INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH VOLUME 6, ISSUE 10, OCTOBER-2015
ISSN 2229-5518

A REVIEW PAPER ON TECHNIQUES AND DESIGN FOR METAMATERIAL ABSORBER

Neelam Singh*, Rekha Chahar**

M.Tech Student, ECE Department, Govt. Women Engineering College, Ajmer (Raj.)*

Assistant Professor, ECE Department, Govt. Women Engineering College, Ajmer (Raj.)**

ABSTRACT:Metamaterials (MTMs) [1], due to their attractive properties, are nowadays experimentally used in many engineering applications like negative refraction [2], perfect lens [3], cloaking [4], antenna miniaturization [5] and so on. Metamaterial absorber has large thickness as compare to microwave absorber.In this review paper a survey is conducted on commonly used techniques and design used in metamaterial absorber papers which has been used by authors for designing of an ultrathin, bandwidth enhanced ,affordable metamaterial absorber.

KEYWORDS: Negative Refraction,Metamaterial, Bandwidth Enhanced,Perfect lens,Clocking, Antenna miniaturization

I.INTRODUCTION

In recent years, electromagnetic (EM) metamaterials (MTMs) [1] have drawn significant research interests due to their peculiar properties. Several potential applications, such as perfect lens [2], cloaking [3], antenna miniaturization [4], and so forth have been proposed over the EM spectrum covering from microwave to visible regimes. Metamaterial uses in application of antenna such as Reduction of mutual coupling, reduction of antenna size, dual band characteristics ,enhancement of directivity, leaky wave radiation application, bandwidth enhancement and antenna performance enhancement.

Standard microwave absorbers are extensively used in many applications to reduce the electromagnetic interference in microwave components. But the large thickness (~λ/4) of the conventional microwave absorber structure is one of the major disadvantages. Recently, metamaterial (MTM) structures are a major breakthrough in this application, where the ultra-thin structures comprising periodic unit cells in the sub-wavelength regime can be used to obtain near unity absorption through ohmic and dielectric loss.

One of the major applications is to design perfect MTM absorbers [5], which can produce nearunity absorption by tuning the effective electric permittivity and magnetic permeability of the homogenized structure. In addition, they also exhibit versatile distinct features over conventional material based absorbers such as ultrathin nature, flexible manipulation of constitutive EM properties, wide incident angle absorption, polarization insensitivity, and so on. Till date, various designs on MTM absorbers have been investigated exhibiting different characteristics, such as single-band [6–8], dual-band [9,10], triple-band [11,12], bandwidth enhanced [13–15], and even broadband operations [16,17], with most of them being polarization-insensitive and wide-angle absorptive. However, there is still a lack of sufficient progress toward the design and implementation of quad-band MTM absorber, which can be used in spectroscopic detection and phase imaging of hazardous materials and prohibited drugs [18]. Although some articles have proposed quad-band absorption by incorporating a set of resonant geometries with scaled dimensions, but they suffer from the constraint of large unit-cell size [19].

