AFRL-SR-BL-TR-98-

0234

REPORT DOCUMENTATION PAGE

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE

3. REPORT TYPE AND DATES COVERED
Final 01 Sep 95 to 31 Aug 97

4. TITLE AND SUBTITLE
(DURIP-95) Instrumentation for phase modulation, stabilization, and control in terabit per second optical network

5. FUNDING NUMBERS
61103D
3484/US

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NE
110 Duncan Avenue RMB115
Bolling AFB DC 20332-8050

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
F49620-95-1-0511

11. SUPPLEMENTARY NOTES

19990211033

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVAL FOR PUBLIC RELEASED: DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

We requested instrumentation (principally lasers and amplified components operating at 1.5 um) to enhance a research program to develop and demonstrate a Tb/s optical network architecture. This ultra high speed architecture, which includes ultra-high parallelism and complete contral over optical phase, is based on several novel optical and optoelectronic technologies such as acousto-optic spectral encoding of femtosecond optical pulses using shaped radiofrequency pulses and all-optical time-division multi-plexing and demultiplexing of picosecond optical pulses. These key technologies enable an optical network architecture based on a combination of wavelength-time-and code-division multiplexing with rapid channel access and several Tb/s aggregate throughput.

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

Final report: F49620-95-1-0511

We requested instrumentation (principally lasers and amplifier components operating at 1.5 μm) to enhance a newly DoD-funded research program (part of a BMDO/AFOSR effort on Photonics for Data Fusion in the Focused Research Initiative, hereafter FRI) to develop and demonstrate a Tb/s optical network architecture. This ultra high speed architecture, which includes ultra-high parallelism and complete control over optical phase, is based on several novel optical and optoelectronic technologies, such as acousto-optic spectral encoding of femtosecond optical pulses using shaped radiofrequency pulses and all-optical time-division multi-plexing and demultiplexing of picosecond optical pulses. These key technologies enable an optical network architecture based on a combination of wavelength-, time- and code-division multiplexing, with rapid channel access and several Tb/s aggregate throughput (see Figure 1). Detailed experimental demonstrations of these technologies have been published by groups in Chemistry and Electrical Engineering at Princeton, but generally at wave-lengths other than 1.5 μm. For example, femtosecond spectral encoding (pulse shaping) is done by Warren's group at chemically relevant visible and mid-IR wavelengths, and optical demultiplexing has been demonstrated by Prucnal and coworkers at 1.3 μm.

Our FRI proposal suggested demonstrating this architecture by connecting the Chemistry and Engineering buildings on the Princeton campus with optical fiber which could carry several thousand Ethernet channels at the same time. Over the last few years, we have made significant progress towards that goal, with this DURIP funding playing a critical role. In Warren's laboratory, for example, high speed laser pulse shaping at λ=1.55 μm has been demonstrated, using a commercial erbium-doped fiber laser (see Figures 2 and 3). In addition, we have demonstrated that the acousto-optic approach to pulse shaping permits optical multiplexers and tunable delay lines with vastly superior characteristics to conventional systems. For example, we can delay laser pulses by tens of picoseconds, and change that delay in approximately one microsecond, completely under electronic control (just changing the center frequency of the AOM, see Figure 4). No other technology can do this quickly and reproducibly. For a physical delay line, that would correspond to accelerating a mirror instantaneously to 10 km•s^{-1} and stopping it a few microseconds later. One could think of ways to do this (with explosives), but reproducibility would be a problem. We have also shown clean electronic control of the pulse dispersion, merely by changing the center frequency of the AOM.

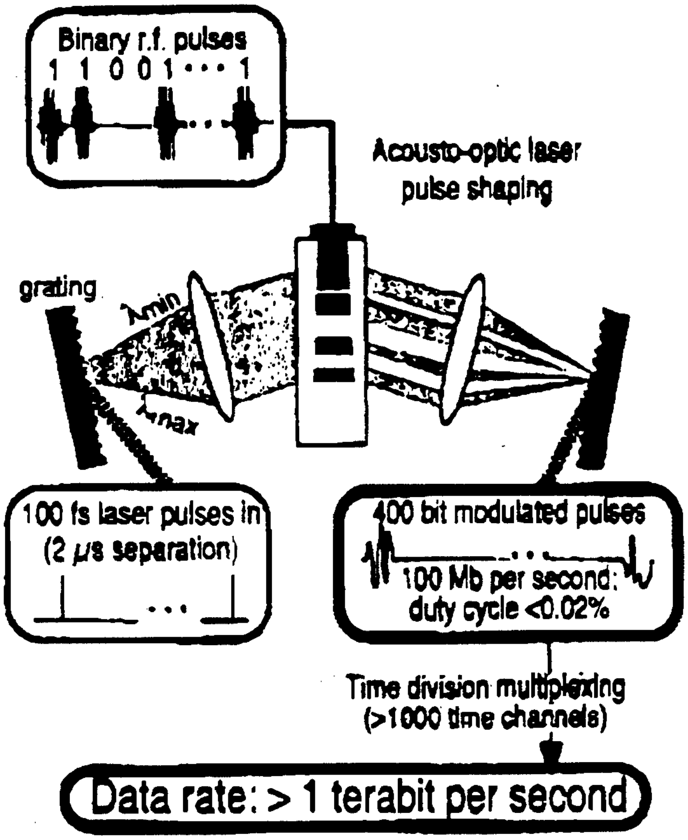


Figure 1

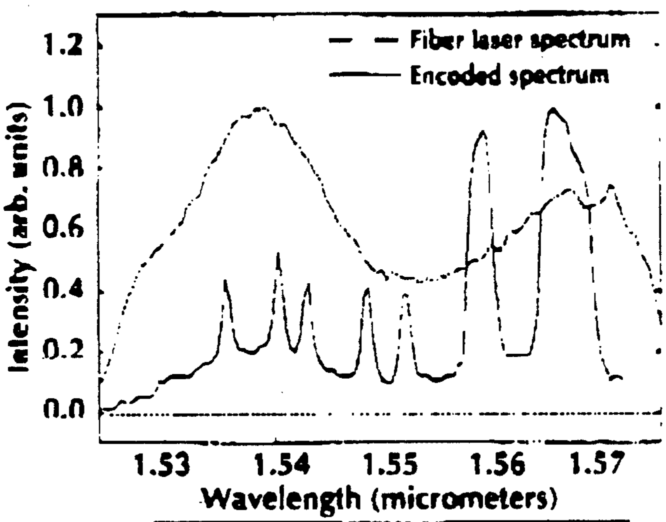


