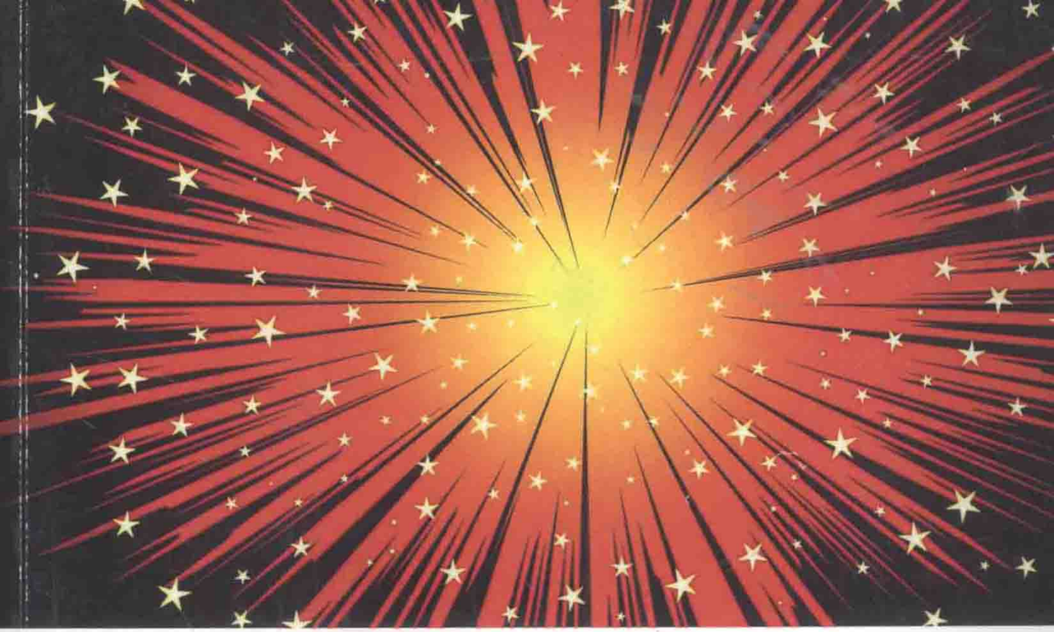

Krishna Acharya

Photocurrent Spectroscopy of Semiconductor Thin Films

Application of Pulsed-laser Deposition in Photosensitive Hetero-pairing of CdS / Plastic, CdS / Glass, and ZnTe / GaAs

VDM
Verlag Dr. Müller

Krishna Acharya

Photocurrent Spectroscopy of Semiconductor Thin Films

Application of Pulsed-laser Deposition in Photosensitive Hetero-pairing of CdS / Plastic, CdS / Glass, and ZnTe / GaAs

VDM Verlag Dr. Müller

Impressum/Imprint (nur für Deutschland/ only for Germany)
Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Coverbild: www.purestockx.com

Verlag: VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG
Dudweiler Landstr. 99, 66123 Saarbrücken, Deutschland
Telefon +49 681 9100-698, Telefax +49 681 9100-988, Email: info@vdm-verlag.de
Zugl.: Bowling Green, Bowling Green State University, Dissertation, 2009

Herstellung in Deutschland:
Schaltungsdienst Lange o.H.G., Berlin
Books on Demand GmbH, Norderstedt
Reha GmbH, Saarbrücken
Amazon Distribution GmbH, Leipzig
ISBN: 978-3-639-15957-8

Imprint (only for USA, GB)
Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de .

Cover image: www.purestockx.com

Publisher:
VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG
Dudweiler Landstr. 99, 66123 Saarbrücken, Germany
Phone +49 681 9100-698, Fax +49 681 9100-988, Email: info@vdm-publishing.com

Printed in the U.S.A.
Printed in the U.K. by (see last page)
ISBN: 978-3-639-15957-8

Krishna Acharya

Photocurrent Spectroscopy of Semiconductor Thin Films

PREFACE

This book is the result of my graduate work at Bowling Green State University (BGSU), Bowling Green, Ohio, USA, during 2004-09. This work presents photocurrent (PC) spectroscopy of thin-film cadmium sulfide (CdS) on plastic, CdS on glass, and zinc telluride (ZnTe) on gallium arsenide (GaAs) hetero-pairs. All samples have been prepared with pulsed-laser deposition (PLD) and the work is organized into three principal sections as described below.

In the first section, the merger of a transparent plastic substrate with thin-film CdS for photonic application was realized using low-temperature PLD, where low-temperature PLD means the substrates were not externally heated. Although plastic is not considered to be a favored substrate material for semiconductor thin-film formation, the deposited CdS film possessed good adhesion to the plastic substrates and showed a blue-shifted photosensitivity with peak at 2.54 eV. The CdS deposition rate was monitored at different laser fluences and the maximum rate was found at 2.68 J/cm^2. The visualization of the surface using an atomic force microscope (AFM) revealed its mosaic structure and electron probe microanalysis showed that target composition was maintained in the film. The study of thickness distribution revealed that the film deposition area is significantly increased with increase in laser fluence. The achieved results demonstrate the capability of PLD to form novel heterostructures with appealing and useful technological properties such as plasticity and low weight.

In the second part, APC control via blue light illumination employing thin-film PLD CdS on a glass is introduced. In fact, the APC driven through the CdS film in conjunction with bias was quenched when the sample was additionally illuminated with a blue light emitting diode (LED). It occurred that the quenching magnitude depends on the blue light intensity, chopped light intensity and its energy, and applied electric field. The quenching phenomenon is attributed to the shortening of available APC carriers because of the generation of direct current channels in the film and is described using a straightforward band diagram model.