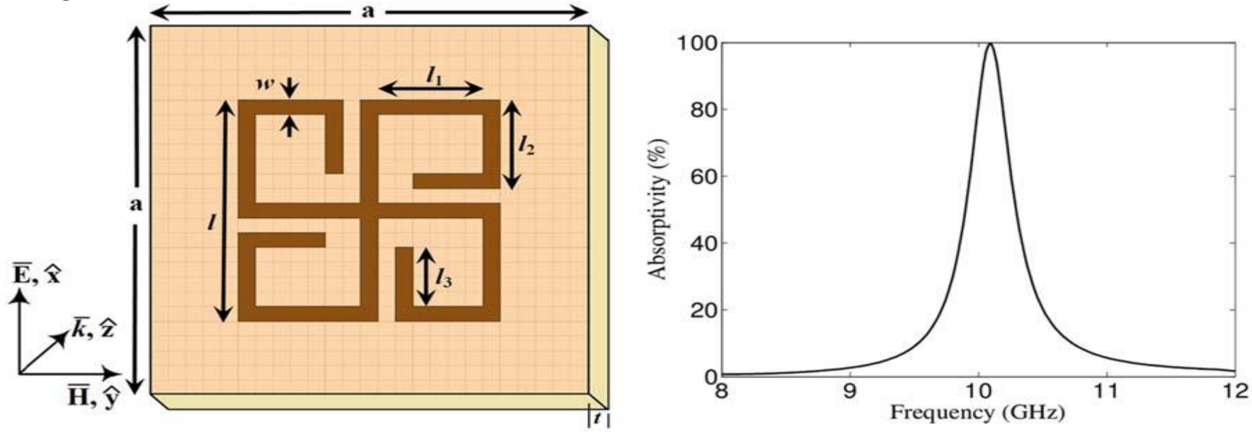
II.LITERATURE SURVEY

1.Research Paper on: ***"BANDWIDTH ENHANCEMENT OF AN ULTRATHIN POLARIZATION INSENSITIVE METAMATERIAL ABSORBER"*** *[15]*.

In this paper, we present the a periodic array of swastika-like structure printed on FR4 dielectric substrate backed by copper ground. The structure is simulated to give rise to nearly unity (99.64%) absorption at 10.10 GHz (X-band). It also shows high absorption (81%) for incident angle upto 60°.
The basic unit cell geometry of the proposed structure is shown in Figure 1(a). The top layer consists of a

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH VOLUME 6, ISSUE 10, OCTOBER-2015
ISSN 2229-5518

swastika-like structure printed on FR-4 dielectric substrate. The back side is completely metal laminated. Both the top and bottom layers are made of copper each having thickness of 0.035 mm. The dimensions of the unit cell along with the directions of field vectors are shown in Figure 1(a). As the structure is completely copper backed, no power is transmitted through it.



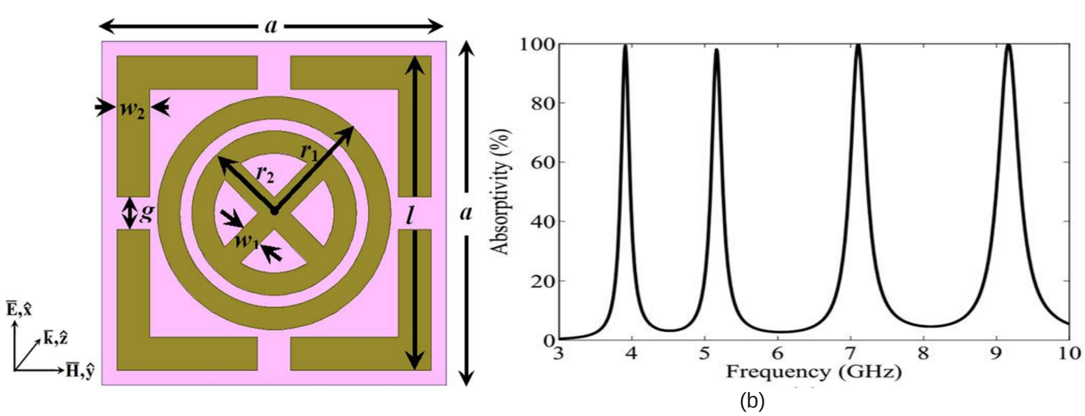
(a) (b)

Figure 1(a) Perspective view of the unit cell structure with geometrical dimensions: a=5, l=3, w=0.2, l1=1.2, l2=0.8, l3=1, t=1 (unit: mm),(b) Simulated absorptivity of the structure.

*2.Research Paper on: "**AN ULTRATHIN QUAD-BAND POLARIZATION-INSENSITIVE WIDEANGLE METAMATERIAL ABSORBER**" [16]*.

In this article, an ultrathin quad-band polarization-insensitive wide-angle metamaterial absorber has been presented. The proposed structure consists of a periodic array of concentric square and circular rings imprinted on grounded FR-4 dielectric substrate. The simulated result shows that the structure has four discrete absorption peaks at 3.91, 5.16, 7.10, and 9.16 GHz with peak absorptivities of 99.35, 98.04, 99.85, and 99.78%, respectively. It also shows high absorption (90%) for wide incident angles upto 45º for both transverse electric and transverse magnetic polarizations. The designed quad-band absorber is easy to manufacture and can be used in various potential applications.

An ultrathin quad-band MTM absorber has been proposed with simultaneous polarization insensitivity and wide-angle absorption characteristics. The proposed structure comprises of a square outer ring with four splits, and two inner circular rings with the smaller one being cross connected. The simulated result shows four distinct absorption peaks at 3.91, 5.16, 7.10, and 9.16 GHz with peak absorptivities of 99.35, 98.04, 99.85, and 99.78%, respectively.Its showinfigure2(a)and(b).



(a) (b)

Figure 2(a) Front view of the unit cell of the proposed structure with geometrical dimensions: a=23, l=21, w1=1.5, w2=2.2, r1=7.8,R2=5.5, and g=2.2 (unit: mm). (b) Simulated absorptivity.

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH VOLUME 6, ISSUE 10, OCTOBER-2015
ISSN 2229-5518

3.Research Paper on: ***"AN ULTRATHIN PENTA-BAND POLARIZATION-INSENSITIVE COMPACT METAMATERIAL ABSORBER FOR AIRBORNE RADAR APPLICATIONS" [17].***

In this article, an ultrathin penta-band polarization-insensitive metamaterial absorber has been presented, which consists of an array of a closed ring embedded in a tetra-arrow resonator. The proposed ultrathin structure exhibits five distinct absorption peaks at 3.4, 8.34,9.46, 14.44, and 16.62 GHz with peak absorptivities of 98.6%, 96.6%,90.1%, 97.8%, and 93.1%, respectively. Due to fourfold symmetry the structure provides nearly unity absorption for all polarization angles under normal incidence. The structure also exhibits high absorptionpeaks (~80%) up to 45^{o} incident angles for both TE and TM polarizations.
The aim of this article is to propose a compact ultrathin penta-band polarization-insensitive MTM absorber with wide incident angle, where the absorption peaks are distributed across S, X, and Ku bands.Its show in figure 3(a) and (b).

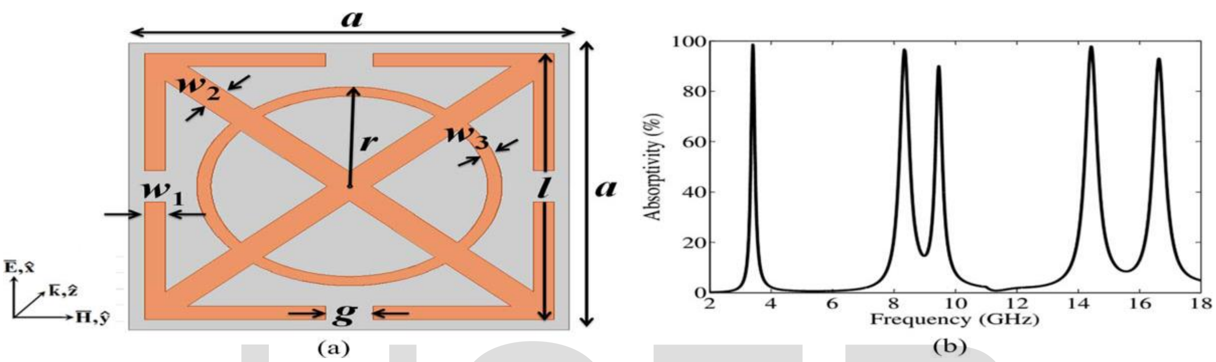
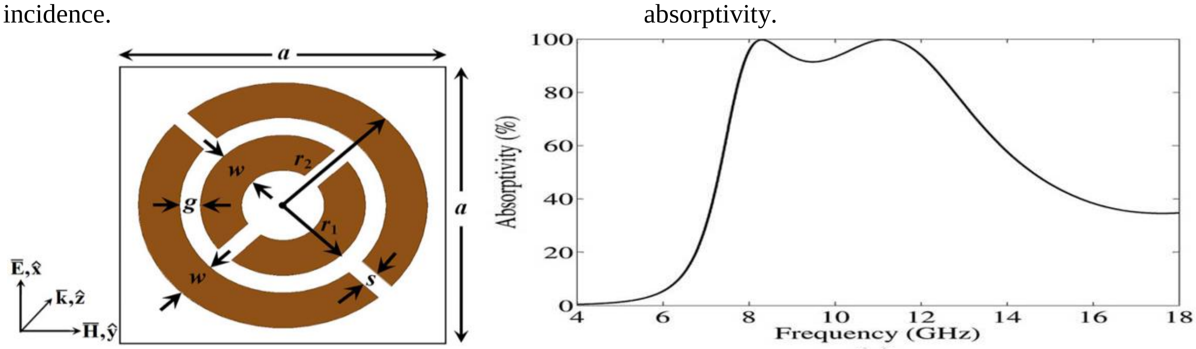


Figure 3 (a) Top view of the unit cell of the proposed penta-band structure with geometrical dimensions: a=14, l=13, g=1.5, w1=1.3, w2=1,w3=0.45, r=4.8 (unit: mm) with and (b) simulated absorptivity responses.

4.Research Paper on: ***"AN ULTRAWIDEBAND ULTRATHIN METAMATERIAL ABSORBER BASED ON CIRCULAR SPLIT RINGS"[18].***

In this paper,the proposed structure is composed of two concentric circular split rings imprinted on a metal-backed dielectric substrate. A 10-dB absorption bandwidth from 7.85 to 12.25 GHz covering the entire X-band has been observed in numerical simulation under normal incidence. The absorptivities of the proposed structure have been investigated under different polarization angles as well as oblique incidence.

In this letter, a novel ultrawideband ultrathin metamaterial absorber has been proposed, which exhibits above 90% absorption bandwidth for the frequency range of 7.85–12.25 GHz. Two circular split rings have been embedded one inside another,where the outer ring provides dual-band absorption and the bandwidth is considerably increased by the inner one. The electromagnetic field distributions and the surface current plots at the absorption peaks have been illustrated to analyze the absorption mechanism of the broadband absorber.
Its show in figure 4 (a) for dimension and (b) is absorptivity.



(a) (b)

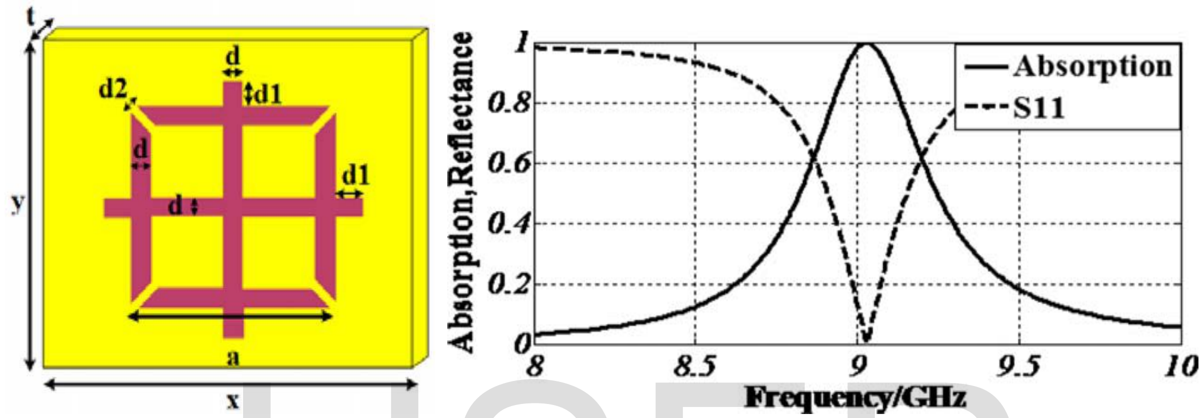
Fig. 4.(a) Front view of the proposed ultrawideband ultrathin unit cell structure with geometrical dimensions:a=7.1, r1=1.8, r2=3.15, w=0.9, g=0.45, s=0.4(units:mm)(b) simulated absorptivity responses.

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH VOLUME 6, ISSUE 10, OCTOBER-2015
ISSN 2229-5518

5.Research Paper on: **"DESIGN AND FABRICATION OF A METAMATERIAL ABSORBER IN THE MICROWAVE RANGE"[19]**

In this paper,We present the design, fabrication, and characterization of a metamaterial absorber which is resonant at microwave frequencies, which shows a wide-band polarization-insensitive and wide-angle strong absorption. In this article, a novel MA with improved bandwidth performance that operates around the middle of the microwave X-band (8.0–12.0 GHz) is presented.

The simulated results of the basic unit cell show a peak absorption rate of 99.98% at 9.028 GHz and FWHM bandwidth of 4.7%. Simulated results show that the absorber has a wide-angle strong absorption and polarization-insensitive. By exploiting the scalability of the elements, we have achieved multiple absorption peaks at the desired frequencies, thus extending our idea to increase the bandwidth of the absorption. Its show in figure 5 (a) and (b).



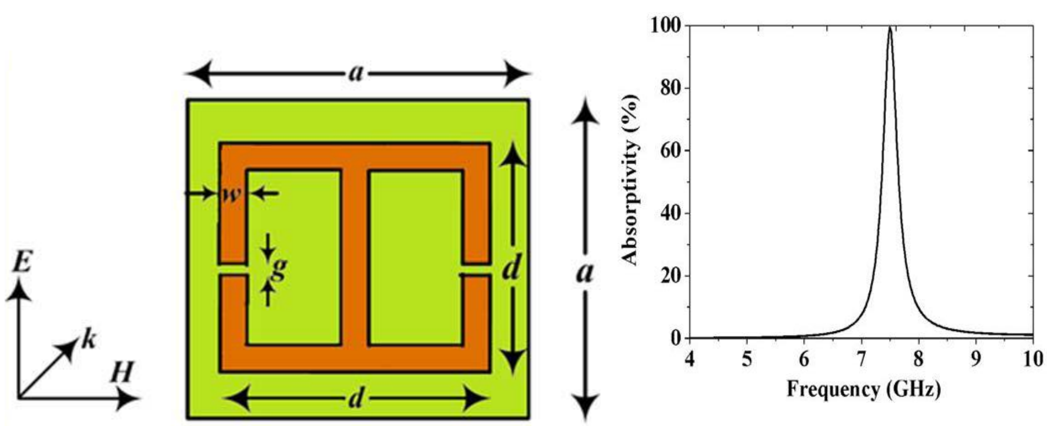
(a) (b)

Figure 5 (a)Unit-cell model in CST.The size parameters are listed as the following: x=y=10mm, a=4.4 mm, t=1 mm, d=0.6 mm, d1=0.8 mm, d2=0.2 mm.(b) simulated absorptivity responses.

6.Research Paper on:**''BANDWIDTH-ENHANCED METAMATERIAL ABSORBER USING ELECTRIC FIELD–DRIVEN LC RESONATOR FOR AIRBORNE RADAR APPLICATIONS"[20]**

In this paper,to construct broadband ultrathin absorbers using metamaterials in microwave frequencies (C-band) for lower band surveillance and air defense applications. The frequencies of absorptions have been brought closer by parametric optimization of electric field driven LC structures to give rise to a higher full width at half maxima (FWHM) bandwidth. The FWHM bandwidth of 0.42 GHz with 8.13% has been theoretically observed ranging from 4.94–5.36 GHz.

It shows two distinct absorption peaks at 5.04 and 5.28 GHz with absorbance of 98.5 and 94.2%, respectively, to offer a full width at half maxima (FWHM) bandwidth of 0.42 GHz with 8.13% bandwidth. Its show in figure 6 (a) and (b).



(a) (b)

Figure 6 (a)The dimensions of the unit cell shown in Figure : a=5 mm, d=3.6 mm, w=0.4 mm, and g=0.2 mm with 0.035-mm-thick copper film.(b) simulated absorptivity responses.

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH VOLUME 6, ISSUE 10, OCTOBER-2015
ISSN 2229-5518

III.CONCLUSION

This paper shows the review and survey of techniques and design for the designing of Metamaterial Absorber. By using one of any above mentioned technique some of the limitations of conventional Metamaterial Absorber characteristics is improved. This review work is done on some characteristics implemented through different techniques. Nevertheless, useful solution are still less and suffer from different problems like complexity of structure ,enhanced bandwidth, reduction of gain etc. Hence, the author feels that further research and more work is needed inthese areas.

REFERENCES

[1] D.R. Smith, W.J. Padilla, D.C. Vier, S.C. Nemat-Nasser, and S.Schultz, Composite medium with simultaneously negative permeability and permittivity, Phys Rev Lett 84 (2000), 4184.

[2] N. Fang, H. Lee, C. Sun, and X. Zhang, Sub-diffraction-limited optical imaging with a silver superlens, Science 308 (2005), 534–537.

[3] D. Schurig, J.J. Mock, B.J. Justice, S.A. Cummer, J.B. Pendry, A.F. Starr, and D.R. Smith, Metamaterial electromagnetic cloak at microwave frequencies, Science 314 (2006), 977–980.

[4] S. Enoch, G. Tayeb, and P. Vincent, A metamaterial for directive emission, Phys Rev Lett 89 (2002), 3901–3904.

[5] 5. N.I. Landy, S. Sajuyigbe, J.J. Mock, D.R. Smith, and W.J. Padilla, Perfect metamaterial absorber, Phys Rev Lett 100 (2008), 207402.

[6] 6. H. Tao, C.M. Bingham, D. Pilon, K.B. Fan, A.C. Strikwerda, D. shrekenhamer, W.J. Padilla, X. Zhang, and R.D. Averitt, A dual band terahertz metamaterial absorber, J Phys D 43 (2010), 225102.

[7] J. Sun, L. Liu, G. Dong, and J. Zhou, An extremely broad band metamaterial absorber based on destructive interference, Opt Express 19 (2011), 21155–21162.

[8] Y.Z. Cheng, Y. Wang, Y. Nie, R.Z. Gong, X. Xiong, and X. Wang, Design, fabrication and measurement of a broadband polarizationinsensitive metamaterial absorber based on lumped elements, J Appl Phys 111 (2012), 044902.

[9] X.-J. He, Y. Wang, J.-M. Wang, and T.-L. Gui, Dual-band terahertz metamaterial absorber with polarization insensitivity and wide incident angle, Prog Electromagn Res 115 (2011), 381–397.

[10] J.F. Federici, B. Schulkin, F. Huang, D. Gary, R. Barat, F. Oliveira, D. Zimdars, THz imaging and sensing for security applications-explosives, weapons and drugs, Semicond Sci Technol 20 (2005), S266–S280.

[11] D. Zheng, Y. Cheng, D. Cheng, Y. Nie, and R. Gong, Four-band polarization-insensitive metamaterial absorber based on flowershaped structures, Prog Electromagn Res 142 (2013), 221–229.

[12] D.R. Smith, D.C. Vier, T. Koschny, and C.M. Soukoulis, Electromagnetic parameter retrieval from inhomogeneous metamaterials, Phys Rev E 71 (2005), 03661.

[13] X. Shen, Y. Yang, Y. Zang, J. Gu, J. Han, W. Zhang, and T.J. Cui, Triple-band terahertz metamaterial absorber: Design, experiment and physical interpretation, Appl Phys Lett 101 (2012), 154102.

[14] S.Ghosh, S. Bhattacharyya, and K.V. Srivastava, Bandwidth enhancement of an ultra-thin polarization insensitive metamaterial absorber, Microwave Opt Technol Lett 56 (2014), 350–355.

[15] D. Chaurasiya, S. Ghosh, S. Bhattacharyya, and K.V. Srivastava, An ultra-thin quad-band polarization-insensitive wide-angle metamaterial absorber, Microwave Opt Techol Lett 57 (2015), 697–702.

[16] Somak Bhattacharyya, Saptarshi Ghosh and Kumar Vaibhav Srivastava, "AN ULTRATHIN PENTA-BAND POLARIZATION-INSENSITIVE COMPACT METAMATERIAL ABSORBER FOR AIRBORNE RADAR APPLICATIONS", Microwave and Optical Technology Letters, Vol.55,Issue 9,pp.2131-2137,September 2013.

[17] Somak Bhattacharyya, Saptarshi Ghosh and Kumar Vaibhav Srivastava, "AN ULTRAWIDEBAND ULTRATHIN METAMATERIAL ABSORBER BASED ON CIRCULAR SPLIT RINGS", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 14, 2015.

[18] Mohammad R. Soheilifar, Ramezanali A. Sadeghzadeh, and Hadi Gobadi, "DESIGN AND FABRICATION OF A METAMATERIAL ABSORBER IN THE MICROWAVE RANGE", MICROWAVE AND OPTICAL TECHNOLOGY LETTERS / Vol. 56, No. 8, August 2014.

[19] Somak Bhattacharyya, Saptarshi Ghosh and Kumar Vaibhav Srivastava, "ELECTRIC-FIELD DRIVEN LC (ELC) ABSORBER ".