**Title:** Coherent Control over Excitations and Signals in Semiconductors

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**Abstract:**

The underlying technology for THz polaritronics – programmable, solid-state, THz-bandwidth signal processing – was developed. Two primary steps enabled this achievement. First, an automated spatiotemporal femtosecond pulse shaping system, through which ultrafast laser pulses could be directed at specified times to specified locations (i.e., to specified addresses), was created. Second, the system was applied to spatiotemporal coherent control over THz-frequency polariton waves (which serve as ultrahigh-bandwidth signals) in crystalline solids. The methods open the way to a versatile electro-optic signal processing platform in which the THz-bandwidth signals are generated, propagated, manipulated, and read out, all without loss of bandwidth. The results of this project have spawned numerous further refinements of polaritronics technology as well as advances toward fundamental and practical applications.
Problem Studied and Principle Results

In this project, entirely novel methods were developed for generation, manipulation, and detection of THz frequency, THz bandwidth lattice waves in semiconductors. Coherent control over mixed lattice vibrations and electromagnetic waves called phonon-polaritons, or simply polaritons, was made possible through these developments. The methods open the way to a versatile THz-bandwidth signal processing system.

First, a fully automated method for high-fidelity spatiotemporal femtosecond pulse shaping was developed. In this method, a single input laser beam with a single ultrashort pulse is transformed into many output beams, each of which has an independently specified pulse sequence or other time-dependent optical waveform. The output beams can be directed to different regions of a sample – i.e. different addresses on a device – for generation and control over polariton waves. In this manner, spatiotemporal coherent control over THz signals is achieved.

These developments have led the way to the dawn of polaritonics – fully programmable, THz-bandwidth solid-state signal processing and control. Further work during the current grant period has demonstrated the versatility and potential of the polaritonics for fundamental and practical applications.

Publications

(a) peer-reviewed journals

(b) conference proceedings

(c) conference presentations (no proceedings)
Note: this is a partial list of invited talks only
Optimal Control of Quantum Dynamics: Theory and Experiment, 9-14 December 2001, Tegernsee, Germany
5th Femtochemistry Conference, 2-6 Sept. 2001, Toledo, Spain
Gordon Research Conference on Coherent Control or Atomic and Molecular Motion, 29 July – 3 August 2001, Mount Holyoke, Massachusetts
The second RIES-Hokudai Symposium, 8-9 March 2001, Sapporo, Japan
Ultrafast Processes in Physical Chemistry, 3-8 Sept. 2000, Champery, Switzerland
International Workshop on Optical Control of Quantum Dynamics: Theory and Experiment, 25-27 July 1999, Tegernsee, Germany

Participating Scientific Personnel
Timothy Crimmins, Ph.D., 1999
Richard Koehl, Ph.D., 1999
Michael Gleason, M.S., 2001
David Ward, current Graduate Student
Nikolay Stoyanov, current Graduate Student