Effect of Scaling on Tunnel Magnetoresistance and Thermal Stability in Magnetic Tunnel Junction

a Thesis submitted by

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(S17005)

for the award of the degree of Master of Science by Research

SCHOOL OF COMPUTING & ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY MANDI

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THESIS CERTIFICATE

This is to certify that the work contained in the thesis entitled “Effect of Scaling on Tunnel Magnetoresistance and Thermal Stability in Magnetic Tunnel Junction” being submitted by Mr. Aijaz Hamid Lone (Enroll. No: S17005) has been carried out under my supervision. In my opinion, the thesis has reached the standard fulfilling the requirement of regulation of the MS by Research degree. The results embodied in this thesis have not been submitted elsewhere for the award of any degree or diploma.

Nov 5, 2020

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Declaration by the Research Scholar

I hereby declare that the entire work embodied in this thesis is the result of investigations carried out by me in the ***School of Computing and Electrical Engineering***, Indian Institute of Technology Mandi, under the supervision of ***Dr. Srikant Srinivasan***, and that it has not been submitted elsewhere for any degree or diploma. In keeping with the general practice, due acknowledgments have been made wherever the work described is based on findings of other investigators.

Place: IIT Mandi, Kamand

Signature:

Name: Aijaz Hamid Lone

Date: Nov 5, 2020

Declaration by the Research Advisor

I hereby certify that the entire work in this Thesis has been carried out by ***Aijaz Hamid Lone***, under my supervision in the ***School of Computing and Electrical Engineering***, Indian Institute of Technology Mandi, and that no part of it has been submitted elsewhere for any Degree or Diploma.

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ABSTRACT

The emerging non-volatile spin based memories, especially spin transfer torque random access memory (STT-RAM), are promising alternatives to memory devices, both in stand-alone configuration and embedding with CMOS for Non-Von Neumann computing. Magnetic tunnel junction (MTJ) as the basic storage cell of STT-RAM, promises low power consumption, high endurance, fast switching performance and compatibility with CMOS due to non-volatility and efficient switching mechanisms such as spin transfer torque and spin orbit torque. This thesis presents the comprehensive study of quantum transport, micromagnetics and interlayer exchange coupling in the MTJ. The effective mass tight binding (EMTB) and mode space approach is used to evaluate and study the role of transverse sub-bands in tunnel magneto-resistance (TMR) of the MTJ. The object oriented micromagnetics framework (OOMMF) based simulations are used to study the area dependence of important MTJ critical current density and thermal stability. The effect of the non-idealities in tunnel barrier on TMR is studied by including the dephasing in device Hamiltonian. Further various interlayer exchange coupling terms present in MTJ are first evaluated using spin dependent quantum well theory then the effect of interlayer exchange coupling on spin transfer torque and switching probability is studied. Finally, the thesis concludes with the proposal of optimized diameter range for different MTJ device applications and future prospects.

Keywords: *Spintronics, STT-RAM, Magnetic Tunnel Junction, Tunnel Magnetoresistance, Transverse modes, Dephasing, Thermal Stability, Critical Current Density, Multi-domain, MTJ applications.*

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AIJAZ HAMID LONE

TABLE OF CONTENTS