PICOSECOND AND FEMTOSECOND SPECTROSCOPIC INSTRUMENTATION FOR ULTRAFAST SP. (U) CITY COLLEGE NEW YORK ULTRAFAST SPECTROSCOPY AND LASER LAB R. R. ALFANO
UNCLASSIFIED 10 MAR 86 AFOSR-TR-86-0498 AFOSR-85-0855 F/G 20/5 NL
AFOSR-TR-85-0055

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FINAL REPORT
APOS R - 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

RF: 447216

This technical report has been reviewed and is approved for public release. AFWAL-TR-85-125.

Distribution is unlimited.

MATTHEW J. HEPPEL
Chief, Technical Information Division
Under this grant the Institute for Ultrafast Spectroscopy and Lasers at CCNY has acquired state-of-the-art ultrafast lasers and diagnostic instrumentation to upgrade its facilities and capabilities. This equipment will keep the Institute's semiconductor research at the cutting edge.

A femtosecond mode-locked CPM dye laser - dye amplifier system was substantially improved by the addition of new YAG laser pump. This femtosecond system will be used in the study of ultrafast processes in semiconductor microstructures and alloys. A multichannel Raman spectroscopic system was installed for use in the study of transient Raman effect in semiconductors and shock wave induced processes. An ultrafast streak camera was acquired for photoluminescence kinetic studies in semiconductor alloys and microstructures with a time resolution of 2 ps.
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.


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Replacement for the outdated Q-switch Nd:YAG laser which is used to pump four amplifier stages.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 F4920-33C-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 un-
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 submission 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/DATR/FUNDING AGENCY**

1. "Picosecond and Steady State Spectroscopy of the Wurtzite Semimagnetic Semiconductor Cd_{1-x}MnxSe" by Mahesh Junnarkar, 1995, AFOSR, NSF

2. "Time Resolved Spectroscopy of Ternary Semiconductors GaAs_{1-x}Px and Ga_xIn_{1-x}Px under Picosecond Laser Pulse Excitation" by Hassan J. Zarrabi, 1985, AFOSR


5. "Energy Transfer between Dye Molecules Investigated by Steady State and Time Resolved Spectroscopy" by Poyang Lu, 1982, AFOSR, NSF


8. "Carrier Transport in Amorphous Silicon utilizing Picosecond Photoconductivity" by Anthony M. Johnson, 1981, BTL

9. "Energy Transfer in the Primary Stages of the Photosynthetic Process investigated by Picosecond Time Resolved Fluorescence Spectroscopy" by Francesco Pellegrino, 1981, NSF

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, 1972, NSF

**PRESENT POSITION**

- IUSL
- General Optronics
- NRL
- Perkin Elmer
- IBM
- GTE
- Bell Labs
- Sperry
- CCNY
- Prof. EE
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
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
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