Comparison of Different Sputter Processes for ITO:
Planar DC versus Planar AC

Applied Films GmbH & Co. KG, Alzenau, Germany
Outline

- Current ITO layers on glass and web
- Motivation for MF coating
- Influence of magnetic field
- Processing Equipment
- Results
- Conclusions
Current ITO layers on glass and web

ITO on glass at higher substrate temperatures > 200°C
Low specific resistivity < 200 micro * Ohm * cm
Thickness of 20 Ohm layer : **100 nm.**

ITO on web at low substrate temperatures < 100°C
High specific resistivity ~ 500 micro * Ohm * cm
Thickness of 20 Ohm layer : **250 nm.**

→ high costs, poor optical properties (absorption, light scattering)
Sheet Resistance of ITO layers for different Applications

- Plasma Display Low-e Filter
- Low-e Solar Control
- Flexible Solar Cells
- Organic Electroluminescence
- Inorganic Electroluminescence
- Touch-Screen
- Antistatic layers

Fraunhofer Institute FeP, Dresden

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Layer thickness for different specific Resistivities of ITO

Sheet Resistance [Ohm/Square]

Sheet Resistance [Ohm/Square]

ITO Layer Thickness [nm]

600 Mikro Ohm * cm

500 Mikro Ohm * cm

400 Mikro Ohm * cm

300 Mikro Ohm * cm

200 Mikro Ohm * cm

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ITO Transmission for different Layer Thickness Values

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Motivation for Mid Frequency Sputtering of ITO

Higher ion energy
- Higher Surface Mobility ?
- Effect similar to higher Substrate Temp. ?
- Lower Specific Resistivity ?

Reduced arcing
- Less nodule growth ?
- Longer target utilization without cleaning ?
- Lower Specific Resistivity ?
Smart Web Sputter Coating Machine
Sputter Deposition of ITO in MF-Mode

Process Conditions:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>P(Cathode)</td>
<td>1-3 kW</td>
</tr>
<tr>
<td>Ar flow rate</td>
<td>100-255 sccm</td>
</tr>
<tr>
<td>Ar/O₂ flow rate</td>
<td>0 - 90 sccm</td>
</tr>
<tr>
<td>Total Target Surface</td>
<td>1400 cm²</td>
</tr>
<tr>
<td>Effective Power Density</td>
<td>0,7-2,1 W/cm²</td>
</tr>
<tr>
<td>Rate (1,2,3 kW)</td>
<td>10, 20, 30 nm*m/min</td>
</tr>
</tbody>
</table>
Sputter Deposition of ITO in DC-Mode

**Process Conditions:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(Cathode on left side)</td>
<td>1,368 kW</td>
</tr>
<tr>
<td>P(Cathode on right side)</td>
<td>1,290 kW</td>
</tr>
<tr>
<td>Ar flow rate</td>
<td>255 sccm</td>
</tr>
<tr>
<td>Ar/O₂ flow rate</td>
<td>0 - 130 sccm</td>
</tr>
<tr>
<td>Total Target Surface</td>
<td>700 cm²</td>
</tr>
<tr>
<td>Effective Power Density</td>
<td>1,95 W/cm²</td>
</tr>
<tr>
<td>Rate of Cathode on left side</td>
<td>16 nm*m/min</td>
</tr>
<tr>
<td>Rate of Cathode on right side</td>
<td>16,6 nm*m/min</td>
</tr>
</tbody>
</table>

**Diagram:**

- DC Power Supply
- Gas Flow
- Cathodes
- Substrate (PET)
Specific Resistivity for different power levels in MF-Mode on Glass
Specific Resistivity on Glass and PET (MF-Mode, 2 kW)
Specific Resistivity on PET (MF-Mode, 2 kW) for different layer thickness values
Specific Resistivity and Roughness of MF sputtered ITO layers on PET (ITO Thickness 80-181 nm, 1.0 kW)
Specific Resistivity and Absorption of MF sputtered ITO layers on PET (Thickness 40 nm, 1.0 kW, A=1-R-T)

![Graph showing specific resistivity and absorption vs. Ar/O2 flow]
Specific Resistivity and Absorption of DC sputtered ITO layers (Thickness 43-48 nm, 1.37 kW, A=1-R-T)
Specific Resistivity of MF-sputtered ITO layers on Glass and PET substrates (P=1.3 kW). Rate of first Cathode: 16 nm * m / min; Rate of second Cathode = 16.6 nm * m / min
Influence of magnetic field on Target utilization and Specific Resistance
Erosion profiles using different magnetic fields

Cathode utilization

HLK 22 %
ToraMag 40 %
Specific Resistivity on PET for different magnetic field strength

ITO
Specific Resistance

HLK
ToraMag

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Conclusions:

- Similar layer properties were obtained with MF and DC sputtering.
- Operating point for sputter process must be optimized for both cathodes separately.
- No beneficial effect of MF sputtering compared to DC.
- Higher Target utilization using adapted mag. Fields for planar cathodes.

Save Money: Use optimized mag. fields
Don’t change from DC to MF sputtering of ITO
Thank you
BACK TO LIST