Introduction to Optical Fiber Communications

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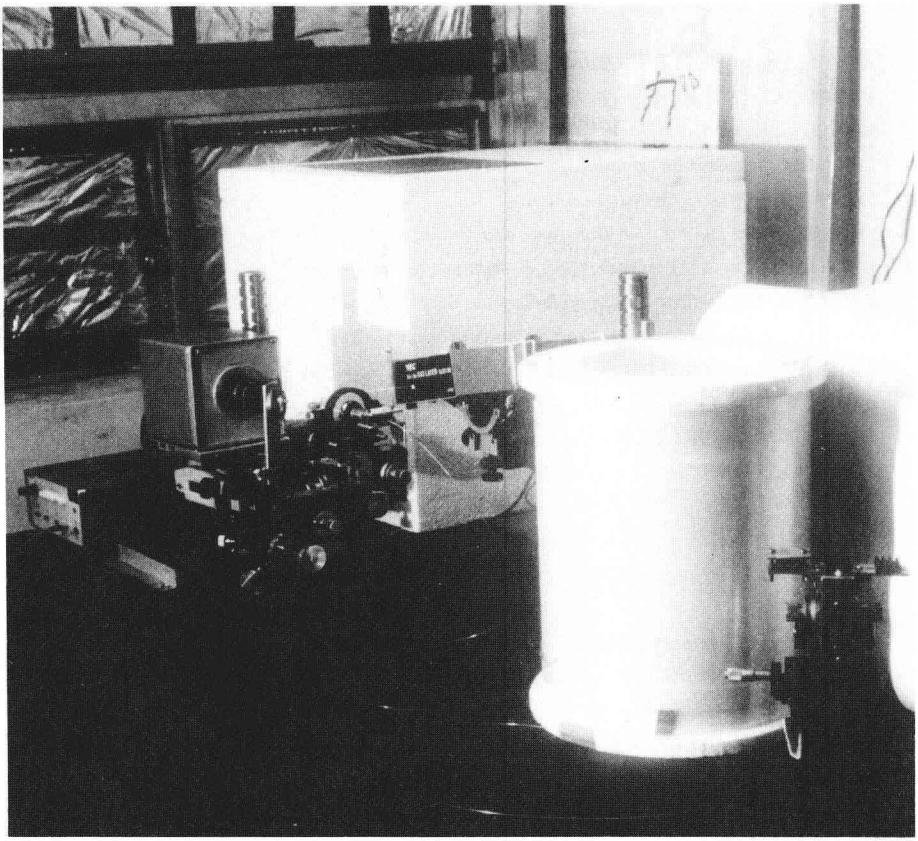

Light from a He-Ne laser is injected into the optical fiber (about 1 km is wound on the drum shown on the right-hand side) used as the transmission line of the optical communication system, and the output, which is only slightly attenuated, is radiated (right-hand side). The semiconductor laser oscillator is on the left.

History of Optical Communication

?	Greece	Observation of light guiding in a piece of glass
?	Venice	Decorative flowers made of glass fibers
1609	Galileo (Italy)	Galileian telescope
1626	Snell (Holland)	Snell's law
1668	Newton (UK)	Reflection telescope
1870	Tyndall (UK)	Light guiding in a thin water jet
1873	Maxwell (UK)	Prediction of electromagnetic waves
1888	Hertz (Germany)	Confirmation of existence of electromagnetic waves and their oneness with light
1897	Rayleigh (UK)	Analysis of a waveguide
1899	Marconi (Italy)	Radio communication (UK-Continent)
1902	Marconi (Italy)	Invention of radio detector
1910	Hondros and Debye (Germany)	Analysis of the dielectric waveguide
1930	Lamb (Germany)	Experiments with a silica fiber
1936–1940	USA	Communication using a waveguide
1951	Heel, Hopkins, and Kapany (UK)	Image transmission by optical fiber bundles
1958	Goubau et al. (USA)	Experiments with the lens guide
1958–1959	Kapany et al. (UK)	Optical fiber with cladding
1960	Maiman et al. (USA)	Operation of ruby laser
1960	Javan et al. (USA)	Operation of He-Ne laser
1961	Kapany and Snitzer (UK)	Mode analysis of an optical fiber
1962	USA	Operation of the semiconductor laser
1964	Goubau and Christian (USA)	Light guidance with periodic lenses
1966	Kao and Hockham (UK)	Suggestion of using optical fibers for long-distance transmission

1969	Uchida et al. Kawakami and Nishizawa	Graded-index optical waveguides
1970	Kapron and Keck (USA)	Fiber transmission loss of 20 dB/km
1972	Ogilvie and Esdaile (Australia)	Liquid-core fibers
1972	Gambling et al. UK)	Gigahertz bandwidth over 1 km
1975	Payne and Gambling (UK)	Prediction of zero material dispersion at 1.3 μm
1976	Horiguchi and Osanai (Japan)	Fiber transmission loss of 0.47 dB/km at 1.3 μm
1978	Gambling and Matsumura (UK)	Zero first-order dispersion in single-mode fibers
1979	Miyashita et al. (Japan)	Fiber loss of 0.2 dB/km at 1.55 μm
1979	Shimada et al. (Japan)	Fiber transmission over 100 km
1981	Beales et al. (UK)	Dispersion of less than 4 ps/km in single-mode fiber

Preface to the English Edition

The rate at which the technology of optical fiber communication is advancing continues unabated. Our understanding of the materials used, the number of fiber types available, and the range of applications continues to increase. Every year a new milestone in low attenuation or larger bandwidth seems to be attained, and the flow of publications has reached such a flood that few individuals can keep up with it. This means on the one hand that an authoritative, simple, but expert, introductory text is badly needed, but on the other that such a book is difficult to write. There is a great temptation to delay publication so that the latest results can be included, but if this approach is followed in such a fast-moving field as optical communications there is a danger that the manuscript will never be ready for publication.

In the present case the same dilemma faces the translator and editor, namely whether to change the Japanese text to take into account major recent advances. It is also necessary to consider how to make such changes without unduly superimposing our own views and styles. Another concern is whether we, who may be experts in optical communication but are not linguists, have rendered correctly the sense and intention of the authors without losing some subtleties of meaning in the transcription from Japanese to English, especially as these two languages are so different in style and construction.

In fact some changes have been made, mainly to the text but also to a few figures. We hope that suitable compromises have been reached and that the modifications and additions are, on the whole, beneficial. It seemed to us essential that the appeal of the Japanese version of this excellent introductory book by Professor Suematsu and Professor Iga, with its emphasis on physical and graphical explanations and a minimum of mathematical complexity, should be preserved. It has already run to eight editions and has been the subject of an award by the Institute of Electronics and Communication Engineers of Japan.

We would like to thank H. Osanai and co-authors of reference 314, and T. Miya and co-authors of reference 353, as well as the editor of *Electronics Letters*, for allowing us to include Figure 5.3 and Figure 7.7, respectively, in the English edition. A considerable debt of gratitude is owed to Mrs. Janet Ditchfield, who typed several versions of the manuscript from handwritten scribblings, and performed much tedious but skilled work with the diagrams, as well as many other organizational tasks. Miss Nicki Pink has given similar invaluable assistance. Our grateful thanks also go to Mr. Issei Sasaki, Dr. M. J. Adams, and Commander R. S. Broom, who kindly provided most helpful comments on various parts of the manuscript.

W. A. GAMBLING
H. MATSUMURA

Preface to the First Japanese Edition

This is a textbook about optical communications using the optical fiber and is intended for students and younger scientists who will shoulder the responsibility for its future progress. The present stage of development of the principles of the optical waveguide, the operating principles and characteristics of optical sources such as the semiconductor laser and the light-emitting diode, modulation methods, optical detectors, optical circuits, characteristics of the optical fiber transmission line, and the optical information-transmission systems are discussed.

In a broad sense, the use of light for communication purposes began with the appearance of the first human beings. However, it is better to say that, during their existence, human beings have learned to make use of light very efficiently. Since the laser was invented in 1960, engineers have paid increasing attention to light as a means of information transmission, since it is capable of adaptation to the highly sophisticated requirements of modern civilization. The real possibility of widespread industrial application arose from the development after 1970 of small and efficient semiconductor lasers as well as low-loss optical fibers.

From the research carried out during these recent years, the optical fiber has been shown to be an information transmission line of very large capacity and to have a lower attenuation than any other transmission line. Optical fiber communication is a newly developed technique that has received considerable attention all over the world and has progressed very rapidly indeed.

The authors are fortunate in having been engaged in research in this field right from the beginning and have reported their results frequently in a number of journals.

The authors are grateful to those researchers who willingly gave us

permission to use their results and who provided photographs and figures. The authors also express grateful thanks to Mr. Mori and Mr. Kuwayama of the Ohm publishing company for their encouragement.

Y. SUEMATSU
K. IGA

Preface to the Fourth Japanese Edition

The rapid progress in optical communication since the first edition was published has resulted in so many publications that our eyes have become strained in trying to read them all. As well as steady progress in all parts of the field, advances have especially taken place in the development of long-wavelength lasers and in wavelength multiplexing communication systems. Therefore, these topics, several references, and a few Appendixes, have been added. We wish to acknowledge our gratitude to a number of readers who drew our attention to errors and misprints.

Y. SUEMATSU
K. IGA

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