Intelligent Deposition of High Grade ITO Film for Touch Screen Process in a High Vacuum Sputter Web Coater

Eiichi Sasaki
FPDPV Division
ULVAC Inc.
October 8, 2019
Agenda

• Introduction
  ULVAC Corp.

• Roll to Roll sputtering system SPW series
  -025, -060, -165

• Touch Sensor – ITO film process
  Cathode and Pre. Process

• Other Process
  AR, FCCL

• Summary
Smart Society: Electronics (Electronic Device, Semiconductor)
⇒ Anytime, Anywhere, Safe, Wireless, High-speed, Low power, Automatic, Prospective.

Technology for Smart Society (Smart system)

- **OSmart semiconductor** (Smart ICT)
  - CPU, DRAM, NAND

- **OSmart Functional Device** (Smart Functionalities)
  - MEMS, Sensor, Communication (5G)

- **ONew Packaging**

- **ONew Material**

- **OSmart Energy**
  - Li Battery, PV, Power Device

- **Portable Power Supply & Management**

- **Smart Devices (e.g. Smart Phones)**
  - w/Edge computing

- **Cloud Server**

- **IoT, AR, VR, Cloud**

- **Big Data, AI**

ULVAC Technical portfolio for Smart Society
ULVAC Technologies within Smart Device

- Display:
  - Optical Film
- Data Process:
  - CPU
  - Logic Board
- Comm. 5G:
  - Antenna
  - Microphone
- Detect:
  - Sensor
  - Finger Print
- Data Storage:
  - Memory
- Photo:
  - Camera
- Energy:
  - Battery

- TFT Back plane
- OLED Front plane
- Touch Screen
- Optical Film AR/AS
- Logic
- EMI Shield
- Advanced Packaging
- High Freq. device
- MEMS
- Non Volatile
- CMOS sensor
- LiB TFB

Advanced Electronic Equip.
Semi conductor Equip.
Flat Panel Display Equip.
Vacuum Equipment for Smart Device

Metal/ITO IGZO

Metal/ITO

PE-CVD for LTPS

Display

Touch Panel / AR film

OLED

Color Filter
R2R Equipment for Smart Device

SPW Series is high performance type sputtering roll coater for touch panel, optical film, window film, electric device. It is ideal for multi layer deposition.

<table>
<thead>
<tr>
<th></th>
<th>SPW-025</th>
<th>SPW-060</th>
<th>SPW-165Cn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Width</td>
<td>Max 250mm</td>
<td>Max 600mm</td>
<td>Max 1600mm</td>
</tr>
<tr>
<td>Web Material</td>
<td>PET, PEN, PI, PC, COP, TAC and others</td>
<td>PET, PEN, PI, PC, COP, TAC and others</td>
<td>PET, PEN, PI, PC, COP, TAC and others</td>
</tr>
<tr>
<td>Web Thickness</td>
<td>PET: 50~200 μm</td>
<td>PET: 25~200 μm</td>
<td>PET: 25~200 μm</td>
</tr>
<tr>
<td>Web Diameter</td>
<td>φ290mm</td>
<td>φ550mm</td>
<td>φ900mm</td>
</tr>
<tr>
<td>Winding Speed</td>
<td>0.2~5.0m/min</td>
<td>0.5~10m/min</td>
<td>0.5~10m/min</td>
</tr>
<tr>
<td>Cathode type</td>
<td>Planer</td>
<td>Planer/Rotation</td>
<td>Planer/Rotation</td>
</tr>
<tr>
<td>Cathode</td>
<td>DC Single: 4sets, AC Dual: 2sets</td>
<td>DC Dual: 4sets, AC Dual: 4sets</td>
<td>DC Dual: 4 x n sets, AC Dual: 4 x n sets</td>
</tr>
<tr>
<td>Sputtering Target Material</td>
<td>ITO, Nb205, SiO2, Cu and Metal</td>
<td>ITO, Nb205, SiO2, Cu and Metal</td>
<td>ITO, Nb205, SiO2, Cu and Metal</td>
</tr>
<tr>
<td>Main Roller Temperature</td>
<td>-5~80°C</td>
<td>-20<del>80°C Option: -10</del>180°C</td>
<td></td>
</tr>
<tr>
<td>Pre-process (Option)</td>
<td>BMG(DC), Heater</td>
<td>BMG(DC, RF), Ion Gun, Heater</td>
<td></td>
</tr>
<tr>
<td>Layout</td>
<td>9mW × 9.8mL × 2.6mL</td>
<td>(Load lock type) 15mW × 10mL × 3.9mL</td>
<td>(CType) 19mW × 17mL × 4.3mL</td>
</tr>
</tbody>
</table>