Figure 2

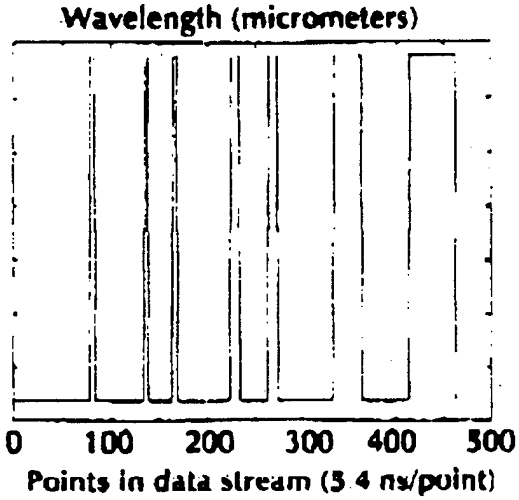
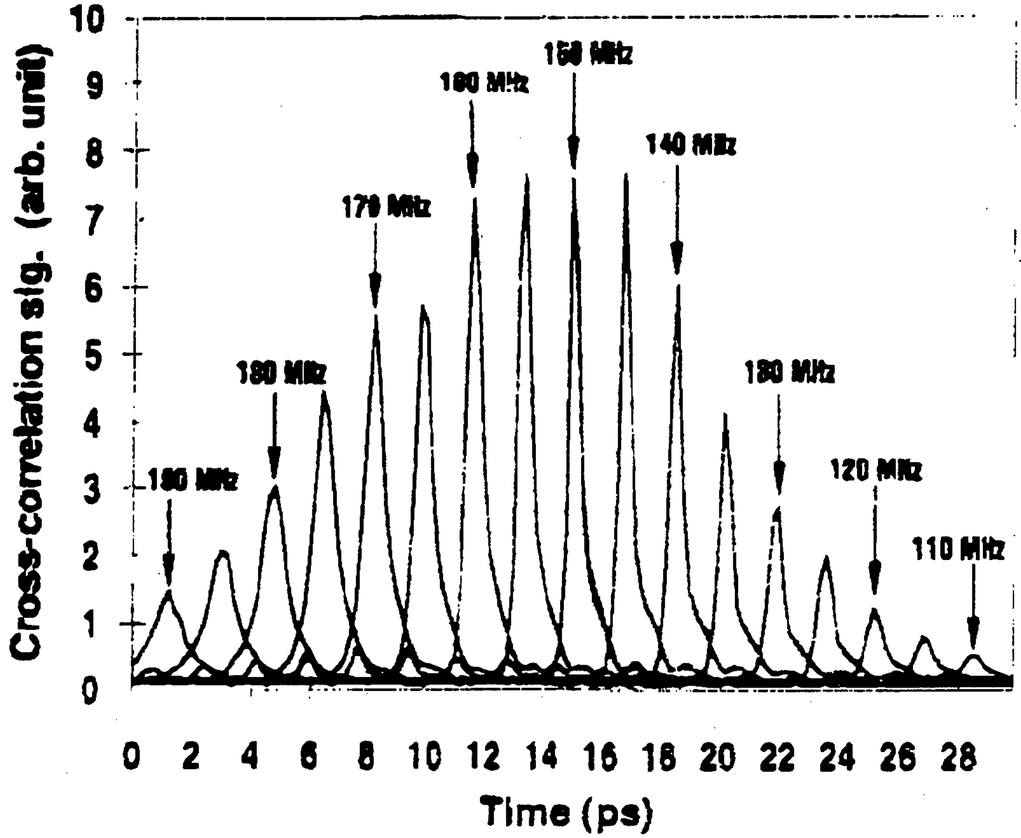


