XI. QUANTUM OPTICS AND ELECTRONICS

Academic and Research Staff

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1. NONLINEAR OPTICAL INTERACTION IN SEMICONDUCTORS

U.S. Air Force – Office of Scientific Research (Contract F49620-79-C-0071)

Michael M. Salour, James G. Fujimoto, Ting K. Yee, Charles B. Roxlo

The aim of this program is to investigate a variety of novel, nonlinear optical interactions that accompany, or immediately follow, the creation of an electron-hole pair in semiconductors. These studies will combine theory and experiments on the basic physics of the interaction of intense picosecond pulses with semiconductor systems involving mobile carriers.

Our laboratory was completed last spring (1980). During the summer this facility was used to develop the first tunable CW Bulk Semiconductor Laser. We have achieved cw output powers of up to 10 MW from a CdS platelet optically pumped by an Ar^+ laser at 476 nm. We have also studied radiative recombination processes in CdS and CdSe and have developed a unique technique for observing the time-resolved induced absorption due to exciton-biexciton transitions in CuCl. These experiments provide a new tool for generation of tunable coherent sources in the new spectral region, and can also be used to study ultrafast nonlinear optical processes in semiconductors on a subpicosecond time scale. Our results imply that the rate constants for ultrafast processes such as exciton-exciton interaction

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and the binding of free carriers into excitons can be easily determined. Several experiments to test enhanced spontaneous and stimulated light-scattering processes are now in progress. Preliminary attempts to generate picosecond optical pulses from a bulk semiconductor platelet have been successful. Thus far, we have generated pulses as short as 8 picoseconds at a repetition rate of 80 MHz. We are now in the process of implementing a stabilization scheme to achieve even shorter pulses.

2. PICOSECOND DYE LASER OPTICS

Joint Services Electronics Program (Contracts DAAG29-78-C-0020 and DAAG29-80-C-0104)

Michael M. Salour, Stanley R. Rotman, Dick Bebelaar

We have developed a new method of pulse-width stabilization of a synchronously pumped dye laser. Our work represents the first attempt to stabilize the pulses by measuring the pulse width and maintaining it at a minimum using analog and digital feedback acting, respectively, on the mode-locking frequency and the cavity length of a synchronously pumped mode-locked dye laser. In this way, we have been able to counterbalance the undesirable effects, such as the plasma instabilities in the Ar^+ laser, thermal drift in the cavity length of the dye laser, and the electronic noise in the oscillator that provides the signal for the acousto-optic mode locking of the crystal, which when combined produce fluctuations both in the amplitude and pulse width of the picosecond pulses. In this way, we have been able to reproducibly generate pulses as short as 0.7 picosecond.

We have also achieved larger interpulse separation and more energy per pulse by both cavity-dumping and amplifying selected pulses from the cavity dumper in synchronism with the frequency-doubled output of an amplified Q-switched Nd:YAG laser. Four stages of amplification are used. We are currently obtaining powers of the order of 3 gigawatts at the repetition rate of 10 Hz with pulses as short as 0.8 picosecond. In addition, we have been able to reproducibly generate sub-picosecond continuums by focusing the output of the last amplifier stage in water.

3. NONLINEAR SPECTROSCOPY OF ATOMS AND MOLECULES

U.S. Navy — Office of Naval Research (Contract N00014-79-C-0694)

Michael M. Salour, Guillaume M.A. Petite, Bartley C. Johnson

We have made the first observation of unidirectional gain in a sodium vapor induced by velocity-dependent light shifts. Our observation was based on creating unidirectional amplified spontaneous emission (ASE) light through Doppler compensation. We have demonstrated that the ASE light intensity depends strongly on the total gain of the medium, $\exp(g \cdot \ell)$, where g is the gain per unit length and ℓ the length. In addition, due to the exponential dependence, we have demonstrated that even a small change of the gain curve width and height will give rise to a dramatic forward/backward (in relation to the compensating laser direction) gain asymmetry, resulting in unidirectional ASE. Our work has also introduced a novel kind of light-induced light switching where the switching is brought about by the rapid relaxation of the population inversion under high-forward-gain conditions, and accompanied by a burst of ASE light.

Publications

S.R. Rotman, C.B. Roxlo, R. Bebelaar, and M.M. Salour, "Stabilization of Picosecond Pulses from a Synchronously Pumped Dye Laser," Appl. Phys. Lett. 36, 886 (1980).

S.R. Rotman, C.B. Roxlo, B. Bebelaar, and M.M. Salour, "Pulsewidth Stabilization of a Synchronously Pumped Dye Laser," Proceedings of the International Conference on Picosecond Phenomena, Falmouth, MA, June 1980; Springer Verlag Series Picosecond Phenomena, Vol. 14 (Springer Verlag, 1980) page 50.

G. Petite, B.C. Johnson, W.K.H. Lange, and M.M. Salour, "Observation of Unidirectional Amplified Spontaneous Emission Induced by Velocity-Dependent Light Shift," Phys. Rev. Lett. 45, 1242-1245 (1980).

S.R. Rotman, "Active Feedback Stabilization of Ultrashort Pulses in a Synchronously Mode-Locked Dye Laser," June 1980.