INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	**Himangshu Jyoti Gogoi**
Roll Number	:	**166102004**
Programme of Study	:	**Ph.D.**

Thesis Title: **Design, Optimization, and Modelling of Hybrid Organic-Inorganic Perovskite Memristors**

Name of Thesis Supervisor(s)	:	**Dr. Arun Tej M.**
Thesis Submitted to the Department/ Center	:	**EEE**
Date of completion of Thesis Viva-Voce Exam	:	**12/5/2023**
Key words for description of Thesis Work	:	Memristor, Resistive Switching, Hybrid Perovskite, SPICE Modelling

SHORT ABSTRACT

Memristor (memory + resistor) is the fourth basic circuit element beyond resistor, capacitor and inductor. It establishes a relationship between flux and charge and its present resistance depends on its past state. With fast switching speeds (~picoseconds), low power consumption (~femto-joule/bit), long write/erase endurance, and high scalability (nano-meter scale), memristors have strongly captured the attention of research community in the fields of neuromorphic computation, artificial intelligence, ultra-dense data storage, and logic circuits.

On the other hand, hybrid organic-inorganic perovskites (HOIPs) have recently become strong candidates for high-efficiency low-temperature solution processable solar cells. HOIPs show a mixed ionic-electronic conduction where the halide counter ions are mobile under an electric field. Due of this, the current-voltage (I-V) characteristics of HOIP devices can be tuned to exhibit the signature memristor property of pinched hysteresis. Also, HOIPs tend to have longer carrier diffusion lengths and higher crystallinity than the organic semiconductors, making them more suitable for flexible memristors. Development of a resistive random-access memory (ReRAM) technology based on HOIP memristors, thus, can realize flexible and fast non-volatile memories. In this context, understanding their switching mechanisms and modelling their I-V characteristics are necessary for performance optimization and circuit simulation. However, to date, there is neither a standard characterization procedure nor a device model are available for these memristors. This thesis work attempts to bridge some of these research gaps.

The effects of electroforming and measurement processes on the performance of commercial memristors have been analyzed to identify the critical parameters determining their switching behaviour. Memristors using 3D methyl ammonium lead iodide ($MAPbI_3$) on glass and on flexible substrates have been fabricated and optimized to obtain reproducible characteristics. A procedure to extract the best possible switching parameters such as ON/OFF ratio, SET voltage, RESET voltage etc. from 3D HOIP memristors has been developed. Two different types of bipolar resistive switching (BRS) have been obtained from the same $MAPbI_3$ device by changing the polarity of the applied field. In addition, by controlling the compliance current, complementary resistive switching, which is highly useful in minimizing sneak-path currents in ReRAMs, has also been obtained from these devices. Dominant current conduction mechanisms under high and low resistance states, for both types of BRSs, have been identified and used in developing an algorithm for SPICE-based simulation of 3D HOIP memristors. The model has been validated by fitting with the experimental data. Layered 2D Ruddelson-Popper (RP) butyl ammonium lead iodide (BA_2PbI_4) memristors, which have better environmental stability than their 3D counterparts, have also been fabricated and characterized at low temperatures. The model developed for 3D $MAPbI_3$ devices has been found to fit these RP devices as well.