DOPING-LESS BIPOLAR TRANSISTORS: DESIGN AND INVESTIGATION

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JUNE 2015

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Submitted

in fulfilment of the requirements of the degree of

Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

JUNE 2015

CERTIFICATE

This is to certify that the thesis entitled "***Doping-less Bipolar Transistor: Design and Investigation***" being submitted by **Mrs Kanika** for the award of the degree of **Doctor of Philosophy** in the Department of Electrical Engineering, **Indian Institute of Technology Delhi**, is a record of bonafied work done by her under my supervision and guidance. The matter embodied in this thesis has not been submitted for the award of any other degree or diploma.

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ACKNOWLEDGMENTS

I am privileged to acknowledge my deeply felt gratitude to my guide and research supervisor **Dr. M. Jagadesh Kumar** for his valuable guidance, energising many-fold my own effort to approach this study. His adorable manner of discipline and dedication shall be an enduring gain for my personal credentials. The multi-task orientation of Kumar Sir has been an inspiration to emulate. The discussions, I had with him, strengthened my basics and also nurtured the research attitude in me. I thoroughly enjoyed the whole learning experience under his guidance.

I am grateful to the esteemed members of my student research committee (SRC): Prof. G.S. Visweswaran, Prof. Kolin Paul and Prof. R. K. Patney for their useful suggestions, motivation and helpfulness. I wish to express my sincere thanks to the Foundation for Innovation and Technology Transfer (FITT) for funding the patent application of my work.

I have been lucky to be affiliated with the most beloved friends who have been my immediate support in inducing a sense of confidence in pursuing this work. I wish to express my loyal thanks to Binish, Garima, Meena, Preeti, Nisha, Gautam, Radhakrishnan, Nitin, Sindhu Janardhanan, Avikal and other co-researchers of the VLSI group for their constant moral support during the entire period of this work.

I am fortunate to be blessed with the most enthusiastic and encouraging parents. My father Mr. A.P Nadda and my mother Mrs. Surekha Nadda, I love and thank the most for always supporting and appreciating my endeavours. I wish to record my appreciation to my siblings, Abhay Nadda and Anchal Nadda and my chachi Mrs Neelam Nadda for being there for me. My father in law, Dr. L.M. Sharma and my Mother-in law, Mrs. Madhu Sharma's adhering support and encouragement were a scaffold in the completion of this work.

This work is also a result of the most cheering support and persuasions of my husband Mr. Kartikeya Sharma. His co-operation and patience has been pivotal for my work. The contribution of my adorable newly born daughter, Myra, has been as unique and as heart warming, as she is.

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ABSTRACT

Although CMOS is increasingly used in integrated circuits, the bipolar transistors are extensively used in high speed and mixed signal circuits. BJTs are still widely investigated to enhance their electrical performance and widen their applications. However, since its invention, bipolar transistors could not be made without doping the semiconductor multiple times to create the emitter, base and the collector region. Doping leads to the defect formation and thermal budgets are a major concern in modern semiconductor technology.

This research work is focussed on realizing bipolar transistors on an intrinsic semiconductor without the need for any doping. Absence of the doped regions avoids the necessity of complicated thermal budgets.

In this thesis, a novel doping-less bipolar transistor named Bipolar Charge Plasma Transistor (BCPT) is first proposed. Using metal electrodes of appropriate work functions, the emitter, base and the collector regions of the BJT are created by inducing electron and hole plasma into the undoped semiconductor. Using two-dimensional simulations, it is demonstrated that the BCPT exhibits a good transistor action with a significantly larger current gain compared to a conventional BJT with the same device geometry.

Since, Schottky collector BJTs provide a better trade-off between the base-collector capacitance and the collector transit time, we have also investigated a Schottky collector bipolar charge plasma transistor (SC-BCPT) on an undoped silicon-on-insulator (SOI) film by inducing charge plasma in the emitter and the base region of the transistor. This research work demonstrates that the proposed SC-BCPT exhibits a significantly higher current gain, higher cut-off frequency and a better current drive compared to that of its conventional counterpart.

To further improve the electrical characteristics of the BCPT, a doping-less Vertical Bipolar Charge Plasma Transistor (V-BCPT) with a buried metal layer on SOI is reported in

this thesis. Using 2-D simulation we have studied the electrical performance of V-BCPT in terms of its current gain, cut-off frequency and $BV_{CEO} \cdot f_T$ product. We have shown that the proposed device is immune to current crowding effect at the edges of the emitter at high collector current densities.

Although poly-Si TFTs are extensively used in several applications such as active matrix displays and memories, research on poly-Si BJTs is very limited. This is due to the low current gain of poly-Si BJTs. This work demonstrates the possibility of realizing a doping-less poly-Si bipolar charge plasma transistor with a high current gain and cut-off frequency. The effect of the grain boundary position on the electrical characteristics of the poly-Si BCPT is also discussed.

In this thesis, a number of doping-less bipolar transistor structures are proposed and investigated. Simulation results show that the doping-less bipolar transistor exhibits a high current gain along with a high $BV_{CEO} \cdot f_T$ product. Our work demonstrates the possibility of realizing not only bipolar transistors but other field effect transistors using low thermal budget fabrication processes. This may enable the realization of electronic circuits on inexpensive non-silicon substrates such as glass and plastic.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES