Brainwave: A Multidisciplinary Journal, Vol. 2, No. 2, December 2021, pp. 315-318 © Brainware University

Review Article on Fiber Optics

Jayanta Aich
Department of Computer Science and Engineering,
Braiware University, Barasat, Kolkata 700125, India,
E-mail: aichjayanta9@gmail.com

The benefits of communication have to be extended to rural areas in order to provide better education, better medical advices/treatments etc. In this context, it is essential that the devices to be employed should have the capacity of transmission of large information traffic. It deserves mentioning in this connection that optical fiber posseses low attenuation loss around 0.15dB/Km and high bandwidth to the extent of a few tera bytes. This is why optical communication system has emerged as an indispensable item for long distance communication. The concerned operating wavelength ranges between 1.3μm and 1.6μm, since optical fiber made of silica has the lowest attenuation loss at 1.55μm while its material dispersion vanishes around the wave length 1.3μm.

With the invention of semiconductor laser and optical fiber, the life style of every person living on the planet has undergone a massive change. The huge bandwidth in optical fiber communication system is the key for providing tele education, tele medicine, tele health, agricultural knowledge etc. to rural population. In fact, fiber optic cables are presently crisscrossing oceans, deserts, mountains etc., to communicate the advanced information to the rural population.

Moreover, it is desirable that in respect of fiber to source coupling, maximum efficiency will be delivered both in field of sensor and communication as well. In this respect micro lenses grown on fiber tips have been found to be most efficient. In fact, the grown micro lenses should be ideal in respect of coupling, if it does not permit spherical aberration, it has large aperature to collect the entire incident light and it matches both laser and fiber modes. In view of the stated criteria, hyperbolic micro lens on the tip of single mode fiber has been found to be most suitable and in fact it has produced nearly 100% theoretical coupling efficiency. But the fabrication of hyperbolic micro lens on the fiber tip requires costly laser micro machining technique. This is why hemispherical microlens in spite of its moderate efficiency is being used worldwide as it can be fabricated easily by simple photolithographic process. In fact tremendous interests have been generated to design different leasing systems for maximizing source to fiber coupling. Tapered lenses of different designs drawn on fiber ends are also being employed in the technology of coupling optics. Further, inherent mismatch losses for different coupling devices are studied in order to predict the tolerance of the concerned device with respect to the offsets. Side by side, refractive index profile of the fiber is also being monitored in order to match the fiber spot size with the laser spot size for maximum coupling optics. Thus coupling optics involve presentation of new projects taking care of polarization maintained fibers as well as nonlinearity. Accordingly reports of such investigation are being added to the literature continuously.

Moreover Er doped fiber amplifier, fiber Raman Amplifier etc., are replacing electronic amplifier whereby the tedious process of E/O conversion and O/E conversion is avoided and things are thus implemented fast since velocity of light exceeds velocity of electron. Here lies the merit of all optical technology.

References:

[1] John J, Maclean TSM, Ghafouri-Shiraz H, Niblett J. Matching of single-mode fibre to laser diode by microlenses at 1.5–1.3 μm wavelength. IEE Proc: Optoelectron 1994;141:178–184.

[2] Neumann EG. Single-mode fibers fundamentals. Berlin: Springer-Verlag, 1988.

[3] Edwards CA, Presby HM, Dragone C. Ideal microlenses for laser to fiber coupling. J Lightwave Technol 1993;11:252–257.

[4] Presby HM, Edwards CA. Efficient coupling of polarization maintaining fiber to laser diodes. EEE Photonics Techn Lett 1992;4:897–899.

[5] Edwards CA, Presby HM. Coupling-sensitivity comparison of hemispheric and hyperbolic microlens. App Opt 1993;32:1573–1577.

[6] Mondal SK, Gangopadhyay S, Sarkar SN. Analysis of an upside- down taper lens end from a single-mode step-index fiber. Appl Opt 1998;37:1006–1009.

[7] Yuan L, Qui A. Analysis of a single-mode fiber with taper lens end. J Opt Soc Am 1992;A9:950–952.

[8] Mondal SK, Sarkar SN. Coupling of a laser diode to singlemode fiber with an upside-down tapered lens end. Appl Opt 1999;38:6272–6277.

[9] Yuan LB, Shou RL. Formation and power distribution properties of an upside-down tapered lens at the end of an optical fiber. Sens Actuators 1990;A23:1158–1161.

[10] Lie Y. Theoretical analysis of tapered fiber microlens parameter and its new fabricating technique. IEEE Int Conf Comput Appl Syst Modeling 2010;13:448–451.

[11] Sankar SP, Hariharan N, Varatharajan R. A novel method to increase the coupling efficiency of laser to single mode fiber. Wireless Personal Commun 2016;87:419–430.

[12] Das B, Maiti AK, Gangopadhyay S. Laser diode to single-mode circular core dispersion-shifted/dispersion- flattened fiber excitation via hyperbolic microlens on the fiber tip: Prediction of coupling efficiency by ABCD matrix formalism. Optik 2014;125:3277–3282.

[13] Das B, Middya TR, Gangopadhyay S. Mismatch considerations in excitation of single-mode circular core parabolic index fiber by laser diode via upside down tapered hemispherical microlens on the tip of the fiber. J Opt Commun 2016. DOI: 10.1515/joc-2016-0043.

[14] Gangopadhyay S, Sarkar SN. Laser diode to single-mode fibre excited via hyperbolic lens on the fibre tip: Formulation of ABCD matrix and efficiency computation. Opt Commun 1996;132:55–60.

[14] Gangopadhyay S, Sarkar SN. ABCD matrix for reflection and refraction of Gaussian light beams at surfaces of hyperboloid of revolution and efficiency computation for laser diode to single-mode fiber coupling by way of a hyperbolic lens on the fiber tip. Appl Opt 1997;36:8582–8586.

[15] Mukhopadhyay S, Sarkar SN. Coupling of a laser diode to single mode circular core graded index fiber via hyperbolic microlens on the fiber tip and identification of the suitable refractive index profile with consideration for possible misalignments. Opt Engg 2011;50:1–9.

[16] Gangopadhyay S, Sarkar SN. Misalignment considerations in laser diode to single-mode fibre excitation via hyperbolic lens on the fibre tip. Opt Commun 1998;146:104–108.

[17] Sarkar S, Thyagrajan K, Kumar A. Gaussian approximation of the fundamental mode in single mode elliptic core fibers. Opt Commun 1984;49:178–183.

[18] Marcuse D. Gaussian approximation of the fundamental modes of graded index fibers. J Opt Soc Am 1978;68:103–109.

[19] Ghatak AK, Thygarajan K. Introduction of fiber optics.Cambridge, NY: Cambridge University Press, 1998.

[20] Yang H-M, Huang S-Y, Lee C-W, Lay T-S, Cheng W-H. High coupling tapered hyperbolic fiber microlens and taper asymmetry effect. J Lightwave Tech 2004;22:1395–1401.

[21] Presby HM, Benner AF, Edwards CA. Laser microlensing of efficient fiber microlenses. Appl Opt 1990;29:2692–2695.

[22] Thyagarajan K, Kakkar C. S-band single-stage EDFA with 25-dB gain using distributed ASE suppression. IEEE Photonics Technol Lett 2004;16:2448–2450.

[23] Pramanik S, Das G, Sarkar S. Comparative study of the influence of the aspect ratio of trapezoidal index profiles on the performance of a fiber Raman amplifier. Opt Eng 2010;49:055001(1–3).

[24] Burdin V.A, Bourdine A.V, Volkov K.A, Spectral characteristics of LP11 mode of step index optical fiber with Kerr nonlinearity, Opt. Technol. in Telecommun., 10774 (2018), 107740N. DOI: 10.1117/12.2318982.

[25] Nesrallah M, Hakami A, Bart G, McDonald C.R, Varin C, Brabec T, Measuring the Kerr nonlinearity via seeded Kerr instability amplification: conceptual analysis, Opt. Express, 25 (2018), 7646-7654.

[26] Patra P, Gangopadhyay S, Sarkar S.N, Confinement and excitation of fundamental mode in single mode graded index fibers of low V number: Estimation by a simple technique, J. Opt. Commun., 22 (2001), 166–171.

[27] Sadhu A, Karak A, Sarkar S.N, A simple and effective method to analyze the propagation characteristics of nonlinear single mode fiber using Chebyshev method, Microw. Opt. Technol. Lett., 56 (2013), 787–790.

[28]Chakraborty S, Mandal C.K, Gangopadhyay S, Prediction of fundamental model field for graded index fiber in the presence of Kerr nonlinearity, J. Opt. Commun. DOI: 10.1515/joc-2017-0126.

[29] Brehler M, Schirwon M, Göddeke D, Krummrich P.M, Modelling the Kerr-Nonlinearity in ModeDivision Multiplexing Fiber Transmission Systems on GPUs, Advanced Photonics, JTu5A-27 (2018). DOI:10.1364/BGPPM.2018.JTu5A.27.

[30] Ekici M,Mirzazadeh M, Sonmezoglu A, Zhou Q, Triki H, Ullah M.Z, Biswas A, Optical solitons in birefringent fibers with Kerr nonlinearity by exp-function method, Optik, 131 (2017), 964-976.

[31] Le S. T, Aref V, Buelow H, Nonlinear signal multiplexing for communication beyond the Kerr nonlinearity limit, Nature Photonics, 11 (2017), 570.

[32] Manafian J, Lakestani M, Application of tan (ϕ/2)-expansion method for solving the Biswas–Milovic equation for Kerr law nonlinearity, Optik, 127 (2016), 2040-2054.

[33] Liu Z., Wright L.G, Christodoulides D.N, Wise F.W, Kerr self-cleaning of femtosecond-pulsed beams in graded-index multimode fiber, Opt. Lett. , 41(2016), 3675-3678.