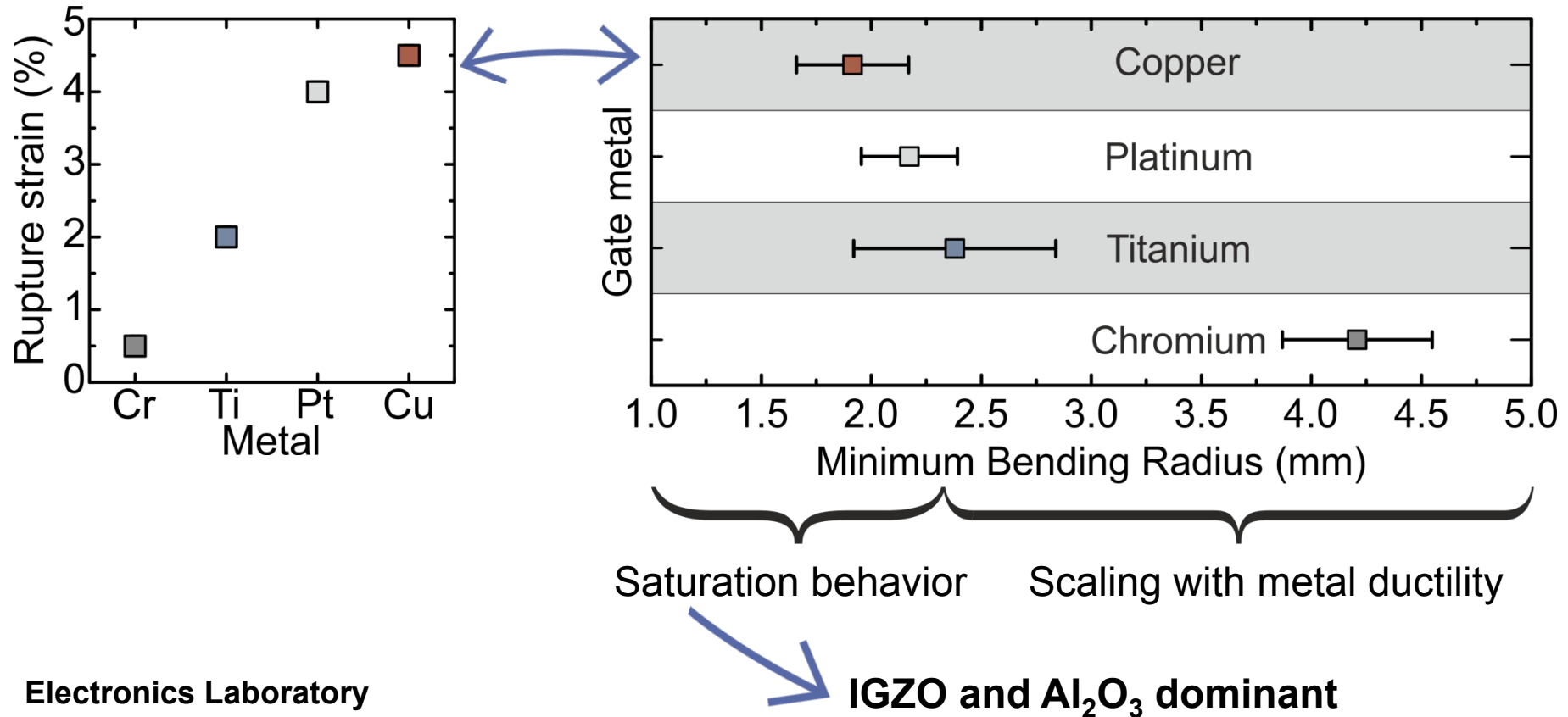
**TFT fully operational**

$\mu$  +2%

$V_{TH}$  - 6 mV

## V. Limitation

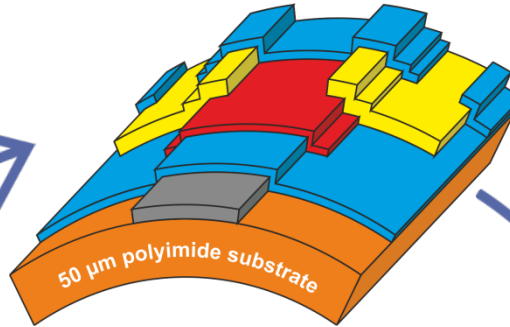
Limited influence of gate metal ductility



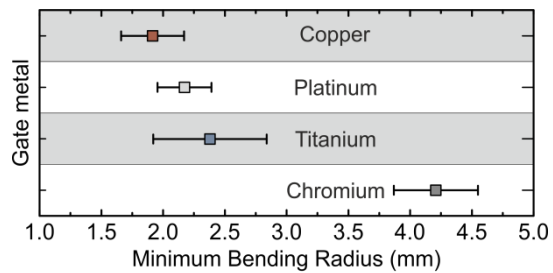


## VI. Summary

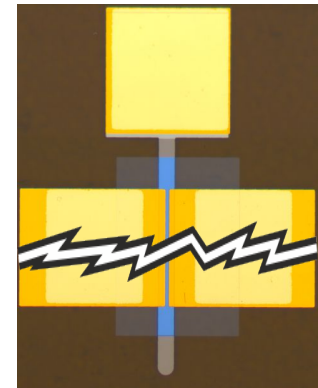
IGZO TFTs



Higher flexibility



Crack formation



Gate metal ductility

