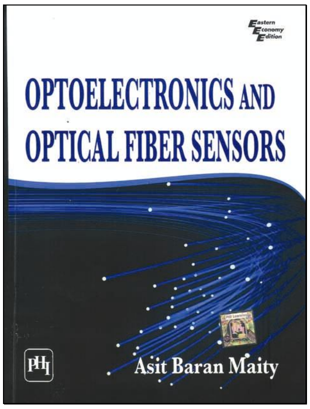

Optoelectronics and Optical Fiber Sensors. Asit Baran Maity. Prentice-Hall of India Pvt Ltd, 111, Patparganj Industrial Estate, Delhi 110 092. 2013. 280 pp. Price: Rs 220.00.

Development of optical fibre technology has been a major driver behind the tremendous progress on global telecommunications, which enabled instant access to the internet and search engines like *Google* in recent years. Low-loss silica-based optical fibres have been one of the key components for this phenomenal growth, which has been recognized through award of Nobel Prize in Physics for 2009 to Charles Kao for ground-breaking achievements concerning the transmission of light in fibres for optical communication. The Nobel Foundation press release said that 'if we were to unravel all of the glass fibres that wind around the globe, we would get a single thread over one billion kilometres long, which is enough to encircle the globe more than 25,000 times … and is increasing by thousands of kilometres every hour.' Colladon demonstrated for the first time in 1841 in Geneva, the phenomenon of light guidance or confinement in a medium through total internal reflections by guiding a beam of light in a flowing water jet. Similar observations were made by Babinet in France even in a bend rod of glass. At the suggestion of Michael Faraday, in 1854, John Tyndall demonstrated the same phenomenon at the Royal Society. Applications of light guides in medical science, e.g. in gastroscope in the form of glass fibre bundles for image transmission were talked about and attempted since early 1920s. However, a major problem was that these could not be used for light transmission through longer distance as the fibres were unclad and light would rapidly leak out as well as suffer scattering at any abrasions on the glass surface. It was Hopkins and Kapany from Imperial College, London, who proposed in a paper in *Nature* in 1954 for the first time, a bundle of thin glass-clad glass core fibre in order to substantially reduce the leakage loss of the transmitted light. However Kao and Hockham at the then Standard Telecommunications in England, were the first to focus attention in mid-1960s on material properties of glass from the viewpoint of optical transmission medium. They reported their findings in a landmark paper in the *Proceedings of Institute of Electrical Engineers* in 1966. They suggested that if glasses could be purified from impurities like iron, chromium, vanadium and water, which are normally prevalent in conventional glasses, and also operate at a relatively longer wavelength to reduce scattering losses like Rayleigh, which vary as inverse fourth power of the wavelength, glass optical fibres should be a potential signal transmission medium for long-distance optical communication provided the transmission loss in the fibre can be brought down to below, 20 dB/km at the operating frequency, a figure typically encountered in coaxial metallic cables. In simple terms, a 20 dB/km loss would imply that after 1 km, the output power is 100 time less than the input power. Taking a cue from this landmark paper, a group of scientists led by physicist Robert Maurer at the Corning Glass Works, USA started working on achieving this target of 20 dB/km loss in silica glasses by following a radically different fabrication route namely, chemical vapour deposition technology extensively used by the semiconductor industries. In 1970, they succeeded in attaining 17 dB/km losses at the He–Ne laser wavelength of 632.8 nm. Indeed it was the first report of a really low-loss optical fibre that paved the way for rapid introduction of fibre optics in optical communication technology. The transmission loss in present-day optical fibres is about 0.2 dB/km (at the wavelength of 1550 nm), which implies a transmission loss of only about 4% after 1 km. An immediate consequence is that for almost 60–80 km in such high-quality optical fibres, one would not require any amplifier to compensate for signal loss.

As in any communication system, in addition to the signal transmission medium, one requires a transmitter and a receiver in an optical communication system. Transmitter and receiver involve the subject of optoelectronics – the former performs conversion from analog to digital electrical signals, which get transformed to equivalent optical signals before the same is transmitted through an optical fibre, while the reverse process of conversion from optical to electrical takes place in a receiver once the signals reach the end of the fibre. Thus for a proper understanding and appreciating the overall optical communication system, a student is required to know basics of topics like optics, semiconductors, optical fibres, lasers, optoelectronic receivers, and so on. During the mid-1970s low-loss technology of optical fibres for telecommunication was evolving at a rapid pace concomitantly with reliable operation of semiconductor laser diodes (suitable for direct modulation with signals through their electronic drive circuits) at room temperature for long hours as well as availability of high-efficiency semiconductor-based photo detectors.

