Highly transparent and conductive ZTO/Ag/ZTO multilayer top electrodes for large area organic solar cells

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Structural and optical properties of ZAZ

ZAZ as bottom electrode for inverted solar cells

- Transparent multilayer contact ZAZ
- Deposition at room temperature
- Very low sheet resistance (< 10 Ω/sq)
- Transmission > 80%
- ZAZ as top contact for organic solar cells
- Similar transmission to ZTO
- Higher PCE for cells with larger cell areas

Semitransparent solar cells:

- Similar device characteristics with ZAZ as electrode compared to ITO
- ZAZ has suitable electronic properties to be used without interlayer
- Transparent characteristics known from TiO₂ can be avoided

Conclusion:

- ZAZ has similar electronic properties compared to ITO
- ZAZ as bottom contact for organic solar cells
- Higher PCE for cells with larger cell areas

Secondary ion mass spectroscopy (SIMS)
- No significant diffusion of Ag in ZTO
- Surface diffusion of Ag completely suppressed by ZTO cap

Transmission electron microscopy (TEM)
- Continuous Ag film at 6 nm
- Polycrystalline structure of Ag

Transmission
- \( T_{\text{VIS}} \) comparable to ITO (60 nm)
- Red shift of \( T_{\text{VIS}} \) due to Ag thickness

4-Point Measurements (sheet resistance \( R_{\text{sc}} \))
- Time dependent decrease of \( R_{\text{sc}} \) for ZTO
- Formation of Ag clusters depends on time

Figures of merit (FOM, \( \Phi_{\text{sc}} = T_{\text{VIS}} / R_{\text{sc}} \))
- ZTO/Ag/ZTO: 38
- ITO/ZTO/Ag/ZTO: 32

Optical transmittance (%)
- Similar for ZAZ as ZTO and Ag thickness
- Optimized FOM at (20/8/40 nm)

Cell area (cm²)
- 3x higher PCE for cells with novel top contact
- Limitation due to the bottom contact (ITO)

Simulation:
- Calculation of PCE for cells with various top contacts
- Comparison of ZAZ and ITO

Efficiency:
- ZAZ shows comparable performance to ITO
- Higher PCE for ZAZ