

VISION INTENSIFICATION USING AUGMENTED REALITY WITH METASURFACE APPLICATION

Dr. Jennifer S. Raj,

Professor,
Department of ECE, Gnanamani College of Technology,
Namakkal, India.
Email: jennifer.raj@gmail.com

Abstract: The auxiliary wavelength configurations that are artificially fabricated are usually utilized in the metasurface nowadays in order to improve its potency in manipulating the light utilizing the unique and extraordinary operations. The paper puts forth the exploration of the metasurface application to comprehend a camouflaged structure using augmented reality with a broader view. The fundamental element utilized is the clear metalens that is integrated with an anisotropic reaction, an enhanced numerical hole with the larger hole aided with attributes related to broadband. The infrared flat metalens inbuilt with these enhanced attributes sidesteps the prevailing obstacles that are caused by the existing systems that reports a narrow vision and largeness. The results obtained shows that the metalens used provides a wider view without changing the color of the objects even on the dense closer to eye spectacle.

Keywords: Vision Intensification, Augmented Reality, Metasurface Applications, Metalens, Enhanced Potency

1. INTRODUCTION

The urge of the people to have a sophisticated living utilizing the latest developed technology has served fundamental reason for the popularity of the portable devices that are flexible. This also paves for the necessity to enhance the prevailing integrated circuits as they utilize the fibers that are tapered and grated in order to accomplish an effective optical connection[1-2].

The metasurface elements are the planar optical components that are usually constructed using the auxiliary wavelength that is fabricated using the artificial methods. Due to their powerfulness and the versatility in the altering the electromagnetic attributes they have also become very attractive nowadays. The latest progress in the

metasurface ensures that the restrictions in the optical elements are overcome by the enhanced attributes of the metasurface elements [3-7].

The two dimensional Meta-materials known as the metasurface are treated as a rare commodity as they could not be obtained in the nature. As they could achieve the control of the light at ease, they have become the common area of research in the last few decades [8-10]. The manipulation of the magnitude, amplitude and the polarization of the nano-scale resolution of the light are possible in the metasurface as the composed of the well-structured sub wavelength diffusions [11]. The figure.1 below shows the metasurface with the capability to create negative refraction [12].



Fig.1 Metasurface Creating Negative Refraction [12]

The fundamental operation of the metasurface relies back on the phenomenon of the diffraction. The periodic flat arrays are visualized as the lattice for diffraction splitting the incident light into few rays. The direction and the count of the rays depend on the wavelength, angle of incidence and the lattice period.

The arrangement of the unit cell sub wavelength decides the energy distribution of incident light among the rays. Most of the applications are possible only through the negative refraction as the light bends towards the opposite

path unlike the positive refractive index in which the light bends towards the normal axis. The image below in figure .2 shows the representation of the negative refraction of the light in the Meta-materials.

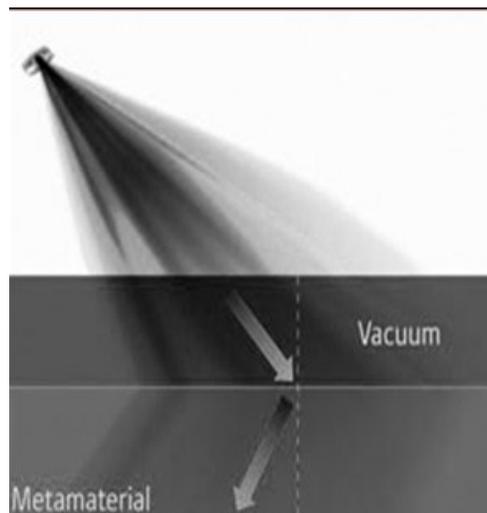


Fig.2 Negative Refraction of Light

Metalens is one of the most common metasurface elements that allows to have a capable working podium integrated with high potential for the metasurface [13]. Many researches have been reported in the recent years to show a progressive development in the metasurface applications.

