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Simple Route to High-performance and Solution-processed ZnO Thin Film Transistors Using Alkali Metal Doping

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Solution-processed metal-alloy oxides such as indium zinc oxide (IZO), indium gallium zinc oxide (IGZO) has been extensively researched due to their high electron mobility, environmental stability, optical transparency, and solution-processibility. In spite of their excellent material properties, however, there remains a challenging problem for utilizing IZO or IGZO in electronic devices: the supply shortage of indium (In). The cost of indium is high, what is more, indium is becoming more expensive and scarce and thus strategically important. Therefore, developing an alternative route to improve carrier mobility of solution-processable ZnO is critical and essential. Here, we introduce a simple route to achieve high-performance and low-temperature solution-processed ZnO thin film transistors (TFTs) by employing alkali-metal doping such as Li, Na, K or Rb. Li-doped ZnO TFTs exhibited excellent device performance with a field-effect mobility of 7.3 $cm^2 \cdot V\text{-}1 \cdot s\text{-}1$ and an on/off current ratio of more than 107. Also, in case of higher drain voltage operation (VD=60V), the field effect mobility increased up to 11.45 $cm^2 \cdot V\text{-}1 \cdot s\text{-}1$. These all alkali metal doped ZnO TFTs were fabricated at maximum process temperature as low as 300°C. Moreover, low-voltage operating ZnO TFTs was fabricated with the ion gel gate dielectrics. The ultra high capacitance of the ion gel gate dielectrics allowed high on-current operation at low voltage. These devices also showed excellent operational stability.

Keywords: Solution-processed zinc oxide, alkali metal doping, thin film transistors (TFTs), operational stability, ion gel gate dielectrics