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Trapping Time Characteristics of Carriers in a-InGaZnO Thin-Film Transistors Fabricated at Low Temperatures for Next-Generation Displays

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The effect of low-temperature annealing treatment for various durations on the stability of amorphous indium gallium zinc oxide (a-IGZO) thin-film transistors was investigated. By this treatment, IGZO TFTs showed enhanced electrical characteristics and better stability under positive gate bias stress with increasing annealing time up to 18,000 s. For all V_G stresses at different annealing times, the experimentally measured threshold voltage shift (ΔV_{th}) as a function of stress time was precisely modeled with a stretched-exponential function. ΔV_{th} was generated by carrier trapping, not by defect creation. It was verified that the decrease of interface trap state density (N_{it}) and free carriers resulted in the decrease of ΔV_{th} with increasing annealing time. However, the characteristic trapping time of the carriers increased up to 5.3×10^3 s with increasing annealing time to 7,200 s and then decreased, implying that the interface quality between active layer/insulator was deteriorated with further annealing. In this study, successful fabrication of IGZO TFTs by post treatment with optimized duration is demonstrated for flexible display applications.

Key words: Low-temperature thermal treatment, IGZO thin-film transistor, double insulators, trapping time characteristics of carriers

INTRODUCTION

Currently, flexible and transparent electronic devices show the most promise in futuristic technological applications, such as flexible displays, solar cells, touch panels, and wearable devices. According to Nomura et al.,[1] amorphous oxide semiconductors are expected to play a key role in advanced electronics due to their superior electrical performance compared with conventional amorphous silicon and polycrystalline silicon thin-film transistors (TFTs). These a-IGZO TFTs have shown excellent performance in the development of future displays, especially those demanding high mobility (>10 cm^2 V^{-1} s^{-1}), flexibility, and transparency in the visible range.[2]

However, investigations on amorphous oxide TFTs have shown that low-temperature-deposited IGZO TFTs suffer from significant stability problems.[3] To overcome these problems, furnace annealing has been applied at temperatures greater than 300°C.[4] It was reported that the annealing process reduces the tail state defects, rearranges the amorphous structure, and improves the oxygen compensation in nonstoichiometric film.[3] However, annealing temperatures above 300°C make this process unsuitable for flexible substrates. Therefore, a low-temperature annealing process is essential for the development of stable IGZO TFTs

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