*This specification may be changed without notice.*
Touch Screen & Optical film Market

Touch Screen & Optical film Market Portfolio

World Wide Market Size (Year 2022 M$)

- Wet AGLR
  - 2022 Market 1,000M$
  - 2018-2022 CAGR 1.8%

- Dry AR
  - 2022 Market 140M$
  - 2018-2022 CAGR 9.7%

- MM Touch Screen
  - 2022 Market 130M$
  - 2018-2022 CAGR 3.2%

- ITO Touch Screen
  - 2022 Market 460M$
  - 2018-2022 CAGR -3.3%

W/W Touch Screen Market Growth

W/W Optical Film Market Growth
**ITO film**

**Key Points;**
- Sputtering Process
- Index Matching(IM) layer.
- Low Resistivity.

![ITO film process diagram](image-url)
Touch Sensor – ITO film process

- Index matching Layer to make ITO “invisible”

<table>
<thead>
<tr>
<th>Layer Structure</th>
<th>Rs (Ω/☐)</th>
<th>T (%)</th>
<th>Haze (%)</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Base Film</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Film/Nb2O5/SiO2/ITO</td>
<td>188</td>
<td>184</td>
<td>88.2</td>
<td>88.5</td>
</tr>
<tr>
<td>2 Film/Nb2O5/SiO2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Reflection vs Wavelength](image1.png)

**Graph Details:**
- X-axis: Wavelength (nm)
- Y-axis: Reflection (%)
- Two curves: ITO and Non-ITO with and without the Index Matching (IM) Layer.

*Images show textures with and without the IM Layer.*
Touch Sensor – ITO film process

- Low Resistance: Crystallization by Annealing.
- Crystallization on web: Low temperature.

Less SnO2 for Crystallization in lower temp.
Touch Sensor – ITO film process

• ITO Cathode
  • Low Voltage Sputter for low resistance film.
  • Low temperature crystallization, uniform film.
Low Voltage Sputter

• Use High magnetic field (Low Voltage).
• Can achieve Low ITO Resistivity
Touch Sensor – ITO film process

- Property of ITO coated by Rotary Cathode
  - Rotary Cathode: High rate, Longer target life.
  - Deposit as Low resistivity film as planer type cathode.
Touch Sensor – ITO film process

- ITO Film Coater

Web Speed: 4m/min.～
Other Process

- Anti Reflection
- Low Reflectance
- Adjustable reflected colors

Film Structure

- SiO₂
- Nb₂O₅
- SiO₂
- Nb₂O₅
- PET Film

<table>
<thead>
<tr>
<th>Reflectance (%)</th>
<th>Wavelength (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>350</td>
</tr>
<tr>
<td>1</td>
<td>450</td>
</tr>
<tr>
<td>2</td>
<td>550</td>
</tr>
<tr>
<td>3</td>
<td>650</td>
</tr>
<tr>
<td>4</td>
<td>750</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.07</td>
<td>0.00</td>
<td>-1.00</td>
</tr>
</tbody>
</table>
Anti Reflection film – High rate Sputtering process

• High deposition rate by transition mode of reactive sputtering.

![Graph showing dynamic deposition rate and refractive index against O2 flow rate and TD position.](image-url)
Other Process

• Anti Reflection film coater.

Cathode Layout

Web Speed: 4m/min.
Leading the World

In Vacuum Technology

ULVAC