

HIGH DENSITY ELECTRON CYCLOTRON RESONANCE LASMA PRODUCTION BY SLOTTED LINE ANTENNAS

by
R. BASKARAN

*THESIS SUBMITTED TO THE
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
FOR THE AWARD OF THE DEGREE
OF
DOCTOR OF PHILOSOPHY*



Centre for Energy Studies
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
INDIA

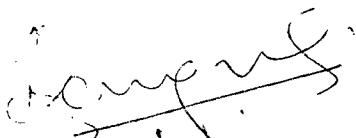
February, 1988

DEDICATED TO MY PARENTS


;

CERTIFICATE

This is to certify that this thesis entitled HIGH DENSITY ELECTRON CYCLOTRON RESONANCE PLASMA PRODUCTION BY SLOTTED LINE ANTENNAS, being submitted by R.Baskaran to the Indian Institute of Technology, Delhi, is a record of bonafide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements, which to our knowledge, have reached the requisite standard for the submission of this thesis. The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.



Dr.A.Ganguli
Centre for Energy Studies
Indian Institute of Technology, Delhi
New Delhi-110016, INDIA.



Dr.G.Umesh
Physics Department
Indian Institute of Technology, Delhi
New Delhi-110016, INDIA.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Dr. A. Ganguli for his constant guidance, encouragement and personal involvement with the work. I am also thankful to Dr. G. Umesh for his invaluable guidance and help.

I am grateful to Prof. M.S. Sodha, who offered me the opportunity to work in the plasma physics laboratory. Only, his constant encouragement, help and kindly care made it easier to complete this work. I am thankful to Prof. D.P. Tewari who advised me to join in the plasma physics laboratory and I thank him again for his invaluable suggestions and constant encouragement.

It is my pleasure to thank Dr. H.D. Pandey for his help in the laboratory and encouragement. I am extremely thankful to Mr.A.J. Josekutty and Mr. V.K. Talwar for their invaluable technical help without which it would have become very difficult to get the experimental system operative in time. In this vein, I should also thank M/s. Bharat Technological Products, New Delhi and M/s. Vecco, New Delhi who have patiently met with the design requirements.

I am also thankful to my laboratory colleagues Mr. P.A. Naidu and Dr. G.V.R. Raju and the other members of the plasma group. It is a pleasure to thank Prof. V.K. Tripathi, Dr. V.K. Jain, Dr. D. Subbarao and Dr. Bhumesht Gupta for their encouragement and discussions from time to time.

The financial assistants from the DST and ISRO are acknowledged.

It is my duty to express my sincere thanks to Mr. Nambi and Mr. Sebastin for the excellent job of typing that they have done in a short time. Mr. R. Kapoor is acknowledged for the neat tracings.

Finally, I would like to thank my friends Mr. Sitha Raman, Mr. Rajendran, Dr. Chandrasekar and Dr. Ashokan for their assistance in the final preparation of the manuscript.

R. Baskaran
R. BASKARAN

CONTENTS

		Page
CHAPTER-1	INTRODUCTION	1
1.1	Use of Slow wave structures in plasmas	4
1.2	Outline of the thesis	9
CHAPTR-2	HIGH POWER MICROWAVE LINE	14
2.1	Absolute power measurement	18
2.2	High-power arbitrary ratio power splitter	18
2.3	Vacuum seal	23
2.4	The coaxial line at the antenna end	25
2.5	Impedance matching section	27
2.6	Integrated microwave line	32
CHAPTER-3	EXPERIMENTAL SYSTEM AND DIAGNOSTICS	35
3.1	The plasma chamber and the vacuum system	35
3.2	The electromagnet coils and power supplies	36
3.3	The water cooling systems	39
3.4	Diagnotics	39
3.4.1	Langmuir probe	40
3.4.2	Energy analyzer	44
3.4.3	Emissive probe	49
3.4.4	RF probes	51
3.4.5	Signal analysis	52
3.4.6	Microwave power measurement	53

CHAPTER-4	THE SLOW WAVE RADIATION FIELDS OF THE SLOTTED LINE ANTENNAS	54
4.1	The SLA and its Operation	54
4.2	Radiation field analysis of the slow wave mode	55
4.2.1	Field Contribution from the axial slots	59
4.2.2	Field Contribution from the azimuthal slots	62
4.3	Results and discussions	65
CHAPTER-5	EXPERIMENTAL RESULTS AND DISCUSSIONS	70
5.1	Experimental Procedure	70
5.2	Excitation of the SLA	71
5.3	Plasma production and characterization results and discussions	73
5.3.1	Feed optimization and choice of the antenna	74
5.3.2	Typical plasma parameters	76
5.3.3	Pressure variation studies	79
5.3.4	Power variation studies	81
5.3.5	Effect of magnetic field (at the antenna region)	87
5.3.6	Plasma instabilities	88
5.4	Concluding Remarks	92
CHAPTER-6	CONCLUSIONS	94
	REFERENCES	98
	PHOTOGRAPHS OF THE EXPERIMENTAL SYSTEM AND COMPONENTS	
	LIST OF PUBLICATIONS	