UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF MgZnO THIN FILMS FOR 1 GHz MONOLITHIC MICROWAVE INTEGRATED CIRCUIT APPLICATIONS

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ABSTRACT

The aims of this research are to prepare magnesium zinc oxide (MgZnO) thin films and to study their physical as well as electrical properties at DC and high frequencies. Current MgZnO thin film deposition methods are incompatible with MMIC processing and costly. Furthermore, existing dielectric films used for MMIC applications offer low dielectric constants which will make the circuit constructed on these material relatively large. The MgZnO films prepared in this work are therefore proposed as a new dielectric material for 1 GHz monolithic microwave integrated circuit (MMIC) applications to replace current dielectrics due to its high permittivity which can lead to size reduction, in addition to being compatible with semiconductor processing.The films were prepared using sol gel spin coating technique and deposited on Pt/Si (100) substrates. Since this is the first time the films were to be made for high frequency applications, the process parameters need to be optimized to ensure production of high quality films as well as to meet the MMIC processing requirements. The effects of sol ageing time, Mg doping and annealing temperatures on the film structural and DC resistivity were studied. The physical properties were analysed using *JEOL JSM6360L* scanning electron microscope (SEM), *Carl Zeiss Supra 40VP* field emission SEM, energy dispersive of X-Ray (EDAX) and *Rigaku* X-Ray Diffractometer (XRD). For DC resistivity, a *Lucas Lab* four-point probe station was used. The optimized processing condition are; 24 hours sol ageing, Mg doping x = 0.2 and annealing temperature 700 °C. Film which undergone optimized conditions are highly crystalline, are 0.36 μm thick, exhibit grain size of 5 to 28 nm and obtain DC resistivity of 77 Ωcm. To test the suitability of this new material, RF properties such as dielectric constant, tan δ and $|S_{11}|$ were measured. A test structure consists of a combination of a 50 Ω transmission line and a 50 μm × 50 μm capacitor constructed on the films in the form of thin film microstrip structure (TFMS). The test structures were patterned using electron beam lithography, wet etching and metalized electrode with evaporated gold. The test structure was simulated using *Genesys* software over 0.5 to 3 GHz frequency range to determine the 50 Ω TL widths and to predict the RF performance. The width obtained for 50 Ω line was 1.8 μm with a dielectric constant of 10.5 was assumed. Further investigations on the RF behaviors have been made for the films with different annealing temperatures. On-wafer probing technique was employed in conjunction with a vector network analyser to measure the S-parameter in the range of 0.5 to 3 GHz. The dielectric constant, tan δ and $|S_{11}|$ improve with the increment annealing temperature. The dielectric constant was found to be 18.8, with tan δ of 0.02 at 1 GHz. These give a corresponding size reduction of ten times compared to conventional dielectrics. These indicate that the material is suitable to be implemented as a new dielectric material for MMIC applications.

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