PHOTOLUMINESCENCE STUDIES OF THE YELLOW SERIES FREE EXCITON IN CUPROUS OXIDE USING PULSED AND CONTINUOUS WAVE TUNABLE DYE LASERS

by

ROBERT M. HABIGER

B.A., Bethany College, 1969

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Physics

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1975

Approved by:

Alvin Compaan

Major Professor

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGEMENTS

I dedicate this work to my wife, Celeste. Her love and encouragement provided the support so necessary for its completion. I would also like to recognize the love and understanding provided by my father, Edwin Habiger, not only throughout the course of this work but also for the many years before.

I am grateful to my committee members, Professor Basil Curnutte and Professor Nate Folland for their assistance in preparing and reviewing this thesis. I extend a special note of thanks to my major professor, Al Compaan, for the inspiration and guidance he provided.

I also express my appreciation to Joe Hesse and Rick Robson for their assistance in the laboratory.

INTRODUCTION

In 1931, J. I. Frenkel proposed the concept of the exciton for explaining absorption in solids that was not accompanied by photoconductivity.[1] This electrically neutral quasi-particle, consisting of an electron and hole bound through a Coulomb interaction, has the interesting property of being able to migrate through a crystal. The exciton can probably best be described in terms of two different limiting approximations, one due to Frenkel and the other due to Wannier and Mott. The Frenkel model considers the exciton tightly bound so that the electron and the hole are usually on the same atom in the lattice although they may migrate from atom to atom. In the Wannier model, the exciton is weakly bound so that the electron-hole separation may extend over many lattice constants. The particular model that is appropriate depends upon the state of the exciton and the properties of the insulator or semiconductor in which it is formed. A discussion of these two models is given in Knox's Theory of Excitons.[2]

Following Frenkel's fundamental work, the exciton hypothesis was used to explain various crystal phenomena. However, it was not until the early 1950's that systematic optical absorption experiments were performed by independent groups that confirmed the existence of excitons. Although nearly all semiconductors show exciton effects, cuprous oxide (Cu_2O) has a particularly rich optical spectrum and was therefore an important crystal in these early experiments. The first observations of exciton spectra were made by Hayashi.[3] Similar observations were made by Gross and Karryev a few months later and reported in 1952.[4] Gross had begun a study of the