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Editorial

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Optical Fibers, Applications and Developments

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Introduction

A fiber-Optic cable is made up of incredibly thin strands of glass or plastic known as optical fibers; one cable can have as few as two strands or as many as a several hundred. Each strand is less than a tenth as thick as a human hair and can carry something like 25000 telephone calls, so an entire fiber optic cable can easily carry several million calls.

Fiber optic technology has advanced at an astonishing pace during the last three decades. This technology is fast becoming a major part of telecommunications infrastructure in many countries around the World. Fiber optics is now an indispensable requirement of high data rate and long haul communication systems, particularly the Internet. The applications of fiber optic technology, however are not limited to information transmission systems. A significant amount of research and development work has also been devoted to other applications such as sensors for measurement of temperature, pressure, magnetic field, etc.., medical diagnostic and operation tools, delay lines in phased array antennas and a host of industrial instrumentation. This special issue of Laser and Optics Technology addresses the latest development on specialty optical fibers as well as some novel sensor applications.

Working of Fiber Optics

Light travels down a fiber-optic cable by bouncing repeatedly off the walls. Each tiny photon bounces down the pipe like a bobsleigh going down an ice run propagating not less than 42 degrees. This phenomenon is called Total Internal Reflection which keeps the light inside the pipe.

Developments in Optical fibers

The papers presented in this issue may be divided into two groups :

1. One group addressing the analysis and design of optical fibers with unique transmission properties and
2. Another group discussing several sensor applications.

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Design of Optical fibers

The first paper by Mastuura., examines et al. examines hollow fibers as a means of high power laser delivery for medical applications. These fibers can be used in surgery, dentistry and dermatology, to name a few. Transmission properties, fabrication techniques, and power launching mechanisms are addresses. The proposed hollow fiber designs cover a wide range of wavelengths from Ultraviolet to far infrared. The second paper by Baghdadi et al. proposes an advanced fiber design for terabit communications over long distances. Refractive-index nonlinearity and polarization-mode dispersion have been recognized as the ultimate factors limiting the information carrying capacity of long-haul fiber optic communication links. The authors in this paper present a single-mode fiber design that, in addition to low bending loss and small dispersion slope, provides large effective area and minimizes the polarization-mode dispersion due to fiber ellipticity in the 1.55 m window. Furthermore, their design allows a small chromatic dispersion in order to reduce four-wave mixing effects in wavelength division multiplexed systems. This dispersion can be managed by alternating positive and negative-dispersion fibers or may be cancelled by using dispersion compensating fibers or devices.

Sensor Applications

The next two papers focus on issues pertaining to sensor applications of optical fibers. Fiber Bragg gratings have emerged as robust, reliable, and cost effective devices for both communication and sensor applications. The first paper, In this group by Chan et al. studies crosstalk effects in fiber Bragg grating sensor arrays using time division multiplexing. They report that the detection sensitivity of the sensor is limited by the extinction ratio of the input pulse modulation. The sensor performance can be improved significantly by properly modulating the laser wavelength. Recently, fiber optic sensors have found important applications in power transmission systems. The next paper by Deng and coworkers proposes a fiber optic sensor system for on-line detection of partial discharge in high-power transformers. Partial discharges occur due to degradation of the transformer oil and may result in catastrophic failures. The sensor system includes an extrinsic Fabry–Perot interferometer, which detects the acoustic signals generated by the partial discharge in power transformers. The authors describe the sensor design and present the experimental results to support the feasibility of the proposed sensor for detection of partial discharges in power transformers.

Applications

Fiber optic cables find many uses in a wide variety of industries and applications. Some uses of fiber optic cables include:

Medical

Used as light guides, imaging tools and also as lasers for surgeries

Defense/Government

Used as hydrophones for seismic waves and SONAR , as wiring in aircraft, submarines and other vehicles and also for field networking.

Data Storage

Used for data transmission

Telecommunications

Fiber is laid and used for transmitting and receiving purposes.

Networking

Used to connect users and servers in a variety of network settings and help increase the speed and accuracy of data transmission.

Industrial/Commercial

Used for imaging in hard to reach areas, as wiring where EMI is an issue, as sensory devices to make temperature, pressure and other measurements, and as wiring in automobiles and in industrial settings.

Broadcast/CATV

Broadcast/cable companies are using fiber optic cables for wiring CATV, HDTV, internet, video on-demand and other applications.

Novel silica-based optical fibers

silica optical fiber doped with special elements including Bi, Al, and Ce, a nd micro-structured multi-core fibers. Fiber optic cables are used for lighting and imaging and as sensors to measure and monitor a vast array of variables. Fiber optic cables are also used in research and development and testing across all the above mentioned industries.

Conclusions

Although, fiber optic technology has matured to high levels of sophistication and many issues have been seemingly resolved, there still remain many research opportunities, often hidden, that need be explored. Further research on optical fibers will undoubtedly lead to innovative devices and novel applications. Optical fibers and fiber devices and sensors are expected to remain an active area of research for years.