So the paper puts forth the flat infrared metalens inbuilt with these enhanced attributes and the broad band capabilities in the augmented reality to comprehend a camouflaged structure with a broader view.

The remaining paper is arranged with the 2. Related Work, 3. Proposed Work, 4. Results and 5. Conclusion.

2. RELATED WORKS

Zhu, et al presents the details of the "Traditional and emerging materials for optical Metasurface." Chang et al [2] provides the "Optical Metasurface: progress and applications." Roth et al [3] details the "Broadband visible reflective metasurfaces for the visualisation of 3D effects (Conference Presentation)." Shaltout et al [4] has developed the "Spatiotemporal light control with active metasurfaces." Bukhari, et al [5] presents the review on the definitions and the application of the metasurface. Hsiao et al [6] provides the "Fundamentals and applications of metasurfaces."

Li et al [7] details the application of the metasurface. Assouar et al [8] is the detailed lecture on the "Acoustic metasurfaces." Wong et al [9] elaborates the. "Reflection less wide-angle refracting metasurfaces." Estakhri et al [11] "describes the "latest progress in the gradient metasurfaces" Avayu,et al [13] details the . "Ultrathin full color visor with large field of view based on multilayered metasurface design."

3. PROPOSED WORK

The Augmented reality [14-15] is the well-known technology to integrate the virtual information and the real world. The proposed work puts forth the usage of the infrared flat metalens to identify the camouflaged objects in the real as well as the virtual world.

The infrared flat metalens [16] used enables to have a high numerical aperture along with a wide and full view of the field. The metalens utilizes the dielectric Metasurface that is fixed up with a randomly devised anisotropy reaction for the entire visible region at a sub-wavelength scale to achieve the high numerical aperture and larger area. The schematic of the dielectric metasurface is shown below in the fig.4

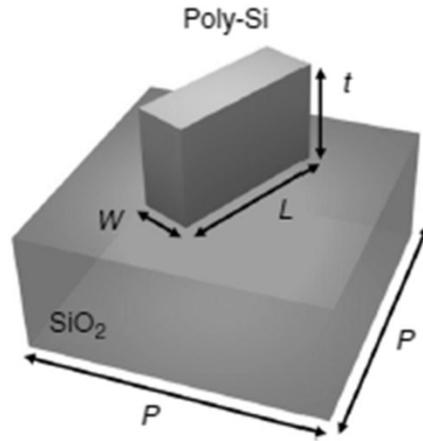


Fig.4 Unit Cell of Dielectric Metasurface

The Jones Matrix T is used to model the random orientation angle of the dielectric nano-rod that is in the rectangular shape. The equation.1 below shows the incident circular polarized light complex transmittance achieved by the nano-rod.

$$T | \sigma | = t + t_r/2 | \sigma | + t - t_r/2 e^{-j2\sigma\theta} | \sigma | \quad (1)$$

Where the ' t ' and the ' t_r ' is the complex transmission co-efficient obtained by the long and the short axes nano rod for the light with the linear polarization and σ is the parameter representing the circular polarization often fixed to be +1 or -1. The ' t ' and the ' t_r ' are regulated by the nano-rod dimensions and are associated with the anisotropy.

The metasurface is converted into the metalens by devising the each unit cell of the metasurface by a spatial phase distribution utilizing the relation present in the equation (6)

$$\theta (i, j) = \frac{\pi}{\lambda} (w - \sqrt{i^2 + j^2 + w^2}) \quad (2)$$

Where $\theta (i, j)$ is the nano-rods orientation angle, and the ‘ i ’ and ‘ j ’ are the positions along the nano-rod axes. This device is made suitable for the augmented reality by involving the clear metalens that is capable of handling a wide variety of polarized light with the varying dexterity. The fig. 5 shows the lens mode of the metasurface.

