**Activation of thin film growth versus plasma damage – the challenge in sputtering of transparent conductors and active semiconductive coatings**

B. Szyszka, N. Alktash, F. Huo, B. B. O. Seibertz

*TU Berlin, Chair Technology of Thin Film Device TFD,*

*Einsteinufer 25, Office HFT 5-2, 10587 Berlin, Germany*

Optoelectronic devices such as thin film solar cells, flat panel displays and (O)LED stacks require transparent and conductive electrodes, where low pressure synthesis by sputtering is a common technique to manufacture degenerate n-doped wide bandgap oxide films as transparent conductors even on sensitive substrates, e. g. on organic ink in AM-LCD displays, on OLEDs on web or even on Perowskite solar cells. With the breakthrough of AM-OLEDs, even more demanding materials properties must be realized. On the firsthand side, the synthesis of amorphous high mobility active semiconductive oxides must be realized for the channel layer. On secondhand side, it’s question of amorphous, dense high-k material to realize the dielectric layers.

For many of these applications, it’s crucial to optimize the thin film growth conditions to obtain smooth and dense films with stable properties under load. The necessary activation of thin film growth is done by both, substrate heating and plasma activation, but the ability for substrate heating are very limited when it comes to sensitive organic materials. The plasma activation, e. g. by RF, pulsed magnetron or biased magnetron sputtering, on the other hand, reveals substantial problems in terms of particle damage due to high energetic species, e. g. due to negatively charges oxygen atoms accelerated in the cathode sheath.

Our studies reveal that particle energies exceeding ~20 eV energy at the substrate have the potential to degenerate the film properties. On the other hand, low energetic high ion flux to the substrates has the ability to improve the film properties. In this paper, we review the subject of plasma damage in oxide film sputtering and we emphasize in particular a novel technique, the pulsed reactive hollow cathode gas flow sputtering, which offers plasma densities of ne = 1010 cm-3 at the substrate under conditions where DC magnetrons operate at ne = 108 cm-3. Pulsed operation of the source allows for extraction of fast particles from the plasma, where the energy can be controlled by the reverse voltage of the generator.

The benefits of this approach will be shown for magnetron and hollow cathode gas flow sputtering of selected transparent conductive oxides, oxide semiconductors and dielectric materials***.***