Figure 3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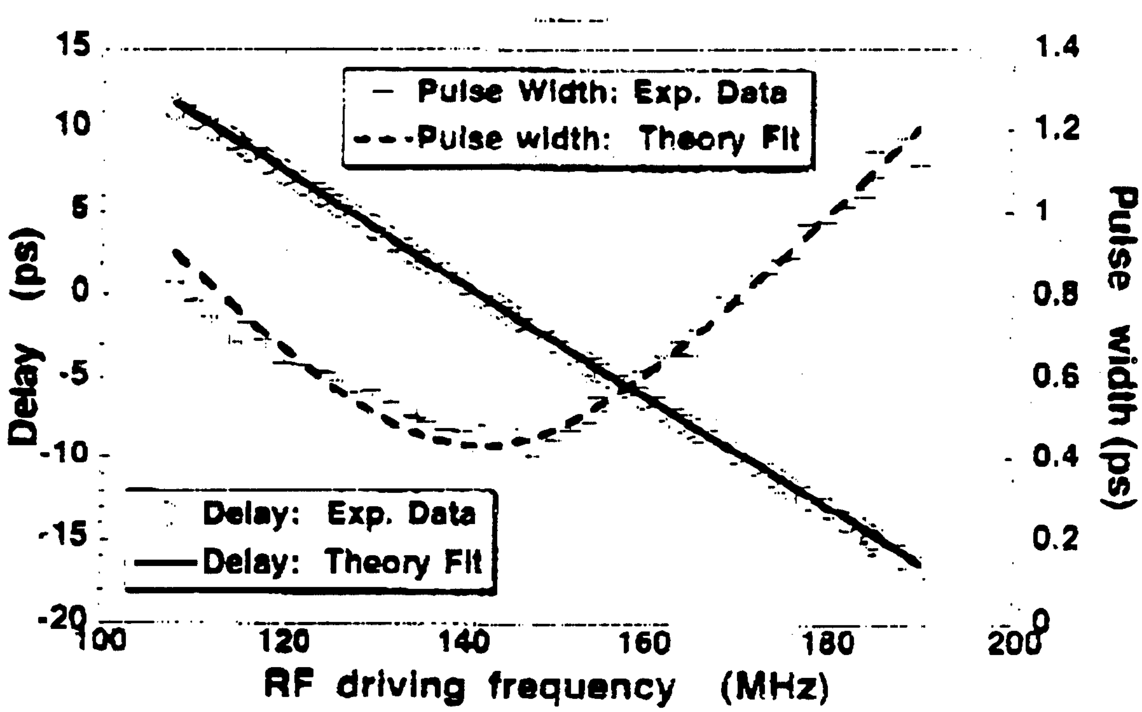
140 MHz
120 MHz
110 MHz
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Time (ps)


Pulse Width: Exp. Data
Pulse width: Theory Fit
Delay: Exp. Data
Delay: Theory Fit
Delay (ps)
15 10 5 0 -5 -10 -15 -20
Pulse width (ps)
1.4 1.2 1 0.8 0.6 0.4 0.2 0
100 120 140 160 180 200
RF driving frequency (MHz)

DURIP funding supported purchase of lasers with 1.5 μm output capability in both the Chemistry Department and the Engineering school, plus a range of equipment for pulse shape modulation and detection. FRI funding was started as a three-year, $1.5M project was started October 1, 1995. Unfortunately, Congressional action in the budget reconciliation process eliminated all funding for the Focused Research Initiative on September 30, 1996, including this and all other ongoing projects. Budgetary reallocations at DoD permitted restoration of partial funding, which terminated November 30, 1997. However, the State of New Jersey, through the newly-funded Center for Ultrafast Laser Applications (which I direct), will provide substantial funding (approximately $150,000 for the year beginning October 1, 1997) to keep this project going during the current funding lapse. The Center for Ultrafast Laser Applications (CULA), funded beginning October 1997 as a Center of Excellence by the New Jersey Commission on Science and Technology (first year funding $857,000), will exploit recent developments in "ultrafast laser systems" which generate intense laser pulses with durations from roughly 10 picoseconds to 10 femtoseconds. The Center will promote a wide variety of medical, chemical, analytical, and communications applications with breakthrough potential for New Jersey companies and for health care delivery in the state. CULA brings together nine research groups at Princeton University and one at NJIT, the two NJ universities with ultrafast research programs, with three groups at Rutgers and the University of Medicine and Dentistry of New Jersey, the universities with expertise in medical applications and fiber optic delivery systems. The Center leverages substantial existing state-of-the-art equipment and facilities, and includes strong connections with small, medium and large NJ-based companies. The four universities also provide financial support for CULA activities.

For the first year, two of the investigators on the DURIP project (Prucnal and I) will receive $250,000 in funding from State money; approximately 60% of this money will involve terabit communications activities. New Jersey State funding cannot replace Federal government support over the long term, but a proposal is currently pending with NSF to provide ongoing funding. The intent of State funding is to provide an academic infrastructure which supports industrial interactions and the creation of high-tech jobs in the region; obviously NSF's goals are far broader. I view this support as very substantial evidence, both that the State is willing to be an important partner in supporting academic research in this field, and that the goals of this project are both feasible and important.