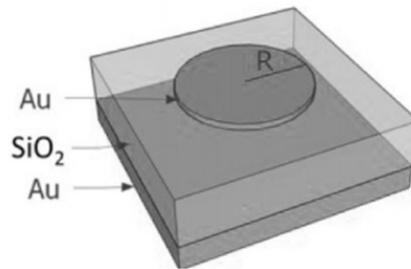


Fig.5 Flat Metalens [16]

The anticipated focusing of the lens is achieved as metalens satisfies the following equation (3) shown below.

$$D_{focussing} (i) = \frac{2\pi}{\lambda_0} * (w - \sqrt{i^2 + w^2}) \quad (3)$$

The oblique incident (OI) beam with the linear phase gradient (LPG) is cancelled by applying the additional phase profile to the metasurface. The equation (4) is framed in this regard.

$$LPG_{OI}(i) = \frac{2\pi}{\lambda_0} * (i * \sin \theta) \quad (4)$$

The Average phase shift (AVG_{PS}) of the lens is devised as shown in the equation (5) below.

$$AVG_{PS} = D_{focussing} (i) + LPG_{OI}(i) \quad (5)$$

So the AR imaging of the camouflaged objects in the real world and the virtual world is achieved using the circular polarization with the σ and the $-\sigma$ respectively [17].

4. RESULTS

The experimental simulations evince the efficiency of the infrared flat metalens in achieving the AR imaging of the Camouflaged objects. The figure 6 and 7 below shows the efficiency of the infrared flat metalens in achieving the vision enhancement in AR imaging for varying wavelength and the angle respectively

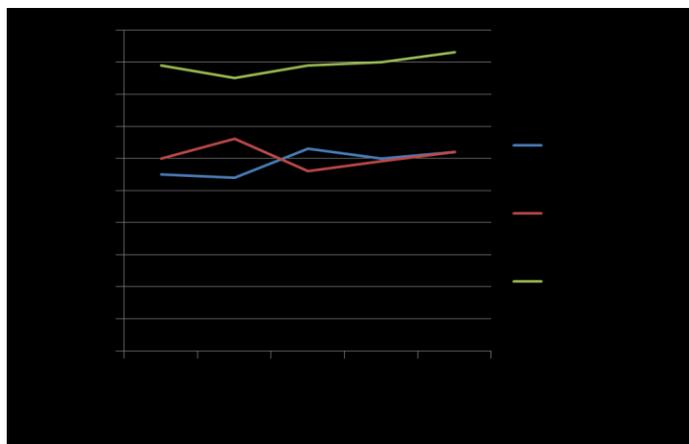


Fig.6 Efficiency % Vs Wavelength

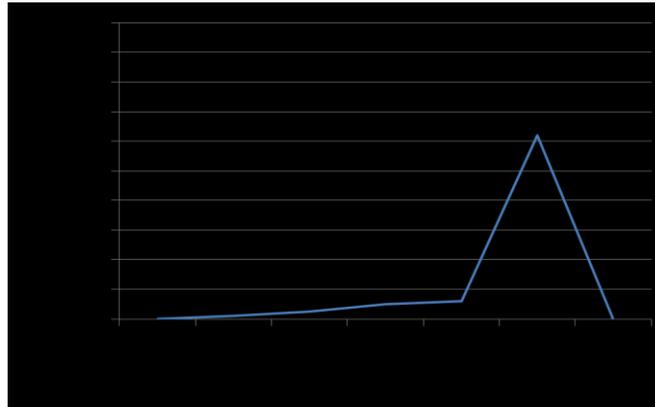


Fig.7 Efficiency % Vs Angle

5. CONCLUSION

The paper has utilized the infrared flat metalens in achieving the AR imaging of the Camouflaged objects enhancing the vision in the augmented reality. The strategy that is founded on revealing the flat lens at an oblique angle provides the advantages of having a simplified experimental set-up compared to the prevailing reflection based measurements that hold a standard rate. The experimental result obtained shows the efficiency of the lens in recognizing the camouflaged objects in the virtual and the real world.

