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A REVIEW ON METAMATERIALS FOR VISIBLE LIGHT COMMUNICATION

Madhu Brahmankar[1], **Manisha Sharma**[2]
[1]*M. Tech student, Department of Electronics and Telecommunication Bhilai Institute of Technology Durg, Chhattishgarh, India*
[2]*Associate Professor, Department of Electronics and Telecommunication Bhilai Institute of Technology Durg, Chhattishgarh, India*

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Abstract: Metamaterials or Metasurfaces are important research topics because of having remarkable electromagnetic properties provided by sub-wavelength structures and functional order. These artificial nanomaterials are typically composed of a metallic patch or dielectric multi-layered configuration of subwavelength thickness, which provides benefits such as ease of fabrication, lightweight, and the ability to adapt electromagnetic waves over a wide frequency range, from microwave to visible light. The use of metamaterials in visible light communications is still in its early stages. We need to change the useable environment and signal using metamaterials to boost data rate and coverage while maintaining low power and cost, great dependability, enormous connection, and low latency. In this paper, we categorize and then explain the concept and fundamental principle so that one can easily choose a metamaterial for visible light communication according to the environment, working frequency and requirements.

Keywords:- *metamaterial, metasurface, VLC, Passive metamaterial, Active metamaterial, Digital metamaterial, Smart intelligent metamaterial*

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I. INTRODUCTION

The metamaterial is a three-dimensional (3D) artificial substance made up of metals and/or dielectrics in a periodic manner [15]. It is popular because to its exclusive interaction involving electromagnetic waves, which enhances the potential of homogeneous materials. Due to its excellent interaction with electric and/or magnetic fields, they provide a resonant effect operated by the geometry of the unit cells, giving them an extraordinary ability to manipulate waves which leads to a broad array of applications such as superlenses, antenna performance enhancement, energy harvesting and, perfect absorbers. However, fabrication of 3D metamaterials is challenging, especially at micro and nanoscale, and high losses also hamper many applications of metamaterials. As s result, the planer version of metamaterial or metasurface is two-dimensional (2D) with sub-wavelength thickness, which is widely applied in electromagnetic applications due to its ease of fabrication and lightweight. When grazing occurs, metasurfaces have the extraordinary capacity to block, absorb, concentrate, direct, and disperse waves at the surface, as well as in space at standard and oblique incidence, from microwave to optical frequencies [1]. The metamaterials based on practical medium theory have been introduced to achieve unusual properties that are based on various applications, like perfect imaging or superlens, invisibility cloaking, and negative reflection.

Since the 1980s, when analog wireless communication systems became the foundation of communication, every decade of revolutionary advancement has been influenced by mobile access technology. The fifth generation of mobile cellular communication (5G) has just been developed. The sixth-generation (6G) technology looks to be an extension of the fifth- generation (5G) technology. It is the future of mobile communications, with increased signal strength, maximum coverage, incredibly low power and cost, excellent dependability, enormous connection, and low latency. Visible Light Communication (VLC), one of the remarkable technologies nowadays where a light source can be utilized to send wireless information regardless of brightness, is one of the communication technologies that can be employed under 6G. It is an excellent contender for a secure, robust, and dependable connection in both an indoor and outdoor setting. It has lately attracted the attentions of industry and science because to the usage of high-power light-emitting diodes (LEDs) in the visible spectrum. The key benefit of employing VLC is that it allows for high-speed and dense wireless communications in interior areas such as hospitals, professional offices, airline cabins, private residences, and retail outlets with consuming less power and lasting longer. However, as electromagnetic waves transmit in such a wireless environment, they are subject to numerous uncontrollable modifications, such as free space path loss, signal absorption, and reflection refractions and aberrations associated with physical objects in the environment, all of which have a significant impact on wireless communications performance. As a result, a physical surface is necessary to alter signals in order to get a line-of-sight LOS signal in order to decrease losses and enhance signal strength. As a result, a planer metamaterial or metasurface can be used to alter

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electromagnetic waves in order to increase signal strength in wireless communication.

