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13. ABSTRACT *(Maximum 200 words)*

We have been investigating optical thresholders capable of distinguishing between properly decoded pulses and lower intensity, improperly decoded multiaccess interface. We are performing ultrashort pulse optical "thresholding" experiments at 1.5 um using GaAs waveguides. Thresholding occurs because the number of carriers generated by two photon absorption is expected to vary inversely with pulse width for fixed pulse energy. Therefore, a short intense pulse will generate more carriers than a longer, less intense pulse. Our new contributions are (1) demonstration of proper scaling with pulse width in the femtosecond to picosecond regime and (2) demonstration of subnanosecond electrical response.

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Femtosecond Laser System for Research on High-Speed Optical Transmultiplexing and Coding

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I. Acquired equipment

We acquired the following equipment, which was installed in our laboratory in November, 1995:

Item	Description
1	Beamlok 2080-15SA 15–watt all-lines visible argon ion laser pump source
2	Model 3960-L1M "Tsunami" Mode-locked femtosecond Ti:Sapphire laser, configured for 780-900-nm operation
3	P/N 0446-7570 Mid-range femtosecond to picosecond conversion optics for the Tsunami
4	Opal 1.5-FS OPO Femtosecond optical parametric oscillator for 1.34-1.60 micron signal wave operation
5	Opal 1.5 to 1.3 conversion kit (converts femtosecond OPO to 1.3μm operation)
6	Tsunami Lok-to-Clock mechanics upgrade.

The equipment is as listed in the original DURIP proposal, with the small exception that the original proposal contained additional optics to allow the laser to tune down to 720 nm wavelengths. The final equipment configuration deleted this additional optics, which left a tuning range of 775 nm to 900 nm. This tuning range is adequate for all the anticipated experiments and freed up money which was used to include the Tsunami Lok-to-Clock mechanics upgrade. This allows future addition of Lok-to-Clock electronics which will allow synchronization with external electronics. This capability could be important for future pulse processing experiments.

The cost of this equipment was $182,000. Of this DoD supplied $121,333 and Purdue supplied $60,667 as a cost share. These numbers are as budgeted in the proposal.

All the equipment is now operational.

II. Research projects summary

Since installation this equipment has been used by approximately five researchers (two post-docs, three graduate students) for three main research projects. These projects are summarized below.

II.A. Pulse Processing Using Nonlinear Guided Wave Devices (AFOSR F49620-95-1-0533)

Motivated by our research on code-division multiple-access (CDMA) optical networks, we have been investigating optical thresholders capable of distinguishing between properly decoded pulses and lower intensity, improperly decoded multiaccess interference. Such thresholders are also important for other temporal pattern recognition tasks. We are performing ultrashort pulse optical "thresholding" experiments at 1.5 μm using GaAs waveguides provided by the group of Prof. John Marsh at University of Glasgow. Thresholding (actually just a strongly nonlinear input-output relation) occurs because the number of carriers generated by two photon absorption is expected to vary inversely with pulse width for fixed pulse energy.

Therefore, a short intense pulse will generate more carriers than a longer, less intense pulse. Using an embedded p-i-n structure, the photogenerated carriers can be swept into an external circuit, where the output is taken as the time-integrated amount of photogenerated charge. Previously such waveguide devices were used as sensitive intensity autocorrelators. Our new contributions are (1) demonstration of proper scaling with pulse width in the femtosecond to picosecond regime and (2) demonstration of subnanosecond electrical response (which means that this device is indeed suitable for Gbit/s CDMA systems). Publications on this work have been accepted by IEEE Photonics technology Letters and by the Conference on Lasers and Electro-optics (CLEO).

II.B. Ultrafast optical transmultiplexing using space-time processing (AFOSR F49620-95-1-0533)

A key goal of our research is to demonstrate all-optical methods for generation, processing, and transmultiplexing (data format conversion) of ultrafast lightwave signals. Recently our effort has focused on incorporating pixellated optoelectronic modulator arrays into femtosecond pulse shaping systems. This work could lead to pulse shaping systems generating (or processing) data signals and packets which can be reprogrammed at rates in the nanosecond regime. This would fill an important need in both TDM packet networks and bit-parallel WDM links. Additionally, this may result in additional processing power in optical pulse shaping systems through the use of smart pixel device arrays.

As one example, we are exploring the use of smart pixel device arrays in optical pulse shaping and processing systems. The particular smart pixel technology we are considering consists of arrays of gallium arsenide multiple quantum well (GaAs MQW) optical detectors/modulators, or SEEDs, bonded onto the surface of silicon CMOS (Si-CMOS) electronic chips. In collaboration with Prof. Kevin Kornegay at Purdue, we designed our first Ultrafast Optical Processing (UOP) chip during fall 1995. Chips were subsequently fabricated by Bell Laboratories under the auspices of the ARPA Consortium for Optical and Optoelectronic Technologies for Computing (CO-OP) program. We are now using the acquired laser system to test these chips in our laboratory. One important functionality for the UOP chip is to serve as an electronically programmable pulse shaping array. A key point is that very fast update times should be possible; our conservative target for our first UOP chip is to demonstrate updates at >155 Mbit/s. Additionally, the UOP chip will play a key role in planned time-slot interchanger experiments.

We have also used the acquired laser system for initial experiments on ultrafast time-to-space conversion using second harmonic generation crystals in femtosecond pulse shapers.

II.C. Femtosecond optical manipulation of terahertz (THz) radiation (NSF 9404677-PHY)

We have investigated the use of shaped femtosecond pulses to manipulate the THz radiation emitted by biased photoconductor samples. We have been able to demonstrate several interesting examples of THz waveform control, e.g., using femtosecond pulse trains to generate tunable narrow band THz radiation in the 750 GHz- 1.2 THz frequency range and using digital optical pulse sequences (both 'ones' and 'zeroes') to generate digital as well as phase-modulated THz waveforms. This is the first time that general pulse shaping techniques have been extended into the THz frequency range. Also, in the case of generating tunable narrow band THz radiation, we have shown that the use of femtosecond pulse trains (compared to unshaped single pulses) allows a considerable (>3x) enhancement at the THz frequency of interest for fixed average optical power. This enhancement, which has not previously been reported, results because the low peak optical powers and peak THz electric field amplitude associated with multiple pulse excitation avoid the strong saturation effects which normally occur when the radiated THz field screens the applied bias field. This work has been reported in Optics Letters and in four conference talks and has been accepted for publication in IEEE Journal of Selected Topics in Quantum Electronics.