Adapted particle bombardment during layer growth by pulse magnetron sputtering

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Magnetron sputtering is very well suited for the deposition of thin films e.g. for optic, electronic or barrier applications. Due to energetic activation during film growth, sputtered films are dense, smooth and show an excellent environmental stability.

Pulsing of the magnetron discharge together with an adapted magnetron design allows adjustment of the particle bombardment during layer growth. In the bipolar pulse mode (pulsed discharge between the two targets of two magnetron of a dual magnetron system), the particle bombardment is high because of the enhancing effect of the magnetic shielded anode. On the other hand, it is much lower in the unipolar pulse mode (pulsed discharge between the target and a separate anode). Therefore, only by varying pulse mode of the discharge, the plasma properties can be widely tuned influencing deposition temperature and layer properties. Layer crystallinity, density and optical properties can be varied without changing the actual hardware of the deposition machine.

In this paper, concepts of the pulse modes, of the design of the magnetron sources and new approaches to exploit the differences will be presented.

The unipolar pulse mode allows deposition of films with low substrate heating and combined with e.g. high magnetic field at the target surface, low damage sputtering allows deposition of films on highly sensitive substrates. This concept is applied for deposition of pre-encapsulation layers in a roll-to-roll line for OLED deposition.

The pulse unit UBS-C2 of Fraunhofer FEP allows the fast switching between the unipolar and bipolar pulse mode (with about 1 kHz) without any hardware change. By changing the share of unipolar and bipolar pulses within a pulse sequence of about 1ms, the particle bombardment can be adjusted between the values of the two pulse modes. This unipolar/bipolar hybrid pulse mode gives a new degree of freedom to optimize film properties as well as to adapt to temperature and particle bombardment sensitive substrates.

The effect of applied the pulse mode on the layer properties was extensively studied for the reactive AlN layer deposition. Using the bipolar pulse mode, the film stress is much more compressive than in case of the unipolar pulse mode. With the unipolar/bipolar hybrid pulse mode, it was possible to adjust the film stress to any intermediate value in between the two values of the pure pulse modes (Fig. 1).

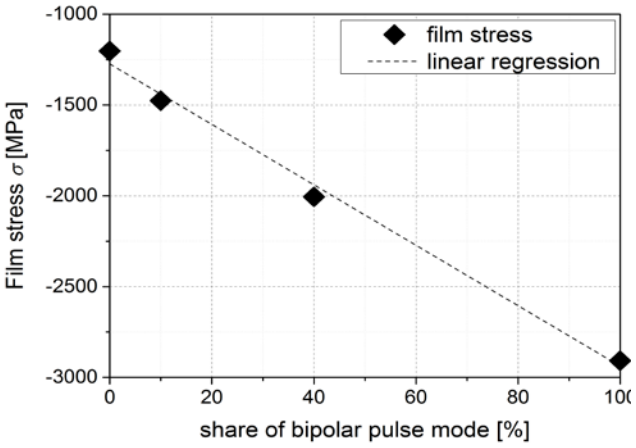

Figure 1: Adaption of film stress of AlN layers (thickness: 500 nm) with the unipolar/bipolar hybrid pulse mode.