UNIVERSITI TEKNOLOGI MARA

MODELLING OF SOL-GEL TITANIUM DIOXIDE MEMRISTIVE DEVICE BASED ON EXPERIMENTAL DATA AND SIMULATION

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

In the past few decades, memristive devices have been introduced as a non-linear circuit element with remarkable inherent properties. Its capability in remembering its current resistance state during the removal of the source as well as its compact metal insulator metal, MIM configuration has allowed it to be integrated in several applications. In order to ensure successful implementation of memristive devices, a lot of studies on the memristor fabrication process and modelling have been carried out. The study on memristor modelling has been performed to predict the behaviour and performance of this non-linear device. The model can be developed using Simulation Program with Integrated Circuit Emphasis (SPICE) simulation tool. Although several models are available to simulate the memristor electrical characteristic, only a few were developed based on the experimental data and device physic behaviour. Regardless of their capability to mimic the characteristics of memristors, the extent to which the above models fit with other memristor device configurations is not yet understood. Furthermore, the dynamical properties due to the resistive switching phenomenon of the proposed models and the influence of the model parameters to the memristor characteristics and their relationship to fabrication condition are not discussed in details. This study is therefore carried out to model and simulate a compact SPICE model for titanium dioxide (TiO_2)-based memristive device. In order to ensure successful development of the SPICE model, the modelling and simulation processes were divided into three phases. In the first phase, various existing memristor models were correlated to the experimental data and the best fitted model was subsequently determined. The knowledge gained in the first phase was then applied in the next phase in order to develop the SPICE model for TiO_2-based memristive device. Lastly in the last phase, the proposed SPICE model was then compared to other experimental data of TiO_2-based memristive device to further verify the developed model and to evaluate the relationship between the model parameters and fabrication process conditions. In this study, the SPICE model was developed based on the combination of Schottky and tunnelling mechanism. The proposed SPICE model known as EDBM SPICE model was further improved by inserting the resistive switching dynamical behaviour into the internal state variable function. The simulation results showed that the inclusion of filamentary based resistive switching resulted in the best fitted memristive behaviour. Among the filamentary based models, using the ion hopping model was chosen to be incorporated into the EDBM. The proposed model was able to reproduce the current-voltage relationship of various memristive behaviour. It is thus suggested that the conduction mechanism and resistive switching phenomenon had a significant impact in obtaining the I-V characteristic of TiO_2 thin film and device conductivity. The knowledge gained from the fitting parameters of the proposed model enables us to predict the performance of fabricated memristive device and engineer the process parameters for desired memristive behaviour.

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