References

- [1] Zhu, Alexander Y., Arseniy I. Kuznetsov, Boris Luk'yanchuk, Nader Engheta, and Patrice Genevet. "Traditional and emerging materials for optical metasurfaces." *Nanophotonics* 6, no. 2 (2017): 452-471.
- [2] Chang, Shengyuan, Xuexue Guo, and Xingjie Ni. "Optical metasurfaces: progress and applications." *Annual Review of Materials Research* 48 (2018): 279-302.
- [3] Roth, Diane J., Alexander E. Minovich, Guixin Li, and Anatoly V. Zayats. "Broadband visible reflective metasurfaces for the visualisation of 3D effects (Conference Presentation)." In *Digital Optical Technologies 2019*, vol. 11062, p. 1106209. International Society for Optics and Photonics, 2019.

- [4] Shaltout, Amr M., Vladimir M. Shalaev, and Mark L. Brongersma. "Spatiotemporal light control with active metasurfaces." *Science* 364, no. 6441 (2019): eaat3100.
- [5] Bukhari, Syed S., J. Yiannis Vardaxoglou, and William Whittow. "A metasurfaces review: Definitions and applications." *Applied Sciences* 9, no. 13 (2019): 2727.
- [6] Hsiao, Hui-Hsin, Cheng Hung Chu, and Din Ping Tsai. "Fundamentals and applications of metasurfaces." *Small Methods* 1, no. 4 (2017): 1600064.
- [7] Li, Aobo, Shreya Singh, and Dan Sievenpiper. "Metasurfaces and their applications." *Nanophotonics* 7, no. 6 (2018): 989-1011.
- [8] Assouar, Badreddine, Bin Liang, Ying Wu, Yong Li, Jian-Chun Cheng, and Yun Jing. "Acoustic metasurfaces." *Nature Reviews Materials* 3, no. 12 (2018): 460-472.
- [9] Wong, Joseph PS, Ariel Epstein, and George V. Eleftheriades. "Reflectionless wide-angle refracting metasurfaces." *IEEE Antennas and Wireless Propagation Letters* 15 (2015): 1293-1296.
- [10] Genevet, P., Capasso, F., Aieta, F., Khorasaninejad, M. and Devlin, R., 2017. Recent advances in planar optics: from plasmonic to dielectric metasurfaces. *Optica*, 4(1), pp.139-152.
- [11] Estakhri, Nasim Mohammadi, and Andrea Alù. "Recent progress in gradient metasurfaces." *JOSA B* 33, no. 2 (2016): A21-A30.
- [12] <https://www.nanowerk.com/what-are-metamaterials.php>
- [13] Avayu, Ori, Ran Ditzcovski, and Tal Ellenbogen. "Ultrathin full color visor with large field of view based on multilayered metasurface design." In *Digital Optics for Immersive Displays*, vol. 10676, p. 1067612. International Society for Optics and Photonics, 2018.
- [14] Smys, S., and Jennifer S. Raj. "VIRTUAL REALITY SIMULATION AS THERAPY FOR POSTTRAUMATIC STRESS DISORDER (PTSD)." *Journal of Electronics* 1, no. 01 (2019): 24-34.
- [15] Kumar, N. Mohan. "ENERGY AND POWER EFFICIENT SYSTEM ON CHIP WITH NANOSHEET FET." *Journal of Electronics* 1, no. 01 (2019): 52-59.
- [16] Smys, S. "VIRTUAL REALITY GAMING TECHNOLOGY FOR MENTAL STIMULATION AND THERAPY." *Journal of Information Technology* 1, no. 01 (2019): 19-26.
- [17] Zhang, Shuyan, Myoung-Hwan Kim, Francesco Aieta, Alan She, Tobias Mansuripur, Ilan Gabay, Mohammadreza Khorasaninejad et al. "High efficiency near diffraction-limited mid-infrared flat lenses based on metasurface reflectarrays." *Optics express* 24, no. 16 (2016): 18024-18034.