
Roll-to-roll sputtered ZnSnO/AgPdCu/ZnSnO multilayer electrodes for flexible thin-film heaters and heat-shielding films

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As a cost-effective, indium-free, flexible, and highly transparent electrode for flexible thin-film heaters and heat-shielding films, ZnSnO(ZTO)/AgPdCu(APC)/ZTO multi-stacked films were fabricated by using 1500-mm-width, roll-to-roll (RTR) sputtering at room temperature. The optimized RTR-sputtered ZTO/APC/ZTO film showed a very low sheet resistance (3.43 ohm/square), high optical transmittance (80.99%), and small inner/outer critical bending radii (1 and 2 mm, respectively), even when it was processed at room temperature. In particular, the better flexibility of the ZTO/APC/ZTO films, relative to typical ITO films, was confirmed by lab-scale bending, rolling, twisting, and folding tests. Due to the very low sheet resistance, superior flexibility, and low transmittance in the near-infrared wavelength region, flexible and transparent thin-film heaters (TFHs) and flexible heat-shielding films (HSFs) made with the ZTO/APC/ZTO film showed better performance than typical ITO-based TFHs and HSFs. This suggests that the RTR-sputtered, indium-free ZTO/APC/ZTO films can be applied as transparent and flexible electrode materials in cost-effective and multi-functional smart windows for buildings and automobiles.