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Performance Transmission Analysis of Micro Strip Lines and its Characteristics

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Abstract*— This paper has presented the characteristic impedance and signal propagation delay time for both surface and embedded microstrip lines that comprise a conducting strip line with width w, thickness t of conductivity σ, on a substrate of thickness h, relative permittivity εr, relative permeability It is observed that the characteristic impedance depends mainly upon the ratio of stripline width to its substrate height.

Keyword*— Surface microstrip, Embedded microstrip, Signal propagation delay, Characteristic impedance, and Dielectric materials.

I. INTRODUCTION

Modified microstrip lines are used to achieve performance goals that can not be obtained using simple, uniform structures [1, 2]. They are categorized according to their physical dimensions, structures, substrate materials, ground plane configurations, and conductor shapes. The historical base of micro line (ML) was a coaxial line, which provides a dominant mode with zero cutoff frequency, low loss, and a very wide bandwidth. However, this line makes it difficult and expensive to create passive and active transmission line based components and devices. The first attempt to overcome this disadvantage was the rectangular coaxial line with strip center conductor. The next step was removing the side walls and extending the top and bottom ground planes, with the result called the stripline (SL). The next modification of transmission line involved removing the top ground plane and the top dielectric substrate. That modified structure was named the microstrip line. The ML is transmission line geometry with a single conductor trace on one side of the substrate and a single ground plane on the other side. The developments of ML are summarized in [3, 4]. The evaluation of MLs began in 1952 when the microstrip line was introduced [5]. During the past 40 years, ML has played a key role in the growth of new radio frequency (RF) and microwave applications. Right now, ML is more popular than SL, but SL is still essential for RF and microwave components having high-Q, low dispersion, and wide frequency range. Also, various printed transmission lines are in use [6].

Today, electromagnetic propagation on multiple parallel transmission lines has been a very attractive area in computational electromagnetic. Multiple parallel transmission lines have been successfully applied and used by designers in compact packaging, semiconductor device, high speed interconnecting buses, monolithic integrated circuits, and other applications. Microstrip lines are the most commonly used in all planar circuits despite of the frequencies ranges of the applied signals. Microstrip lines are the most commonly used transmission lines at high frequencies. Quasi-static analysis of microstrip lines involves evaluating them as parallel plates transmission lines, supporting a pure “TEM” mode. Development in microwave circuits using rectangular coaxial lines as transmission medium has been improving over the past decades [7]. Advances in microwave solid-state devices have stimulated interest in the integration of microwave circuits. Today, microstrip transmission lines have attracted great attention and interest in microwave integrated circuit applications. This creates the need for accurate modeling and simulation of microstrip transmission lines. Due to the difficulties associated with analytical methods [8] for calculating the capacitance of shielded microstrip transmission lines, other methods have been applied. Such methods include finite difference technique, extrapolation, point-matching method, boundary element method, spectral-space domain method, finite element method [9], conformal mapping method [10], transverse modal analysis [11], and mode-matching method [12].

II. MODELING ANALYSIS

Microstrip lines are the most commonly used transmission lines at high frequencies. Modeling and simulation of microstrip lines becomes essential technique to investigate.

II.1. SURFACE MICROSRTIP LINE

The signal propagation delay time and characteristic impedance for this type can be described by [13]:

$$T_{pd} = 0.654 x 10^{-4} \sqrt{0.475 \varepsilon_r + 0.67} \quad \text{ns/mm} \qquad (1)$$

$$Z_0 = \left(87/\sqrt{\varepsilon_r + 1.41}\right) \ln\left(5.98h/(0.8w + t)\right) \quad \Omega \qquad (2)$$

Equations. (1, 2) can be rewritten as a function of refractive index n, where n=$(\varepsilon_r)^{0.5}$as the following formulas:

$$T_{pd} = 0.654 x 10^{-4} \sqrt{0.475\, n^2 + 0.67} \quad \text{ns/mm} \qquad (3)$$

$$Z_0 = \left(87/\sqrt{n^2 + 1.41}\right) \ln\left(5.98h/(0.8w + t)\right) \Omega \qquad (4)$$

II. 2. EMBEDDED MICROSRTIP LINE

The signal propagation delay time and characteristic impedance for this type can be described by [14]:

$$T_{pd} = 0.654 x 10^{-4} \sqrt{\varepsilon_r} \quad \text{ns/mm} \qquad (5)$$

$$Z_0 = \left(60/\sqrt{\varepsilon_r}\right) \ln\left(4h/0.67\pi(0.8w + t)\right) \quad \Omega \qquad (6)$$

Equations. (5, 6) can be rewritten as a function of refractive index n, where n=$(\varepsilon_r)^{0.5}$as the following formulas:

$$T_{pd} = 0.654 x 10^{-4} n \quad \text{ns/mm} \qquad (7)$$

$$Z_0 = (60/n) \ln\left(4h/0.67\pi(0.8w + t)\right) \quad \Omega \qquad (8)$$

For different selected materials based both micro strip lines, the investigation of both the thermal and spectral variations of the effective refractive index require empirical equation. The set of parameters required to completely characterize the temperature dependence of the refractive index is given below, Sellmeier equation is under the form [15-17]:

$$n = \sqrt{A_1 + \frac{A_2\lambda^2}{\lambda^2 - A_3^2} + \frac{A_4\lambda^2}{\lambda^2 - A_5^2} + \frac{A_6\lambda^2}{\lambda^2 - A_7^2}} \;, \qquad (9)$$

Where the Sellemeier coefficients for Silicon (Si), Silicon germanium (SiGe), and gallium arsenide (GaAs) are listed in the following Table 1. Where T is the ambient temperature, and T_0 is the room temperature respectively.

Table 1: Sellemeier coefficients for different selected materials based micro strip lines [15-17].

Coefficients	Si	SiGe	GaAs
A_1	1	1	8.95
A_2	0.6063 (T/T_0)	0.10543 (T/T_0)	2.054 (T/T_0)
A_3	14.6 $(T/T_0)^2$	443.26 $(T/T_0)^2$	0.390
A_4	2.5426 (T/T_0)	54.526 (T/T_0)	0.0
A_5	0.04512 $(T/T_0)^2$	0.00052 $(T/T_0)^2$	0.0
A_6	0.549 (T/T_0)	12.54 (T/T_0)	0.0
A_7	5.43203 $(T/T_0)^2$	0.0543 $(T/T_0)^2$	0.0

III. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

The model has presented surface and embedded micro strip lines characteristic impedance and its signal propagation delay in optical transmission regions under the set of the wide range of the operating parameters as shown in Table 1 is listed below.

Table 1: Proposed operating parameters in different micro strip lines [5, 8, 12, 18].

Operating parameters	Value
Ultra violet optical signal wavelength, λ_{UV}	200 nm-400 nm
Visible optical signal wavelength, λ_V	400 nm-700 nm
Near infrared optical signal wavelength, λ_{NIR}	700 nm-1600 nm
Stripline thickness, t	0.1 mm
Ambient temperature, T	300 K–400 K
Stripline width, w	0.3 mm
Strip line height, h	1.6 mm

Based on the model equations analysis, assumed set of the operating parameters as listed in the Table 1 above, and based on the series of the figs. (1-12), the following facts are assured:

Figs. (1-6) have assured that signal delay time for both surface and embedded micro strip lines increase with increasing both operating optical signal wavelength and ambient temperature variations for different materials based micro strip lines under considerations. It is observed that surface micro strip line has presented lower signal propagation delay time for different materials based this type in compared to embedded micro strip line.

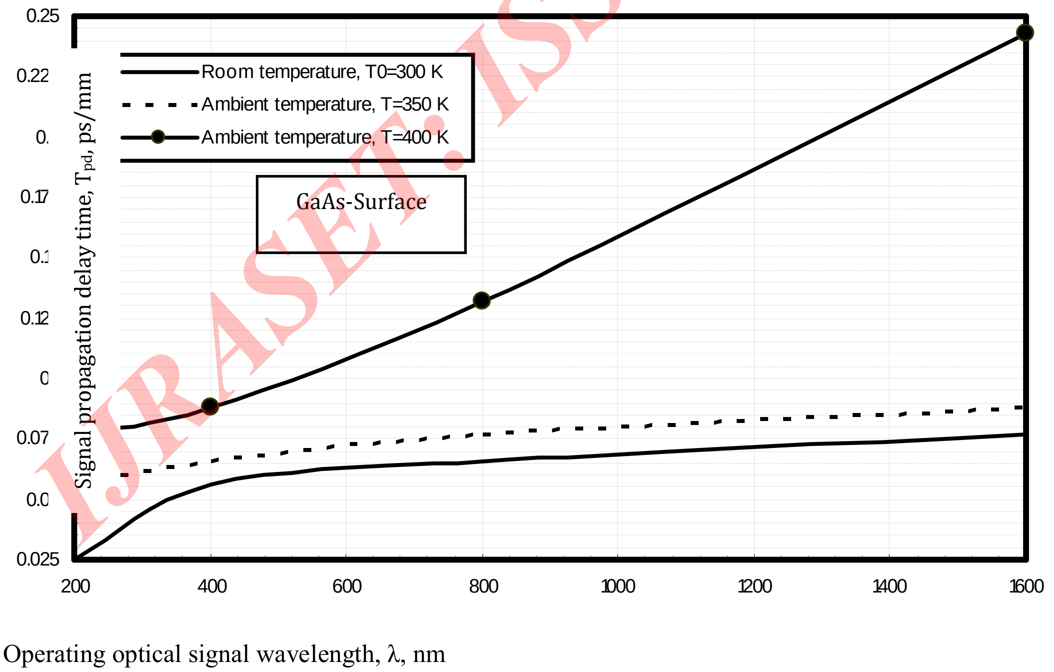
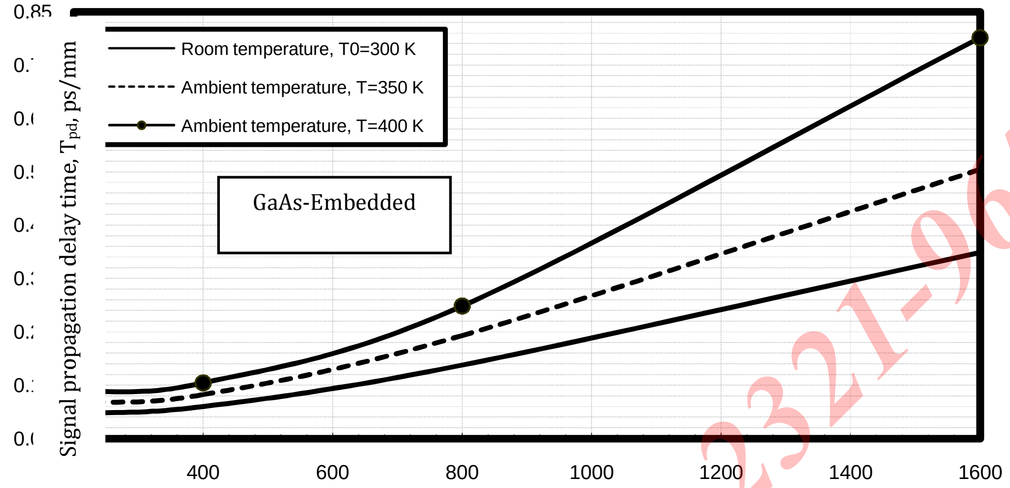
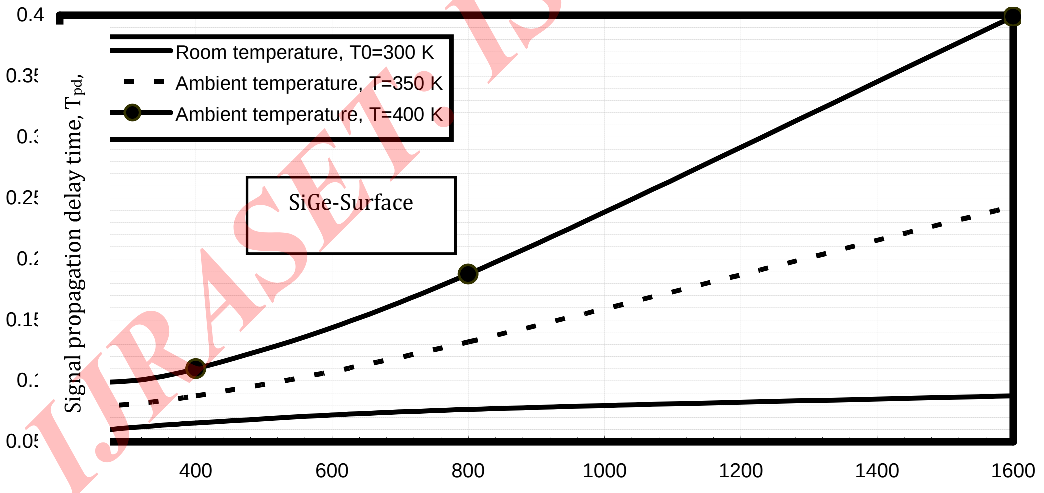


Fig. 1. Signal propagation delay time in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



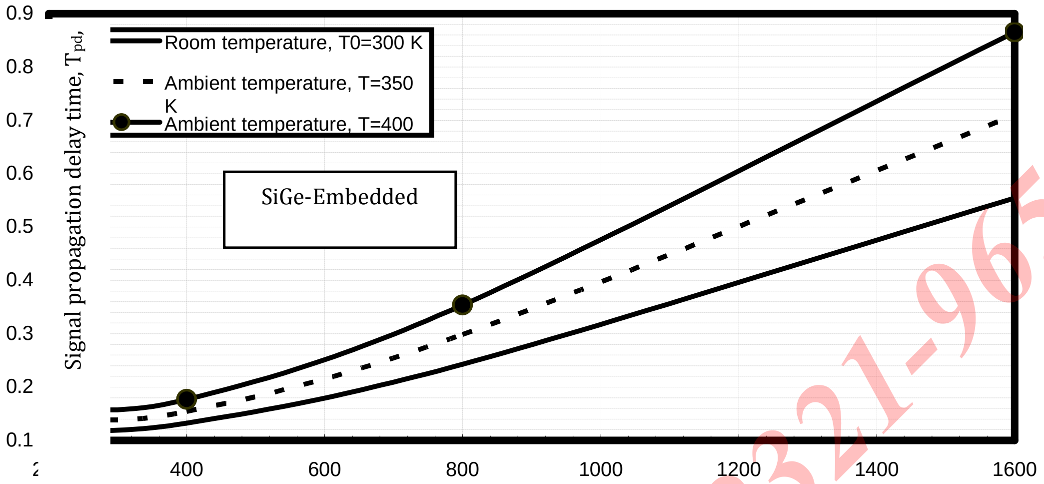
Operating optical signal wavelength, λ, nm

Fig. 2. Signal propagation delay time in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



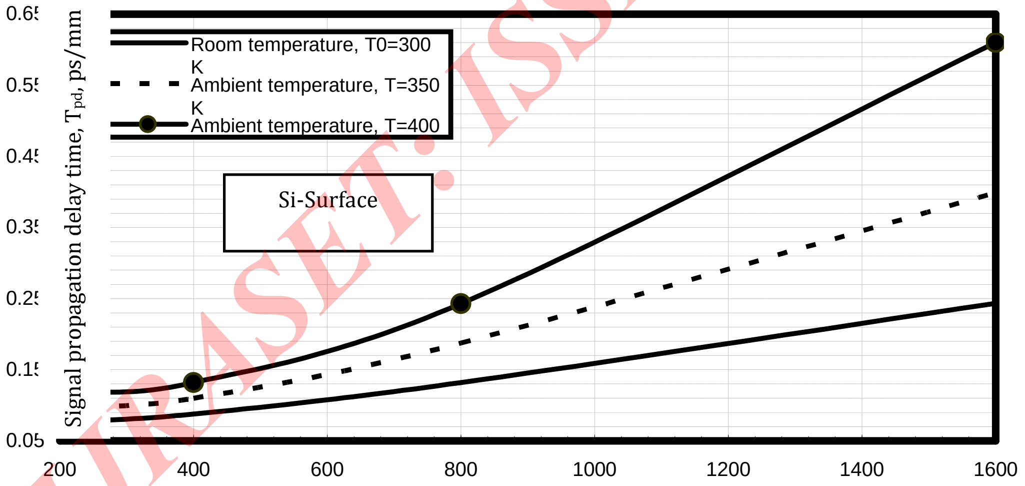
Operating optical signal wavelength, λ, nm

Fig. 3. Signal propagation delay time in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



Operating optical signal wavelength, λ, nm

Fig. 4. Signal propagation delay time in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



Operating optical signal wavelength, λ, nm

Fig. 5. Signal propagation delay time in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.

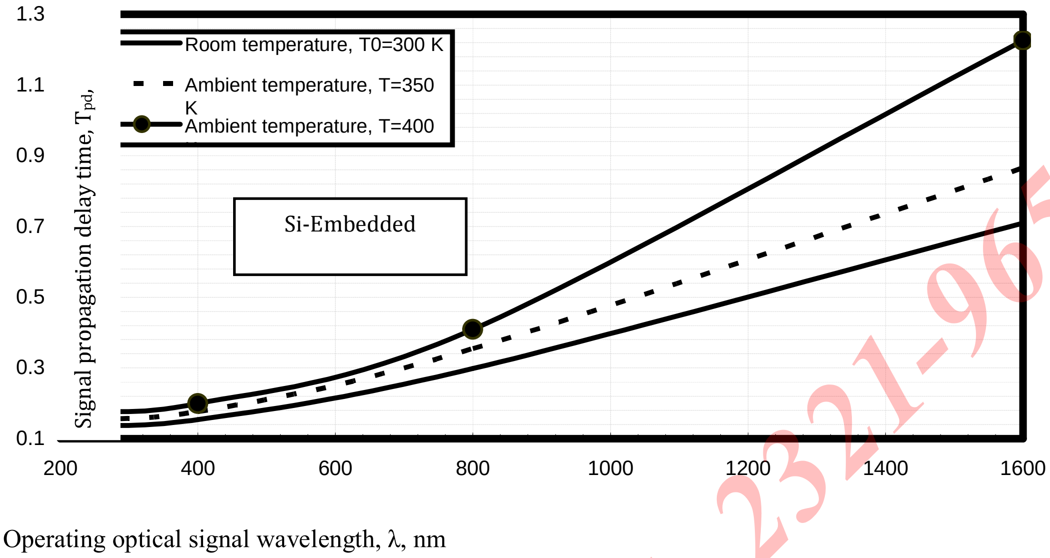


Fig. 6. Signal propagation delay time in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.

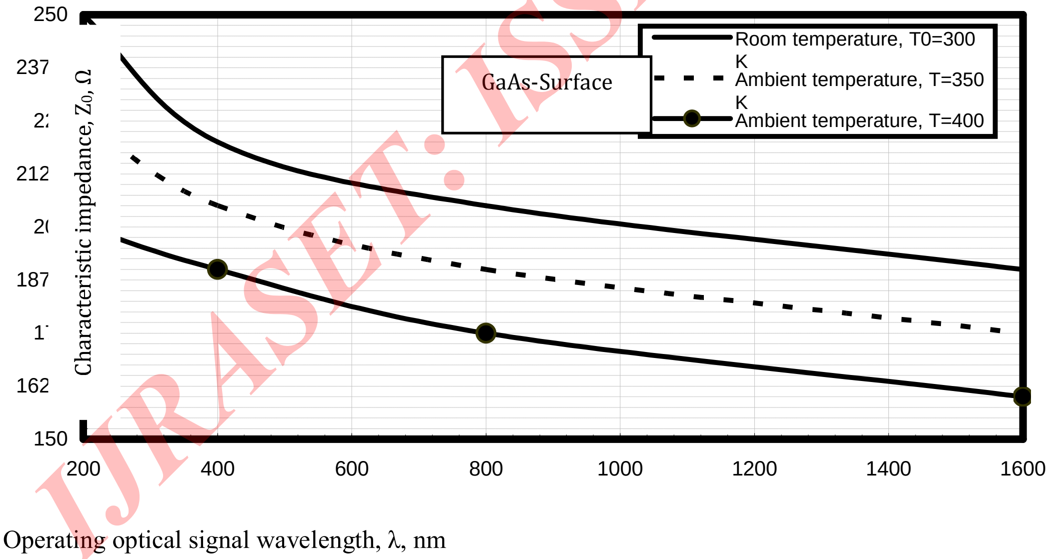
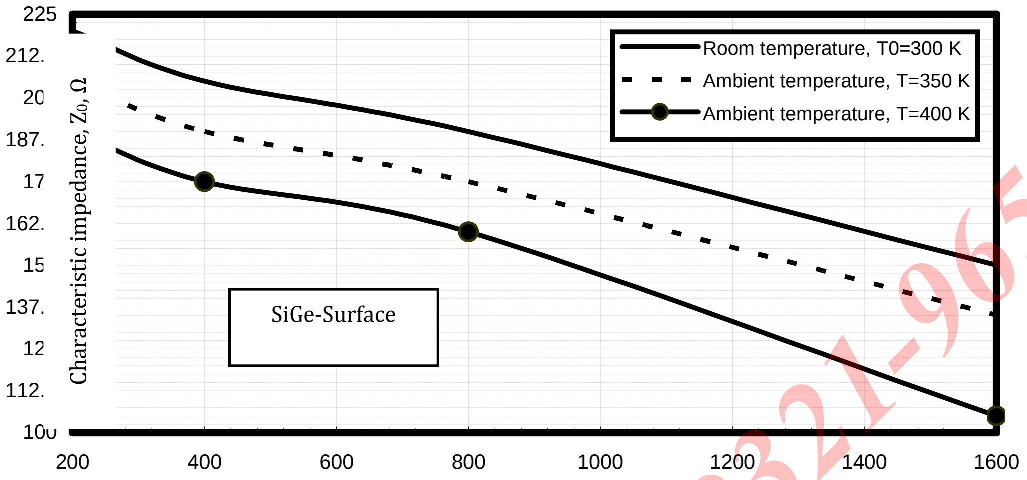
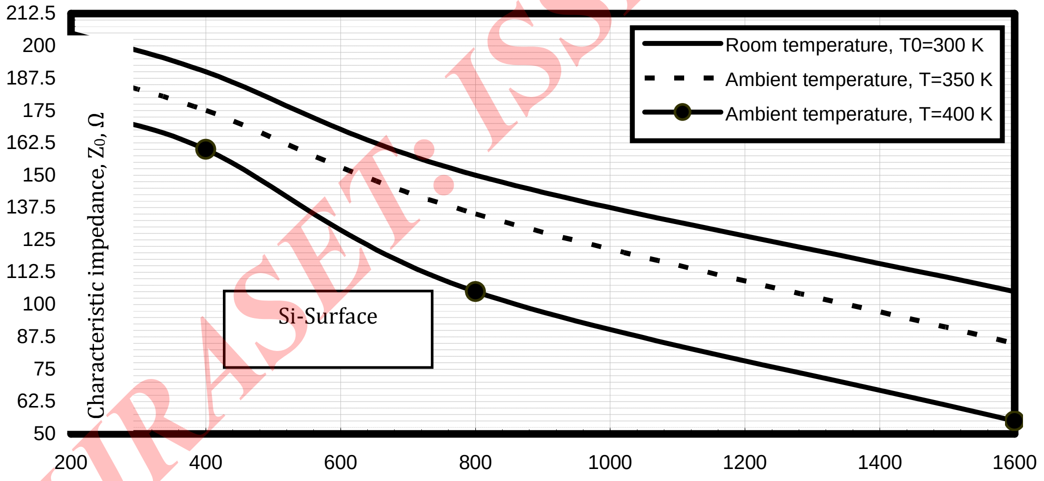


Fig. 7. Characteristic impedance in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



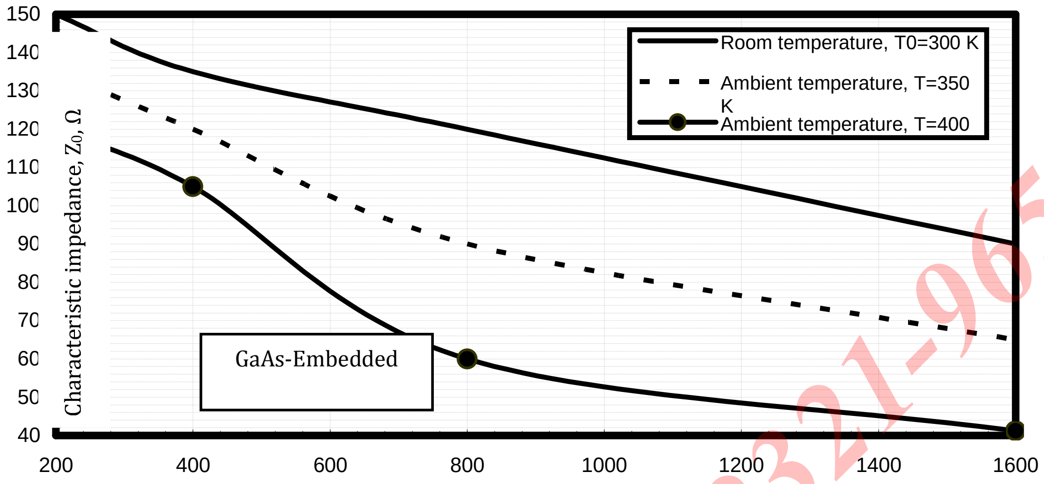
Operating optical signal wavelength, λ, nm

Fig. 8. Characteristic impedance in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



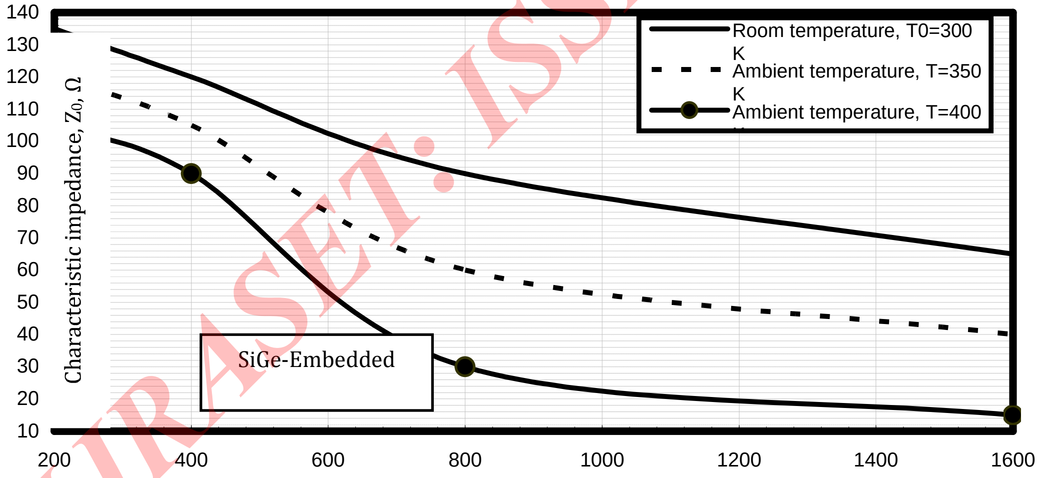
Operating optical signal wavelength, λ, nm

Fig. 9. Characteristic impedance in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



Operating optical signal wavelength, λ, nm

Fig. 10. Characteristic impedance in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.



Operating optical signal wavelength, λ, nm

Fig. 11. Characteristic impedance in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.

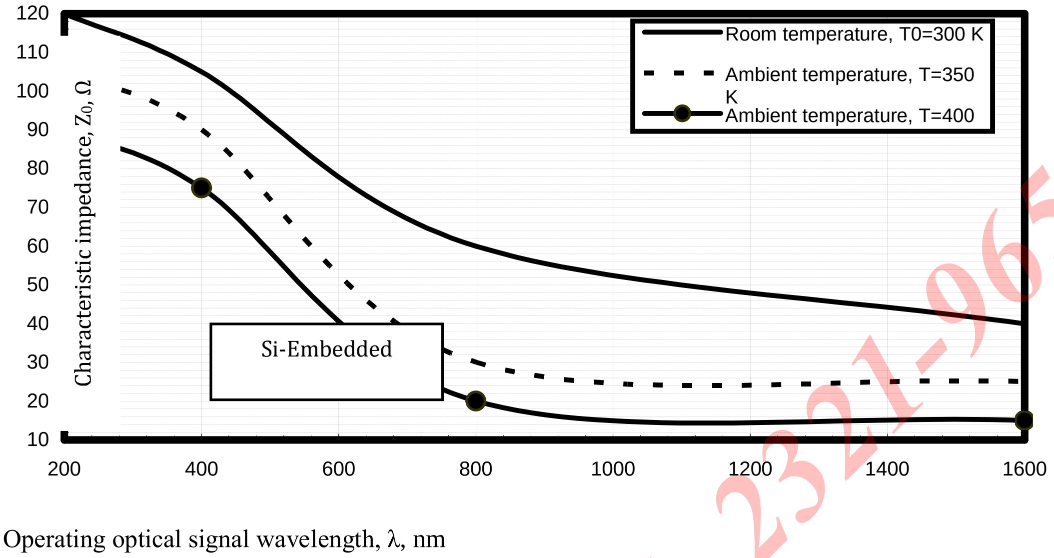


Fig. 12. Characteristic impedance in relation to operating optical signal wavelength and ambient temperature variations at the assumed set of the operating parameters.

Figs. (7-9) have indicated that characteristic impedance decreases with increasing both spectral and thermal variations for different materials based surface micro strip line. Moreover it is indicated that Si based surface micro strip line has presented the lowest characteristic impedance compared to other materials based this micro strip type.

Figs. (10-12) have indicated that characteristic impedance decreases with increasing both spectral and thermal variations for different materials based embedded micro strip line. Moreover it is indicated that Si based embedded micro strip line has presented the lowest characteristic impedance compared to other materials based this micro strip type.

Figs. (7-12) have indicated that characteristic impedance of surface micro strip line has present higher values than embedded micro strip line type under the same operating conditions and materials based these types.

IV. CONCLUSIONS

In a summary, the model has been investigated to show the dramatic effects of spectral and thermal variations on both surface and embedded micro strip lines performance transmission operation. It is theoretically found that signal propagation delay time within embedded micro strip lines have presented higher time delays for different materials based this type in compared with surface micro strip lines. Characteristic impedance and signal propagation delay times are taken into account for these micro strip lines under sturdy considerations in optical transmission spectrum regions.

REFERENCES

[1] M. L. Crawford, “Generation of standard EM fields using TEM Transmission cells,” IEEE Transactions on. Electromagnetic Compatibility, vol. EMC-16, pp. 189-195, Nov. 1974.

[2] J.R. Reid and R.T. Webster,” A 60 GHz branch line coupler fabricated using integrated rectangular coaxial lines,” Microwave Symposium Digest, 2004 IEEE MTT-S International, Vol. 2, pp.41 - 444 , 6-11 June 2004.

[3] S. Xu and P. Zhou, “FDTD analysis for satellite BFN consisting of rectangular coaxial lines,”Asia Pacific Microwave Conference, pp. 877-880, 1997.

[4] J. G. Fikioris, J. L. Tsalamengas, and G. J. Fikioris,” Exact solutions for shielded printed microstrip lines by the

Carleman-Vekua method", IEEE Transactions on Microwave Theory and Techniques, Vol. 37, No. 1, pp. 21-33, Jan. 1989.

[5] S. Khoulji and M. Essaaidi," Quasi-Static analysis of microstrip lines with variable-thickness substrates considering finite metallization thickness", Microwave and Optic Technology Letters, Vol. 33, No. 1, pp. 19-22, April. 2002.

[6] T.K. Seshadri, S. Mahapatra, and K. Rajaiah," Corner function analysis of microstrip transmission lines", IEEE Transactions on Microwave Theory and Techniques, Vol. 28, No. 4, pp. 376-380, April. 1980.

[7] S.V. Judd, I. Whiteley, R.J. Clowes, and D.C. Rickard," An analytical method for calculating microstrip transmission line parameters", IEEE Transactions on Microwave Theory and Techniques, Vol. 18, No. 2, pp. 78-87, Feb. 1970.

[8] N. H. Zhu, W. Qiu, E. Y. B. Pun, and P. S. Chung," Quasi-Static analysis of shielded microstrip transmission lines with thick electrodes", IEEE Transactions on Microwave Theory and Techniques, Vol. 45, No. 2, pp. 288-290, Feb. 1997.

[9] T. Chang and C. Tan," Analysis of a shielded microstrip line with finite metallization thickness by the boundary element method," IEEE Transactions on Microwave Theory and Techniques, Vol. 38, No. 8, pp. 1130-1132, Aug. 1990.

[10] G. G. Gentili and G. Macchiarella," Quasi-Static analysis of shielded planar transmission lines with finite metallization thickness by a mixed spectral-space domain method", IEEE Transactions on Microwave Theory and Techniques, Vol. 42, No. 2, pp. 249-255, Feb. 1994.

[11] A. Khebir, A. B. Kouki, and R. M. Mittra," Higher order asymptotic boundary condition for finite element modeling of two-dimensional transmission line structures", IEEE Transactions on Microwave Theory and Techniques, Vol. 38, No. 10, pp. 1433-1438, Oct. 1990.

[12] G. W. Slade and K. J. Webb," Computation of characteristic impedance for multiple microstrip transmission lines using a vector finite element method", IEEE Transactions on Microwave Theory and Techniques, Vol. 40, No. 1, pp. 34-40, Jan. 1992.

[13] M. S. Alam, K. Hirayama, Y. Hayashi, and M. Koshiba,"Analysis of shielded microstrip lines with arbitrary metallization cross section using a vector finite element method", IEEE Transactions on Microwave Theory and Techniques, Vol. 42, No. 11, pp. 2112-2117, Nov. 1994.

[14] J. Svacina," A new method for analysis of shielded microstrips", Proceedings of Electrical Performance of Electronic Packaging, pp. 111-114, 1993.

[15] Ahmed Nabih Zaki Rashed, "High reliability optical interconnections for short range applications in high performance optical communication systems," Optics and Laser Technology, Elsevier Publisher, Vol. 48, pp. 302–308, 2013.

[16] Ahmed Nabih Zaki Rashed, "Performance signature and optical signal processing of high speed electro-optic modulators," accepted for publication in Optics Communications, Elsevier Publisher, 2013.

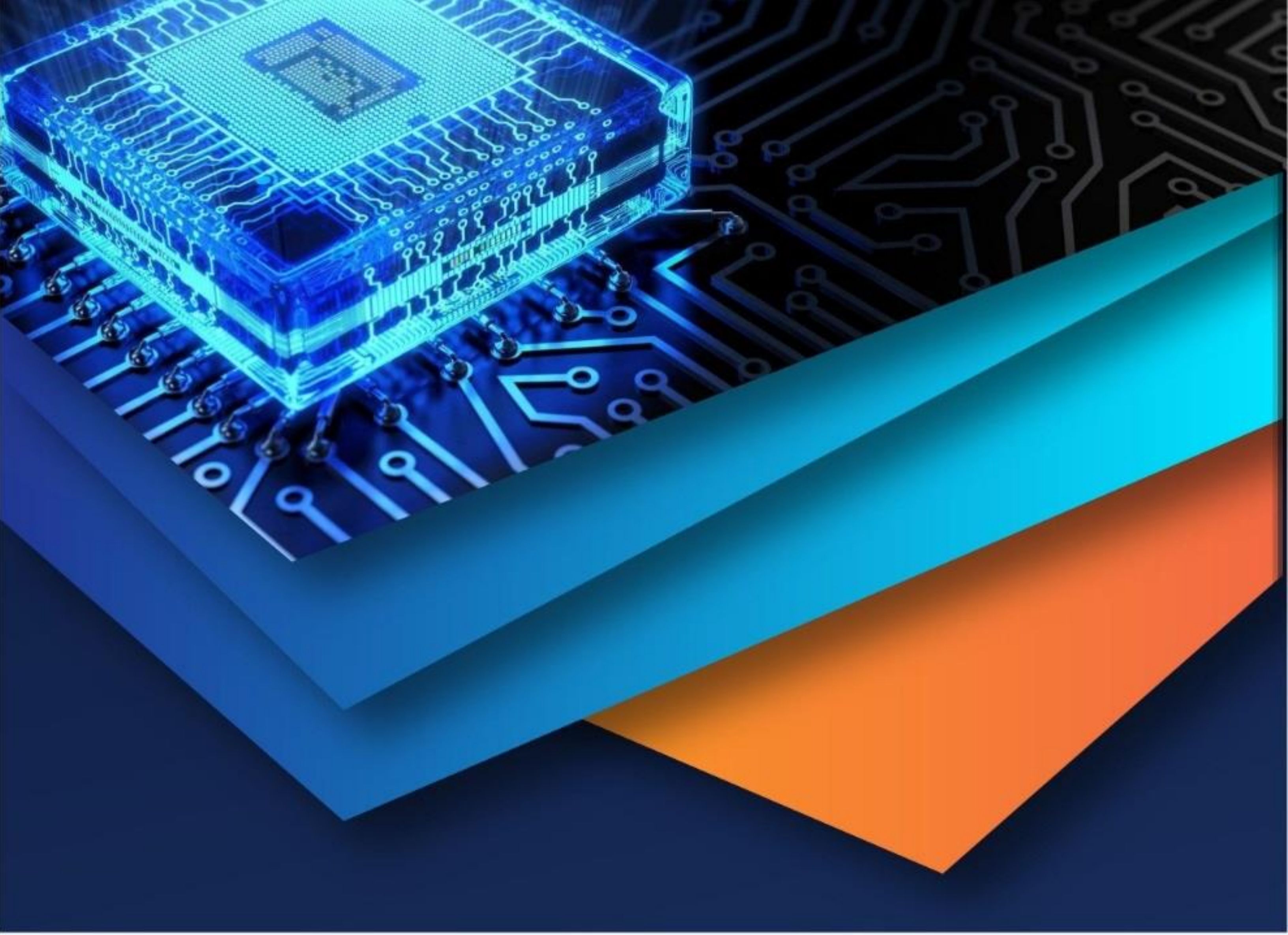
[17] Ahmed Nabih Zaki Rashed, "Optical Fiber Communication Cables Systems Performance Under Harmful Gamma Irradiation and Thermal Environment Effects," accepted for publication in IET Communications, IET Publisher, 2013.

[18] T. S. Chen, "Determination of the Capacitance, Inductance, and Characteristic Impedance of Rectangular Lines," IEEE Transactions on Microwave Theory and Techniques, Volume 8, Issue 5, pp.510–519,Sep 1960.

Author Biography

Dr. Ahmed Nabih Zaki Rashed was born in Menouf city, Menoufia State, Egypt country in 23 July, 1976. Received the B.Sc., M.Sc., and Ph.D. scientific degrees in the Electronics and Electrical Communications Engineering Department from Faculty of Electronic Engineering, Menoufia University in 1999, 2005, and 2010 respectively. Currently, his job carrier is a scientific lecturer in Electronics and Electrical Communications Engineering Department, Faculty of Electronic Engineering, Menoufia university, Menouf. Postal Menouf city code: 32951, EGYPT.

His scientific master science thesis has focused on polymer fibers in optical access communication systems. Moreover his scientific Ph. D. thesis has focused on recent applications in linear or nonlinear passive or active in optical networks. His interesting research mainly focuses on transmission capacity, a data rate product and long transmission distances of passive and active optical communication networks, wireless communication, radio over fiber communication systems, and optical network security and management. He has published many high scientific research papers in high quality and technical international journals in the field of advanced communication systems, optoelectronic devices, and passive optical access communication networks. His areas of interest and experience in optical communication systems, advanced optical communication networks, wireless optical access networks, analogy communication systems, optical filters and Sensors, digital communication systems, optoelectronics devices, and advanced material science, network management systems, multimedia data base, network security, encryption and optical access computing systems. As well as he is editorial board member in high academic scientific International research Journals. Moreover he is a reviewer member and editorial board member in high impact scientific research international journals in the field of electronics, electrical communication systems, optoelectronics, information technology and advanced optical communication systems and networks. His personal electronic mail ID (E-mail:ahmed_733@yahoo.com).



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