

## Low-damage ITO sputtering for LED application

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In the recent decades indium-tin-oxide (ITO) has been introduced into various commercial applications such as display and lighting devices (e.g. LED, OLED) as electrodes, current spreading and out-coupling layers. The benefits of ITO are its high transparency in the visible range while additionally featuring a high conductivity. The sputtering of ITO via DC, RF or combining methods is well known for decades, but still open for research and improvement. One reason is that devices can be very sensitive to the deposition method itself.

In light-emitting diodes (LEDs) ITO is used as current spreading layer, meaning ITO is deposited with an imminent risk of damaging the previous layer. Therefore it is important to use low-damage deposition methods. One possibility of low-damage sputtering is the usage of a facing-target source (FTS). To the best of our knowledge, FTS sputtering is known since 1978<sup>(1)</sup>, and has been demonstrated for a variety of materials but has not been used for process integration on device level.

In the recent years we have performed extensive investigations on the possibility of a FTS sputtering system for ITO deposition on LED wafers. In these studies we have found that FTS sputtering enables extremely thin and homogenous layers at very low-damage deposition, even without damaging the previous layer at relatively high rates. LEDs including such FTS sputtered ITO layers show comparable or improved performance to devices featuring alternatively deposited ITO layers. In overall conclusion TCM FTS sputtering is one promising technique for a possible adoption for production. Whereas we at OSRAM Opto Semiconductors think there is always room for further improvement.

(1) M. Naoe, Y. Hoshi, S. Yamanaka *High rate deposition of magnetic films by sputtering from two facing targets*, J. Cryst. Growth, 45 (1978), pp. 361-364.