In addition to its extensive use in telecommunication, optical fibre-based sensing has also evolved over the last three decades as a burgeoning field of research with a host of applications in many diverse areas, including medical diagnostics. Optical techniques have long played an important role in instrumentation and sensors for non-contact measurements and sensing. Some of the key advantages and potentials offered by optical fibres in sensing and instrumentation are: being dielectric sensed signal transported through it is immune to electromagnetic interference and radio frequency interference, intrinsically safe in explosive environments, occupies very low volume and weight, optical fibres can be designed to function either as radiation (nuclear)-resistant or radiation-sensitive, can be easily interfaced with low-loss telecommunication-grade optical fibres, and hence enable remote sensing, in which the sensor head could even be tens of kilometres away from the signal processing end. In this context, in view of its inherently large transmission bandwidth, a fibre sensor could be used to multiplex a large number of individually addressed point sensors in a long fibre network (e.g. monitoring health of civil structures) and hence offer distributed sensing, i.e. continuous sensing along the length of the sensing fibre, which is possibly the biggest advantage of fibre optic sensors. Furthermore, these sensors could be readily employed in chemical process and biomedical instrumentation due to their small size, mechanical flexibility and chemical inertness. These advantages led to the development of a variety of fibre optic sensors for accurate sensing and measurement of physical parameters and fields, e.g. pressure, temperature, liquid level, liquid refractive index, liquid pH, antibodies, electric current, rotation, displacement, acceleration, acoustic, electric and magnetic fields. Initial developmental work had concentrated predominantly on military applications like fibre optic hydrophones for submarine and under-sea applications and gyroscopes for applications in ships, missiles and aircraft. Gradually, a large number of civilian applications have also begun. Researchers soon realized that the transmission characteristics of optical fibres exhibited strong sensitivity to certain external perturbations like bends, microbends, pressure, etc. An alternate school of thought took advantage of these observations and focused on exploiting these sensitivities of optical fibres to external effects, which would essentially represent a variety of measurands to configure a large variety of sensors and instruments. This off-shoot of optical fibre telecommunication soon witnessed a flurry of R&D around the world to use optical fibres for sensing. Today, fibre optic sensors play a major role in industrial, medical, aerospace and consumer applications.

This book addresses most of the above-mentioned topics and provides a broad-based coverage, albeit mostly very brief, except for some in reasonable details. It contains a total of 9 chapters spread over 253 pages. The first chapter is titled 'Prospects of optics, optoelectronics and fibre optic sensors'. The chapter title is a misnomer in my opinion, as there is no discussion on fibre optic sensors. Moreover, essentially this chapter covers basic principles of optics and also functional principles of external modulation of light via electro-optic, acousto-optic, magneto-optic schemes as is required for understanding the subsequent chapters, which contain optoelectronic components and devices. Chapter 2 discusses physics of bandgap in a semiconductor – both doped and undoped – followed by some of the technological processes to grow optoelectronic devices. On p. 41, a section has been sub-titled as 'Photoresisting'; however, no such word exists. It should have simply been 'Photoresist coating' in the context of photolithography. An important issue as to the roles of a positive or negative photoresist is missing here. This should be discussed possibly in a future edition of the book. Likewise, mask fabrication process with an e-beam has been missed out. Light–matter interaction forms the content of the next chapter, especially with semiconductors in reasonable details. Optoelectronic display devices are also discussed in this chapter. Two chapters that follow contain descriptions on LEDs and lasers of various types. Applications of lasers are covered briefly at the end of the chapter. Chapter 6 is devoted to photodetectors and chapter 7 to optical fibres. On p. 139, resistance as a function of luminance (lux) is given with numerical values, but the adjacent figure for relative sensitivity with wavelength is a schematic one. Again on p. 144, in the figure for responsivity versus wavelength, responsivity scale is left unnumbered although wavelength scale is numbered. I would have liked to see a plot that would contain responsivity versus wavelength, for different detector materials for comparison and wavelength windows over which different materials function as a detector. The chapter ends with a discussion on optocouplers useful in high voltage isolation. In Chapter 7 where fibre optics is discussed, the descriptions lack rigour and are a bit sketchy. Single-mode fibres are completely ignored, which is a surprise because multimode fibres are rarely used in modern optical communication. As a consequence waveguide dispersion has been missed. Reference to figure 7.10 is missing and likewise in several other places, the author has missed referring to original reference while presenting figures. Guided mode of a fibre as representing one kind of rays is misleading. Ray optical results and wave optical results under WKB approximation merge in case of multimode fibres. But for single mode or very low moded fibres, one cannot relate mode to a ray. In the fibre technology section, figures appear to have been either taken from original references or redrawn after those references; somehow the references are not cited. Section 7.7.2 is too sketchy and a student would not be able to understand the functional principle of these components. Chapters 8 and 9 are devoted to describing fibre optic sensors. In figure 8.1, input and output optocouplers are shown in the generic diagram for such a sensor. The same term 'optocoupler' was used earlier in the chapter on photodetectors. I believe the author did not mean these to be same in the context of coupling of light from a source to a fibre or from fibre to detector. While describing the beam splitter, it would have been more appropriate to use a diagram to show the functioning of a cube beam splitter. Temperature sensor based on Raman scattered light is discussed in the light of relying on optical time domain reflectometry, but OTDR technique/instrument is not discussed in the book. In chapter 9, fibre sensors for special applications are discussed, including hydrophones, rotation sensors based on Sagnac interferometers, fibre optic electric current sensors, chemical and biosensors based on long-period fibre grating and the contemporary topic of surface plasmon-based sensors.

Overall the book touches on a variety of topics, all of which are of interest to the scientific community in the broad area of optoelectronics. In the preface the author himself mentions that the main theme of the book is fibre-optic sensor systems, which are covered in two chapters only exclusively devoted to this topic. Also mentioned in the preface is that the aim has been to write a textbook on this subject area. It has indeed been a good effort, but I would not completely agree that it can be really used as a textbook, unless each sub-topic or device is covered with more rigour and depth, including underlying algebra. It could be good reference book on fibre optic sensors, which needs to be amplified to make it a classroom text. The book provides a good exposure for those who wish to get a quick feel of the field. I would recommend that the author could think of a future edition with more focus on only the components, which are useful in configuring a variety of fibre optic sensors and leave out communication applications to be covered in another independent book.

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