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ULTRAFAST SPECTROSCOPY AND LASER LABORATORY OF THE CITY COLLEGE OF NEW YORK NEW YORK, NY 10031

DEPARTMENT OF PHYSICS

PROFESSOR R.R. ALFANO

FINAL REPORT
AFOSR - 85-0055

PICOSECOND AND FEMTOSECOND SPECTROSCOPIC INSTRUMENTATION FOR ULTRAFAST SPECTROSCOPY AND LASERS

R. R. Alfano

Program Manager: Dr. Gerald Witt

Research Title:

Dynamics of Elementary Excitations in Semiconductors investigated by Femtosecond and Picosecond Laser Techniques and Vibrational Relaxation and Energy Transfer in Organic Solids induced by Shock Waves.

Report Date: March 10, 1986

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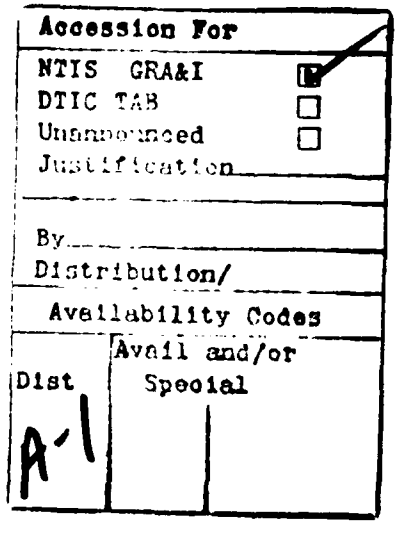

DoD - University Research Instrumentation Program

AFOSR 85-0055 (12-4-84)

FINAL REPORT

Picosecond and Femtosecond Spectroscopic Instrumentation for Ultrafast Spectroscopy and Lasers

by

Professor R. R. Alfano

City College of NY - IUSL

138th Street & Convent Avenue

New York, NY 10031

The scope of this program "DoD University Research Instrumentation Program" was to upgrade the research capabilities of the Institute for Ultrafast Spectroscopy and Lasers (IUSL) by acquiring state-of-the-art ultrafast laser and diagnostic instrumentation.

The following areas were targeted for enhancement.

1. Femtosecond Laser System. Replacement of the obsolete Q-switch Nd:YAG laser.

2. Multichannel spectroscopic system for ultrafast time-resolved spectroscopy.

3. A 2-psec streak camera system for time-resolved luminescence spectroscopy.

In what follows we will expand on these three enhancement areas.

Femtosecond Laser System

Replacement for the outdated Q-switch Nd:YAG laser which is used to pump four amplifier stages. The new Nd:YAG laser system (Quanta Ray DCR-2A) has been installed and has greatly improved the beam profile and the stability of the

laser. The stability has improved because of the overall stability of the Nd:YAG laser and the lower jitter (<250 psec) which allows for better synchronization between the femtosecond oscillator and the Nd:YAG laser. In addition, the repetition rate of the amplifier is 30 Hz instead of 10 Hz of the old laser. Thus improving the quality of the signal-to-noise ratio.

This equipment is used for existing AFOSR supported research programs, namely, AFOSR contract F4920-83C-0027. The scope of this research is to study the relaxation of highly photogenerated carriers in semiconductors and under microstructures femtosecond laser excitation. The goal is to understand the temporal behavior of carrier-carrier interactions, momentum and energy relaxation, transient development of distribution functions, diffusion, interaction strengths between phonon, many body effects and screening effects.

Multichannel Spectroscopic System

The system consists of a triple spectrograph (Spex) connected to a diode intensified array (OMA III). The system has been installed and is operational. The system has been interfaced to a PDP/11/23 plus and most of the software for data handling and analysis has been written. This system has been developed to measure time-resolved Raman spectroscopy using 30 ps laser excitation. It has been used by the laser shock wave group to study the energy transfer from the shock front to the vibrational states in condensed matter. This research is supported by ONR under contract N0014-82-K0630. The goal of this research is to study the conditions and pathways of energy transfer from the shock front to vibrational states with picosecond resolution. From theoretical consideration it is expected that energy first flows to intermolecular modes and subsequently to intramolecular modes leading to bond breakage and chemical reactions. In explosives this process leads to detonation under shock conditions. It is clear, therefore, that understanding these mechanisms of energy transfer will lead to a better under-

standing and perhaps the ability to control the stability of explosives. This system will be used for Raman studies on semiconductors under AFOSR contract.