In the final part of the dissertation, the PC spectra modification of a *n*-GaAs substrate due to the PLD of thin-film ZnTe is presented. The intrinsic and extrinsic room temperature PC spectra of the *n*-GaAs and ZnTe/*n*-GaAs samples were investigated with lock-in technique by employing various optical chopping frequencies and biases. The PC magnitude of the bulk *n*-GaAs was increased with increasing chopper frequency, while PC of the ZnTe/*n*-GaAs sample showed an increase and decrease with frequency in the lower and higher energy range, respectively. Noteworthy, a frequency independent isosbestic point was observed at the crossover between these two behaviors at 1.88 eV. Additionally, a defect related PC peak at 1.37 eV was observed only for ZnTe/*n*-GaAs sample. The magnitude of the peak-and even its appearance-was found to be sensitively dependent on the sign of bias. This phenomenon caused by PLD created defect states on *n*-GaAs surface referred to "photonic-doping".

I would like to express my sincere gratitude to my academic advisor Dr. Bruno Ullrich, without whose inspirations, guidance, and support; this work would not be possible. My PhD committee members Dr. Deanne Snavely, Dr. John Cable, and Dr. Lewis Fulcher are highly acknowledged for their valuable inputs and suggestions in this work. I am indebted to Dr. Artur Erlacher for his help and assistance in the laboratory and many invaluable suggestions and inputs during my graduate work at BGSU. Dr. Chinthaka Liyanage, Dina Atoyan, Dr. Dale Smith from BGSU; Dr. Himal Khatri, Jonathan Skuza,; Dr. Alejandra Lukaszew from University of Toledo; H. Sakai from Hiroshima Kokusai Gakuin University Japan; and K. Mahalingam, F. Meisenkothen from the Air Force Research Laboratory Dayton are highly acknowledged for their help and research collaboration.

I would like to extend many thanks to Nora Cassidy and Alita Frater of the Center for Photochemical Sciences; and Diana Tussing of the Department of Physics and Astronomy for their administrative support during my graduate study at BGSU. I would like to highly acknowledge the Department of Chemistry and Department of Physics and Astronomy of BGSU for providing me assistantships and scholarships during my graduate work. Especially, I am grateful to the Department of Physics and Astronomy for providing me J. Robert and Gretchen Overman Scholarship Award in 2007 and 2009. The other funding agencies such as the Defense Advanced Research Projects Agency (grant no. HR0011-07-1-0003), the National Science Foundation (grant no. HER-0227899), and the Ohio Board of Regents (OBOR Technology Innovation Enhancement Grants, PI Ullrich), are gratefully acknowledged for their generous financial support.

This work is dedicated to my family members, especially, to my wife Shobha, daughter Eliza, and son Kushal for their company, love, and support that always inspired me to succeed.

ABBREVIATION AND ACRONYMS

AES: Auger electron spectroscopy

AFM: Atomic force microscopy

APC: Alternating photocurrent

As: Arsenic

CB: Conduction band

CdS: Cadmium sulfide

CW: Continuous wave

DPC: Direct photocurrent

eV: Electron volt

ETRI: Electronics and telecommunications research institute

Ga: Gallium

GaAs: Gallium arsenide

GaSb: Gallium antimonide

GPIB: General purpose interface bus

He-Ne: Helium neon

HOMO: Highest occupied molecular orbital

HRTEM: High resolution transmission electron micrograph

HWE: Hot wall epitaxy

IR: Infrared

I-V: Current versus voltage

LED: Light emitting diode

LUMO: Lowest unoccupied molecular orbital

MBE: Molecular beam epitaxy

meV: Millielectron volt, 10^{-3} electron volt

min.: Minute

MOCVD: Metal-organic chemical vapor deposition

ms: Millisecond, 10^{-3} second

mW: Milliwatt, 10^{-3} W

Nd:YAG: Neodymium doped yttrium aluminum garnet nm: Nanometer, 10^{-9} meter

ns: Nanosecond, 10^{-9} second

PC: Photocurrent

PET: Polyethylene terephthalate

PL: Photoluminescence

PLD: Pulsed-laser deposition

PR: Photoreflectance

RHEED: Reflection high energy electron diffraction.

S: Sulfur

SEM: Scanning electron microscopy

Si: Silicon

SIMS: Secondary ion mass spectroscopy

SQUID: Superconducting quantum interference device

Subs.: Substrate

Te: Tellurium

TEM: Transmission electron microscopy.

Temp.: Temperature

TGVPD: Temperature gradient vapor phase deposition

TGVTD: Temperature gradient vapor transport deposition

VB: Valance band

XRD: X-ray diffraction

YBCO: Yttrium barium copper oxide

ZnTe: Zinc telluride

Filename: buchblock.02.11
Directory: C:\Users\Krishna\Desktop\book.project
Template:
C:\Users\Krishna\AppData\Roaming\Microsoft\Templates\Normal.dotm
Title: PHOTOCURRENT SPECTROSCOPY OF CdS/PLASTIC, CdS/GLASS, AND
Subject:
Author: ITS
Keywords:
Comments:
Creation Date: 3/9/2009 6:10:00 PM
Change Number: 386
Last Saved On: 2/11/2010 7:37:00 PM
Last Saved By: Krishna
Total Editing Time: 5,645 Minutes
Last Printed On: 2/11/2010 7:38:00 PM
As of Last Complete Printing
Number of Pages: 98
Number of Words: 19,002 (approx.)
Number of Characters: 108,316 (approx.)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES