FAR-INFRARED AND SUB-MILLIMETER

MICROBOLOMETER DETECTORS

APPROVED BY
DISSERTATION COMMITTEE:

____
Dean Neikirk (Supervisor)

____
Joe Campbell

____
Alex de Lozanne

____
Harris Marcus

____
Ben Streetman

FAR-INFRARED AND SUB-MILLIMETER MICROBOLOMETER DETECTORS

by

JASON MATTHEW LEWIS, S.B.

DISSERTATION

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

THE UNIVERSITY OF TEXAS AT AUSTIN

May 1994

Acknowledgments

Wow! It's been quite a ride getting to this point, and I owe many thanks to several of people for many things. I'd like to give tremendous thanks to my advisor, fellow coffee drinker, and vacuum wizard, Dean Neikirk, for opening his door to me, and providing me the opportunity to become a Team Neikirk Member. Thanks for your guidance, patience, direction, and good cheer. I would also like to thank my former undergraduate advisor, and all around good guy, Dave Rudman, for spurring my interest in graduate school. Both of you share an enthusiasm and personable spirit that I'd like to share with others as I move on. I'd also like to thank Stu Wentworth, a truly unforgettable character, for his assistance and merriment during my early years as a TN member. I owe appreciation to Kiran Gullapalli, another Club Med member, for his feedback on the thermal modeling, and for providing good cheer during my time at UT. I'd also like to thank John, Philip, Alwin, Doug, John, Shiva, Vijay, Saiful, Kim, Emre, and Vikas for their contributions and their jestering. Special thanks goes to Terry Mattord, for not only for his expertise in vacuum systems, but for also lending an ear from time to time. I'd also like to thank Alan Berezin and Dr. Alex de Lozanne for providing the YBCO films. I'd also like to thank Mark McCormick for his hand in helping me wrap this thing up.

Thank you, Doug Miller. I thank you not only for your technical help, but especially for the times in which you reached out to help as a friend. I think I speak for everyone at Team Neikirk in saying that we miss you. Our memories of you will always be with us.

I'd like to give special thanks to Jeff Lewis, for buying me my first CRC book when I was in tenth grade while he was a poor undergraduate in college. I used that book to look up some of the numbers for this dissertation. I'd like to give Jeff thanks for being the person most responsible for my initial interest in science and academics.

Special thanks goes to my mom, who has always been there, and has always provided encouragement like no one else can. And thanks to the rest of my family, who has always been there.

FAR-INFRARED AND SUB-MILLIMETER
MICROBOLOMETER DETECTORS

Publication No. _______________

Jason Matthew Lewis, Ph.D.
The University of Texas at Austin, 1993

Supervisor : Dean Paul Neikirk

Electromagnetic signals near the sub-millimeter wave (SMMW) and far-infrared (FIR) region are very difficult to process, and present many challenges to researchers who work in this field. Antenna-coupled microbolometers are broad-band detectors which operate well throughout this spectral range. Understanding the issues which affect microbolometer performance are important for designing and optimizing these detector systems. Since the dynamics of microbolometer performance involve components of current flow as well as heat flow, both circuit analysis and thermal modeling must be integrated in order to model actual microbolometer performance. By developing such models, the electrical and thermal responses can be related to material properties and device geometry. An understanding of these relationships is essential in evaluating material and geometric choices for these devices.

Analytical and numerical techniques were developed and used to explore and expand the theory behind microbolometer performance. A three dimensional finite difference numerical method was used to quantitatively model the thermal properties of various microbolometer devices. Both steady state and transient analysis techniques are discussed. Numerical simulations were used to develop a new empirical relation for accurately estimating the thermal impedance of the detector into the substrate while accounting for arbitrary length-to-width ratios of the detector. A new numerical algorithm for transient analyses developed for this study is discussed. A composite microbolometer which uses a Y-Ba-Cu-Oxide superconducting detector element was modeled, fabricated, and tested.

Table of Contents