Related Work

Over the past several decades, metamaterials have shown exceptional skills in light manipulation skills such as phase, amplitude, dispersion, and polarisation, which is particularly useful for signal enhancement in visible light communication. In 2012, Ilya V. Shadrivov et al. [27] demonstrated that arbitrary gradients of the effective material parameters can also be worth emphasising by adjusting the illumination based on the phase of the reflection coefficient on the control voltage, allowing for the prototype of reconfigurable mirrors or lenses. In 2018, Xin Ge Zhang et al. [14] [16] classified a light-controllable and frequency-dependent digital coding metasurface that enables electromagnetic wave alteration by modifying the intensity of light or incident wave frequency using an optically interrogated digital platform (OIDP). In 2020, Cheng Gong et al. [23] reported a bandwidth and frequency tunable terahertz switch that can be manipulated by the spatial distribution of light illumination rather than light intensity change and a tunable absorber was designed, and Lei Chen et al. 2020 [26] creatively combined luminous control with microwave scattering, realizing an optically coding metasurface for beam deflection based on anomalies.

For software metamaterials, Sergi et al. 2017[19], says Software-defined metamaterials (SDMs) integration of a network of controllers within the structure of the metamaterial, are a much sought-after paradigm shift, exhibiting electromagnetic properties that can be reconfigured at runtime using a set of software primitives. In 2018, Yangyang et al. [24], introduce a programmable elastic metasurface with sensing-and-actuating units, allowing to adapt and reprogram its wave control functionalities in real time. In 2019, Ertugrul et al.[20], revealed that reconfigurable intelligent surfaces (RIS) can effectively control to shape the radio waves, in multipath propagation, and to realize low-complexity and energy efficient transmitters that require only active RF chain. In 2020, Qian Ma et al. [13] presented a smart metasurface with self-adaptively reprogrammable features that detect ambient surroundings and provide an online feedback algorithm as a control system, allowing the smart metasurface to perform adaptive single-beam and multibeam steering. Also Sergi Abadal et al. 2020[21] illustrated, with the introduction of modelling strategies such as the coding metamaterial approach or the use of neural networks, the programmable metamaterial paradigm become intelligent and self-adaptive metamaterials in sensing, imaging, or communications application by adapting the environment or communicate with other metamaterials. In contrast Amr M. Abdelhady et al. 2020[4] proposed intelligent reflecting surfacesbased VLC systems built using metasurface and mirror array-based reflectors by deriving irradiance expressions for both reflectors under general relative source, reflectors, detector dimensions, and locations assumptions

Using liquid crystals, Andrei Komar et al. 2018 [11] demonstrate how a silicon-nanodisk dielectric metasurface infiltrated with liquid crystals may dynamically change beam deflection by heating the metasurface to change the liquid crystal state from nematic to isotropic. In 2019, Alexander Zharovet al. [25] demonstrated the control of light transmission through a slab of plasmonic liquid metacrystal by an external electric field which induced macroscopic anisotropy, which caused the polarization-dependent suppression of transmission at resonant frequencies. In 2020, Jianxiong Li et al. [29] projection systems including liquid crystal displays and digital micromirror devices can impose spatial light modulation and actively shape light waves. The metasurface pixel in a digital metasurface device (DMSD) is electrically reconfigurable with well-controlled programmability and addressability by modulating the intensity of light with high contrast and shaping the wavefront of light generated by each metasurface pixel and dynamically switching between arbitrary holographic patterns.

Tunable metasurfaces benefiting from both global and local tuning were invented by Fu Liu et al. [22] in 2020, leading to greater control of electromagnetic waves by artificial skins, which opens the door to a plethora of applications.In contrast, Cheng Gong et al. 2020 [23] reported bandwidth and frequency tunable terahertz switch can be manipulated by the spatial distribution of light illumination, rather than the light intensity change and a tunable absorber designed. In addition, Li-Hua Gao et al. [17] propose a general coding unit based on a Minkowski closed-loop particle that can generate multi-bit coding metasurfaces which can

effectively control terahertz waves by employing sequence-specific coding which is fabricated by a standard photolithography method.

In 2010, Sangeeta et al. [18], explained how the resonant metamaterial response is itself completely transformed by the control of SRR-based metamaterials by the parametric control of the capacitance, the control of nanorod plasmonic loop metamaterials by the control of the surface plasmon resonance via the background di-electric environment and the control of the plasma-like behaviour of the nanorod metamaterial by changing the bulk average dielectric permittivity, which shows an entirely new way of reducing the dissipation in metamaterials. In 2016, Xiang Wan et al. [30] presented a field-programmable reflective antenna based on the coding metasurface at the microwave frequency, in which the binary units are realized by loading pin diodes to subwavelength artificial structures. In 2017, Meng-Xin Ren et al. [28] combined the metallic nanostructure layer with a thin layer of photoisomerizable azo ethyl red, where the coupling between the resonant plasmonic modes and the switchable isomeric states of ethylred.

