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# Ultrafast Photonic Technologies for Ultra-wideband Communications, Instrumentation and Signal Processing

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The development of high speed communications interconnects and signal processing is critical for an information based economy. Lightwave technologies offer the promise of high bandwidth connectivity from component development that is manufacturable, cost effective, and electrically efficient. Most recently, the concept of optical frequency/wavelength division multiplexing has revolutionized methods of optical communications, however the development of optical systems using 100's of wavelengths present challenges for network planners. The development of compact, efficient optical sources capable of generating a multiplicity of optical frequencies/wavelength channels from a single device could potentially simplify the operation and management of high capacity optical interconnects and links. In addition, the potential for exploiting the coherent nature of light opens the possibility for spectrally efficient communications and signal processing.

Modelocked semiconductor lasers emit short (<1 picosecond) optical pulses at high pulse repetition frequencies (> 1 GHz) and can be utilized for a wide variety of applications, but are typically geared towards time domain applications, e.g., optical time division multiplexed optical links, optical sampling, etc. It is interesting to note that the periodic nature of optical pulse generation from modelocked semiconductor diode lasers also makes these devices ideal candidates for the generation of high quality optical frequency combs, or multiple wavelengths, in addition to the ultrashort temporally stable, high peak intensity optical pulses that one is accustomed to. The optical frequency combs enables a variety of optical communication and signal processing applications that can exploit the large bandwidth and speed that picosecond pulse generation implies, however the aggregate speed and bandwidth can be achieved by spectrally channelizing the bandwidth, and utilize lower speed electronics for control of the individual spectral components of the modelocked laser. This paper will highlight recent results in using modelocked semiconductor lasers for applications in networking, instrumentation and signal processing.

An example of the flexibility and utility of modelocked optical pulses/optical frequency combs in ultrahigh capacity communications and signal processing is shown in Figure 1. This figure shows 3 possibilities of how optical frequency combs can be used in: 1) analog or digital wavelength division multiplexed formats, 2) ultrahigh speed optical time division multiplexed formats and 3) optical code division multiplexed formats. The key aspects of this approach are to use the optical frequency comb source in three different modalities that exploit the fundamental nature of phase coherent optical frequency combs. These salient features are: 1) the short optical pulse duration generated (for OTDM formats), 2) the narrow linewidths and multiplicity of optical frequency components (for direct and coherent detection analog or digital WDM formats) and 3) the spectral phase coherence which will allow for frequency domain based coding techniques (for secure OCDMA formats).

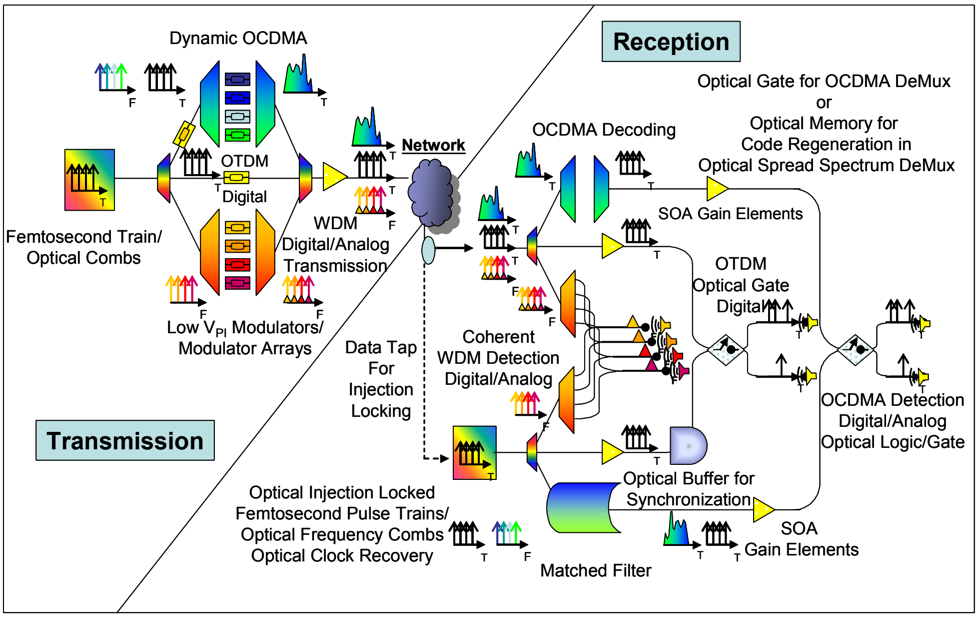


Figure 1. Schematic illustration of the use of optical frequency combs generated from a modelocked laser and their use in high data rate communication links.

This presentation will highlight our recent results in using modelocked semiconductor lasers for applications in networking, instrumentation and signal processing. We will show our recent results for ultrashort pulse generation, low timing jitter pulse for sampling and metrology, optical frequency combs for coherent communications, and the use of ultrafast semiconductor diode lasers for potential applications in nonthermal ablation and machining.

## References


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(S'79–M'94–SM'96–F'02) received the Ph.D. degree from the City University of New York in 1988 where his work focused on developing a real-time ultrafast spectroscopic probe to study molecular and phonon dynamics in condensed matter using optical phase conjugation techniques. He then joined Bell Communication Research as a Member of the Technical Staff, where he concentrated his efforts toward generating ultrafast high-power optical pulses from semiconductor diode lasers, for applications in applied photonic networks. Some of his technical accomplishments were the development of the world's fastest, most powerful mode-locked semiconductor laser diode, the demonstration of an optically distributed clocking network for high-speed digital switches and supercomputer applications, and the first observation of the optical nonlinearity induced by the cooling of highly excited electron-hole pairs in semiconductor optical amplifiers. He joined the faculty at the School of Optics and the Center for Research and Education in Optics and Lasers (CREOL), University of Central Florida, Orlando, in 1993 and currently holds the positions of University Trustee Chair Professor of Optics, Electrical and Computer Engineering, and Physics. He has published over 300 articles in refereed journals and conference proceedings and has been awarded 17 U.S. patents. Dr. Delfyett is a Fellow of the Optical Society of America, a Fellow of the IEEE Lasers and Electro-Optics Society (LEOS), and is a former member of the Board of Governors of IEEE LEOS. He is the Editor-in-Chief of the IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS and was an Associate Editor of IEEE PHOTONICS TECHNOLOGY LETTERS. While at Bellcore, he was the recipient of numerous awards for his technical achievements, including the Bellcore Synergy Award and the Bellcore Award of Appreciation. He is also the recipient of the National Science Foundation's Presidential Early Career Award for Scientists and Engineers (PECASE), which is awarded to the Nation's top 20 young scientists, the 1999 University Distinguished Researcher of the Year Award, the 2000 Black Engineer of the Year Award—Outstanding Alumnus Achievement, and the 2000 Excellence in Graduate Teaching Award. He was also the recipient of the University of Central Florida 2001 Pegasus Professor Award, which is the highest honor awarded by the University.