P11 Tuning the electronic properties of metal oxides by low temperature annealing

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With the rise of the Internet of Things, the field of electronics has moved away from a one-size-fits-all approach, as in silicon-based transistors on rigid substrates, to application specific devices and technologies [1]. For example, flat panel display technologies employ transparent thin film transistors (TFTs) to minimise the current necessary for the intended luminosity. and with more applications shifting towards flexible devices, material engineering requirements are more stringent.

TFTs are composed of a dielectric, a semiconductor layer and three separate electrodes and ideally, all these need to be transparent to maximize their efficiency in display applications. Metal oxides have surfaced as the most promising candidates for a wide range of applications. They can be readily deposited using standard vapour deposition techniques at room temperature, ideal for flexible electronics applications. Metal oxides have a wide band gap, providing optical transparency in the visible range which is especially attractive for display applications. Depending on composition, metal oxides can either be applied as electrodes, dielectrics or semiconductors. For flexible electronics, metal oxide semiconductors have advantages over amorphous silicon, as they provide higher carrier mobility in the amorphous phase, allowing room temperature deposition [2].

A major challenge with semiconducting metal oxides is the complex defects present in the films, commonly in the form of oxygen vacancies (V_O). These defects create trapping centres for electrons and lead to reduction of the number of charge carriers, resulting in changes in the film electronic properties. In a fully built TFT, this can translate to higher sub-threshold swing and increased hysteresis.

High temperature annealing (>520 ºC) in air atmosphere has been well documented and shown to reduce the number of V_O, however, it has also been demonstrated that excess oxygen can be incorporated in the film during the anneal process, negatively impacting performance. Low temperature annealing (<300 ºC), compatible with flexible substrates, has also been reported to contribute to a reduction of the number of V_O. however limited studies are available on the conditions required and the defect mechanism [3, 4].

The main goal of this work is to understand the effects of low temperature annealing on the electrical properties of metal oxide thin films. We aimed to find the ideal set of annealing conditions, temperature and time, for tuning and optimising the electrical properties for flexible electronics deposited by vapour phase deposition at room temperature. In this study, X-ray reflectivity (XRR) Will be used to determine film thickness, density and surface roughness of both film interfaces. Electrical measurements Will be taken by 4 point probe to obtain parameters such as sheet resistance and resistivity and some Hall-effect Will be used to provide electron hall mobility. The relationship between structural properties and functional electrical behaviour Will be presented.

References

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