INTRODUCTION

Large-area, roll-to-roll (R2R) fabrication of thin-film circuits on plastic foils demands low-cost manufacturing and the integration of devices onto flexible plastic substrates. We have developed a fully dry process to fabricate low-voltage organic thin-film transistors (OTFTs) featuring a 10-nm-thick bi-layer dielectric based on aluminium oxide (AlOx) and n-octylphosphonic acid (C8PA) monolayer. Two commercially available polyethylene naphthalate (PEN) plastic foils were compared as possible flexible substrates for OTFTs. Teonex Q65FA features an adhesive layer on the bottom side to prevent film slippage during R2R processing, while Optfine PQA1 includes a planarisation layer on the top (device) side.

AIMS

- Study the effect of annealing at 160°C on bare Teonex and Optfine PEN foils.
- Fabricate low-voltage OTFTs on both substrates.
- Compare Al/AlOx/C8PA/DNTT/Au and Al/AlOx/DNTT/Au transistors and metal-insulator-metal (MIM) structures fabricated on each PEN foil.

EXPERIMENT

- Teonex and Optfine PEN films were pre-annealed at 160°C for 24 hours prior to OTFT fabrication.
- Subsequently, Al/AlOx/C8PA/DNTT/Au and Al/AlOx/DNTT/Au OTFTs were fabricated on non-annealed Optfine and pre-annealed Teonex foils.

ANNEAL: OPTFINE SUBSTRATE

Prior to anneal

24-hour anneal at 160°C

Radius of curvature ~ 17 cm

Radius of curvature ~ 1.5 cm

RESULTS: GATE DIELECTRIC

<table>
<thead>
<tr>
<th>C8PA (nm)</th>
<th>Optfine PQA1</th>
<th>Teonex Q65FA</th>
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<tbody>
<tr>
<td>0.41</td>
<td>0.38</td>
<td>0.36</td>
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<tr>
<td>Current @ 5 V (A/cm²)</td>
<td>2.57 × 10⁻⁸</td>
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RESULTS: BIAS STRESS

- Performed on 4 transistors: Teonex Q65FA – bare-Al, OTFT, Teonex Q65FA – AlOx/C8PA OTFT, Optfine PQA1 – bare-Al, OTFT, and Optfine PQA1 – AlOx/C8PA OTFT.
- Bias stress performed about 1 week after the initial measurements shown on the left were taken.
- Bias stress up to 1000 seconds with VGS = −2 V, whilst grounding the source and drain electrodes.
- At certain intervals, transfer characteristics were measured to determine OTFT parameters including VON, μ, S, Ioff, and Ionx.

RESULTS: TRANSISTORS

CONCLUSIONS

- Teonex PEN is easier to handle, since it remained flat upon heating at 160°C.
- Optfine PEN curves significantly upon heating and presents a substantial challenge if used as a free-standing substrate with our OTFT fabrication procedure.
- Planarisation layer on Optfine PEN results in a factor of three greater field-effect mobility for AlOx/C8PA OTFTs compared with Teonex PEN.
- OTFTs on Optfine PEN appear to remain more stable after application of bias stress in terms of mobility compared with OTFTs on Teonex PEN.