Lightwave Technology: An Update

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This issue of the *AT&T Technical Journal* is dedicated to lightwave technology and photonics. It is an update to the *Journal's* January/February 1987 issue, entitled "Lightwave Technology." In the five years that have passed, lightwave technology has revolutionized telecommunications. Its large-scale deployment has been accompanied by proven technical and operational success. At the same time, the tempo of advances has accelerated within the technology, producing rapid, extensive progress. Among the highlights of this issue are six topics not even mentioned in the forecasts of 1987: cable television (CATV) transmission, erbium-doped fiber amplifiers, quantum-well lasers, photonic integrated circuits, soliton propagation in fibers, and free-space digital optics. Although this issue cannot hope to tell the complete story of lightwave technology and photonics, the topics selected illustrate the pace of their progress.

Introduction

The field of lightwave technology and photonics has made major strides in the five years since our last report in the *AT&T Technical Journal.*[1] By 1987, the optical fiber had emerged as the medium of choice for transporting large amounts of information. Lightwave systems running at bit rates up to 1.7 gigabits per second (Gb/s) were deployed in metropolitan areas and between cities to connect central offices and major switching nodes. Lower-bit-rate systems (up to 90 megabits per second) were operated as subscriber loop carriers linking central offices to remote terminals in business and residential areas. Single-mode fibers with transmission losses as low as 0.2 decibel per kilometer (dB/km) were available commercially, but not on a routine basis; and high-performance semiconductor lasers with good reliability were being incorporated in systems under development.

The first undersea cable system was yet to be installed for service across the Atlantic Ocean. Lightwave technology was just beginning to arouse the interest of the CATV industry. Indeed, these first applications of lightwave systems exploited the unrivaled transmission bandwidth that the optical fiber has to offer at a lower cost compared to other media. In the meantime, the research community has been exploring the full potential of the fiber medium and of photonic devices, to increase transmission capacity, enhance network functionality, simplify operations, and lower cost. This issue is a continuing progress report of the research results and of the systems being developed for the intended applications.

Since 1987, progress has been so rapid and extensive that six of the topics highlighted in this issue were not even forecast in 1987: CATV transmission, erbium-doped fiber amplifiers, quantum-well lasers, photonic integrated circuits, soliton propagation in fibers, and free-space digital optics.

The story of lightwave technology and photonics has grown beyond the bounds of a single issue. The nine topics presented here can only give the reader an idea of the progress in this field. AT&T is also actively working on photonic local-area networks, optical interconnects, $LiNbO_3$ and semiconductor switch arrays, silicon optical-bench technology and passive components, advanced fiber technology, tunable semiconductor lasers, vertical-cavity lasers, optoelectronic integrated circuits (OEICs), and optoelectronic packaging. No doubt, by the time the next lightwave issue is prepared, we will be exploring topics not seriously considered at this time.

In This Issue

The papers in this issue illustrate the present uses and hint at the future direction of lightwave technology and photonics. P. K. Runge tells the story of the first lightwave system crossing the Atlantic, in 1988, and the completion of another system across the Pacific in 1989. He describes plans to use the new optical amplifier technology and to construct an extensive international communications network connecting population centers in Europe, North America, and the Pacific Rim.

On land, photonics has played a key role in the digitization of the U. S. long-haul network; the Federal Communications Commission (FCC) reports that more than 5 million miles of fiber have been installed in the U. S. FT-2000, an intelligent lightwave system with microprocessor-based control, is capable of operating in a sophisticated network environment. P. F. Deduck and S. R. Johnson describe terrestrial transmission in the form of the new FT-2000 lightwave transmission system, which will operate at 2.5 Gb/s, conforming to the new synchronous optical network (SONET) standards.

For short-haul transmission up to several kilometers, progress has been made on three fronts: P. P. Bohn et al. report on fiber in the loop (FITL); C. J. McGrath describes the potential of CATV trunk transmission; and D. J. Wasser gives an account of the advances in optical datalinks (ODL) for computer connections. In the loop, fiber-based feeder systems are being widely used, and the economic feasibility of bringing fiber to the curb or all the way to the home is being evaluated in trial installations.

Lightwave systems for CATV are relative newcomers. The use of analog amplitude modulation in lightwave systems increases cost-effectiveness and promises to expand the bandwidth and performance of current coaxial television distribution networks.

The emergence of the erbium-doped fiber amplifier (EDFA) represents one of the most surprising and rapid advances in lightwave technology. The paper by J. L. Zyskind et al. describes how, in less than three years, EDFA technology has advanced from its infancy in the laboratory to a prototype stage ready for trial applications in the marketplace. Its simplicity, high gain, and near-ideal noise properties are destined to have a significant effect on future lightwave systems.

The paper on EDFAs is one of several dealing with recent technological advances. J. E. Geusic et al. describe quantum-well lasers based on crystalline layers approximately 100 angstroms thick, which create potential wells that confine the carriers in the semiconductor device. Because of their superior performance, quantum-well lasers are expected to become the preferred semiconductor laser for advanced lightwave systems. T. L. Koch and U. Koren relate how photonic integrated circuits (PICs) use quantum-well laser technology to integrate and provide waveguide connections for such diverse devices as lasers, modulators, optical amplifiers, detectors, and couplers on a single semiconductor chip.

Free-space photonics is an emerging technology that exploits the spatial bandwidth available in the optical domain. In their paper, H. S. Hinton and D. A. B. Miller explore the use of free-space photonics as a high-density optical interconnect for large-dimensional digital switching fabrics.

We hope that the papers in this issue will help the reader experience the excitement created by the rapid growth of photonics, stimulate new concepts and applications in communications networks, and spur the creation of new applications.

Reference

1. *AT&T Technical Journal issue on Lightwave Technology,* January/February 1987, Vol. 66, No. 1.

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