OPTIMIZED UTILIZATION OF DUAL MAGNETRON SETUPS

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VON ARDENNE’S EXPERTISE IN WEB COATING

- First “FOBA” in 1971, first “FOSA” in 1996
- Actual install base: ~30 coating systems for flexible substrates
- Various applications, mainly high volume production
Base for calculation:
- Patend pending layer stack system
- Ag based DLE
- Automotive application

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{vis}$</td>
<td>&gt;75%</td>
</tr>
<tr>
<td>$T_{TS}$</td>
<td>50%</td>
</tr>
<tr>
<td>TIRR</td>
<td>93%</td>
</tr>
<tr>
<td>$R(a^*)$</td>
<td>-2.9</td>
</tr>
<tr>
<td>$R(b^*)$</td>
<td>0.0</td>
</tr>
</tbody>
</table>
MOTIVATION
THROUGHPUT

(A) Single drum coater with forward & backward operation
- 62" $\rightarrow$ ~1,422,000 m² p.a.
- 84" $\rightarrow$ ~1,880,000 m² p.a.

(B) Dual drum coater
- 62" $\rightarrow$ ~2,380,000 m² p.a.
- 84" $\rightarrow$ ~3,140,000 m² p.a.

$\rightarrow$ Flexibility for multiple coatings required
No anodes advantageous:
- Less components, feedthroughs
- No cooling needed
- Less maintenance parts
- Less space → more design options

How about bipolar @ low frequency (= quasi DC)?
Same films?

Monte Carlo simulation of dual rotary DC magnetron with DAS
Target parameters:
- 60min @ 150°C annealing
- $R_s < 100 \, \Omega/\square$
- $Y(T) \geq 87.5\%$
- $-2.0 \leq b^* \leq 2.0$

Setup:
- RDM with dimensions as in FOSA web coating systems
- Pre-treatment
- 90:10 ITO target
- DC vs Bipolar power supply
- 2 different PET substrates
- O2 variation
ITO RESULTS
DC VS BIPOLAR

Sheet resistance before / after annealing

DC

Bipolar 0.5kHz

Substrate A: 71 Ω/sq, Y(T)=88,5%, b*(T)=1,8
Substrate B: 70 Ω/sq, Y(T)=86,2%, b*(T)=3,2
ddr 90 nm*min @ 2x 5kW/m

Substrate A: 82 Ω/sq, Y(T)=88,5%, b*(T)=1,7
Substrate B: 82 Ω/sq, Y(T)=86,3%, b*(T)=3,1
ddr 60 nm*min @ 2x 5kW/m
Target parameters:

- $R_{\text{spec}} \leq 0.5 \, \mu\Omega\text{cm}
- \text{Adhesion} \geq 5B \, (\text{ASTM 3359 D})$

Setup:

- RDM with dimensions as in FOSA web coating systems
- Solid Cu target
- Pre-treatment
- DC vs Bipolar power supply
- Moderate power level
- 3 different PET substrates
CU RESULTS

DC VS BIPOLAR

→ No difference in sheet resistance between DC and bipolar modes

→ Only small variations in sheet resistance from substrate type

- Slight differences in adhesion observed, substrate dependent

Sheet resistance for different PET substrates

Specific resistivity [µOhmcm]

Bipolar 0.5kHz  Bipolar 45kHz  dcdc
WHAT ABOUT SUBSTRATE HEAT IMPACT?

- Measurements done @ VA, vgl. (II)

![Graph showing relative substrate energy impact (P_{sub} / P_{MAG} %) for different frequencies and setups.]

TiO$_2$, dual ceramic tube-targets, total 25kW, length = 1m
WHAT ABOUT SUBSTRATE HEAT IMPACT?

- Measurements done @ VA

![Graph](image)

Relative substrate energy impact ($P_{\text{sub}} / P_{\text{MAG}} \%$)

- TiO$_2$, dual ceramic tube-targets, total 25kW, length = 1m
CONCLUSION

LOW FREQUENCY BIPOLAR SPUTTERING

- Similar layer properties can be achieved utilizing low frequency bipolar pulsed sputtering mode
- Demonstrated for ITO and Cu
- That enables new coating system designs
CONCLUSION

FOSA MX

Up to 5 compartments allow for
- Either up to 10 single tubes in LF bipolar mode
- Or 5 dual magnetrons for reactive AC-MF process
- Or mix of both
+ Compact design
- Total height ≤ 4.0m
Acknowledgements
Technology & Application Center at VON ARDENNE.
Our customers.

References
(I) Pelleymounter et al., Raising the bar on reactive deposition sputter rates, Advanced Energy Inc. White Paper, 2015
(II) H. Proehl et al., DC-Dual-Anode Reactive Sputter Deposition of Transparent Dielectrics with Low Substrate Heating, SVC Conference 2016
(III) H. Proehl et al., Rotatable Magnetron Sputtering in R2R Web Coating of Optical Layer Stacks, AIMCAL Web Coating & Handling Conference 2013

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