Streak Camera System of 2 psec Resolution

This system provides improved resolution (2 psec versus old 10 psec streak cameras) for time-resolved spectroscopy. This instrument has recently been delivered. This instrument is shared by the semiconductor group (AFOSR) and the shock wave group (ONR). The goal of the research supported by this system is the study of relaxation processes in semiconductor alloys and microstructures as well as the study of dynamic processes in condensed matter under shock conditions.

US Graduate Students Training

In conclusion, one of the aims of this program is to train US citizen students and researchers in the areas of ultrafast technology. This goal remains of high priority at IUSL. The US citizens working on this technology are Mr. Alvin Katz, Mr. Peter Delfyett, Mr. Ardie Walser, Mr. Winston Lam, and Mr. Peter Ryerson. Since the submissior of this proposal, Dr. David Rosen has graduated and has joined the NRL; Mr. S. Krimchansky has joined the Harry Diamond Laboratory of the US Army; Mr. Ray Tsu has joined the General Electric Research Lab; Dr. P. Lu has joined IBM; Dr. H. Zarrabi has joined General Optronics; and Dr. S. Yao has joined IBM.

Ph.D. Thesis at the Institute for Ultrafast Spectroscopy and Lasers

The City College of New York

	TOPIC/DATE/FUNDING AGENCY	PRESENT POSITION
1.	"Picosecond and Steady State Spectroscopy of the Wurtzite Semimagnetic Semiconductor $Cd_{1-x}Mn_xSe$" by Mahesh Junnarkar, 1986, AFOSR, NSF	IUSL
2.	"Time Resolved Spectroscopy of Ternary Semiconductors $GaAs_{1-x}P_x$ and $Ga_xIn_{1-x}P_x$ under Picosecond Laser Pulse Excitation" by Hassan J. Zarrabi, 1985, AFOSR	General Optronics
3.	"Picosecond and Steady State Spectroscopy of Defects in Semi-Insulating CdSe" by David L. Rosen, 1985, AFOSR	NRL
4.	"A Study of Energy Transfer in the Photosynthetic Blue-Green Algae Nostoc Sp. probed by Picosecond Spectroscopy" by Aaron Dagen, 1985, NSF	Perkin Elmer
5.	"Energy Transfer between Dye Molecules Investigated by Steady State and Time Resolved Spectroscopy" by Poyang Lu, 1982, AFOSR, NSF	IBM
6.	"The Emission and Absorption Characteristics of Chalcogenide Semiconductors using Steady State and Time Resolved Picosecond Spectroscopy" by Shingshwang Yao, 1982, AFOSR	IBM
7.	"Electron Spin and Energy Relaxation in Highly Photoexcited Gallium Arsenide" by Robert J. Seymour, 1981, AFOSR, NSF	GTE
8.	"Carrier Transport in Amorphous Silicon utilizing Picosecond Photoconductivity" by Anthony M. Johnson, 1981, BTL	Bell Labs
9.	"Energy Transfer in the Primary Stages of the Photosynthetic Process investigated by Picosecond Time Resolved Fluorescence Spectroscopy" by Francesco Pellegrino, 1981, NSF	Sperry
10.	"Reorientational Relaxation Kinetics of Polyatomic Molecules in Different States of Condensed Media investigated by Picosecond Laser Pulse Induced Kerr Effect" by Ping-Pei Ho, 1978, NSF	CCNY Prof. EE

Ph.D. Thesis in Progress

1. "Ultrafast Transient Diffraction Gratings of Photoexcited Carriers in GaAs Structures" by A. Katz, AFOSR

2. "Ultrafast Quantum Well Physics" by Kai Shum, H. Chao, P. Ryerson, AFOSR

3. "Picosecond Raman Induced Phase Conjugation in Semiconductors and Polymers" by P. Delfyett, A. Walser, AFOSR

4. "Laser Induced Shock Wave Interaction Physics in Solids and Liquids" by S. Lee, B. Willman, ONR

5. "Nonradiative Relaxation Dynamics in Tunable Solid State Lasers" by V. Petricevic, B. Wang, ARO, NASA

6. "IR Phase Conjugation in Semiconductors" by N. Chen, AFOSR

7. "Ultrafast Interference Optical Computation" by Yao Li, AFOSR

8. "Spin Relaxation of Carriers in Semiconductors" by Winston Lam, X. Liu, NSF, AFOSR

9. "Supercontinuum Generation" by V. Caplan, X. Wang, NSF, AFOSR