Analysis Discription

Significant progress has been achieved in the field of metamaterials during the last twenty years, and evolution has occurred as numerous novel discoveries, devices, and even systems have been presented in this subject. As seen in Figure 1.2, the development of metamaterials is divided into four stages.

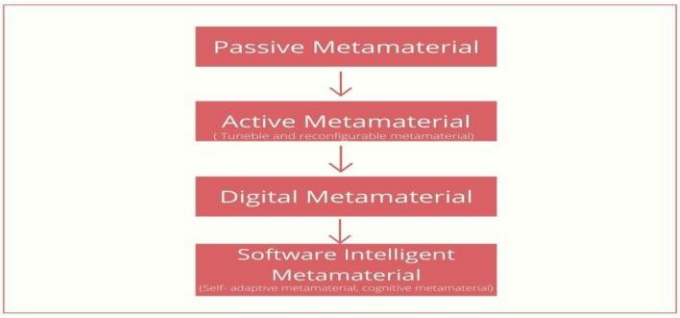

Figure1.2:- Refinement in metamaterials

1.The passive metamaterial is made up of a one-of-a-kind synthetic structure composed of periodic or non-periodic pattern of sub-wavelength unit cells (also known as meta-atoms) [6]. It has been developed mainly in microwave and optical frequency ranges, demonstrating a great capacity to manipulate electromagnetic waves (EM) in the required ways and achieving a variety of outstanding physical phenomena and valuable gadgets. However, homogeneous metamaterials have limited capacities for regulating EM waves.

2.Tunable metamaterials and reconfigurable metamaterials are examples of active metamaterials. The addition of active components and functionalities controlled by an external device that dynamically processes EM waves results in a tunable metasurface and/or reconfiguration. The device has two applications: a tunable/homogeneously reconfigurable metasurface that exhibits coherent orientation on EM waves and a tunable/reconfigurable heterogeneous metasurface that controls EM wavefronts. Furthermore, tuning and switching the distinct states of tunable metamaterials and reconfigurable metamaterials in real-time is extremely challenging.

3.The digital coding presentation of the meta-atom enables the realization of digital meta-material. The digital metamaterial is a subset of active metamaterials in which the active device’s control state is set to 2, 4, or 8 states to achieve the meta-atom digital states of 1-bit coding having two numeric states 0 and 1 with 180^0 phase shift, 2-bit coding having four numeric states 00, 01, 10, 11 with 90^0 phase shift, and 3-bit coding having eight states digital 000, 001, 010, 011, 100, 101, 110 and 111 with a phase shift of 45^0, respectively shows that the spatial coding sequence on the metamaterial completely controls the EM waves[6].

4.Software intelligent metamaterial senses and gather data from their surroundings, resulting in metamaterial sensing processes as varied as resonance spectrum, polarization, and mechanical[13]. Programmable interaction modules and sensing mechanisms are important components of metamaterial intelligence that can accomplish the general imaging of a surrounding, focus EM beams on a target such as a person or device, and determine actions like hand movements and breathing employing three main deep-learning algorithms that are computer code, software, and machine learning algorithms which are simple to construct intelligent software based metamaterial.

In this article, we will briefly explain the concept and principles of passive metamaterials, active metamaterials, digital metamaterials, and software intelligent metamaterials by reviewing some papers to gain a better understanding of the metamaterial and demonstrating their ability to manipulate EM waves in optical frequency range. As a result, it will be simple to choose metamaterial for visible light communication using optical source according on the environment and requirements. The development of digital programmable metamaterials, software/intelligent metamaterials, self-adaptive metamaterials, and cognitive materials, among others, has considerably increased the usefulness of metamaterials by combining different electrical devices and machine learning algorithms. We hope that this review might serve as a valuable resource to assist people gets started in the field efficiently. Finally, we end this analysis by discussing our thoughts on future advancements and problems in this sector of visible light communication.

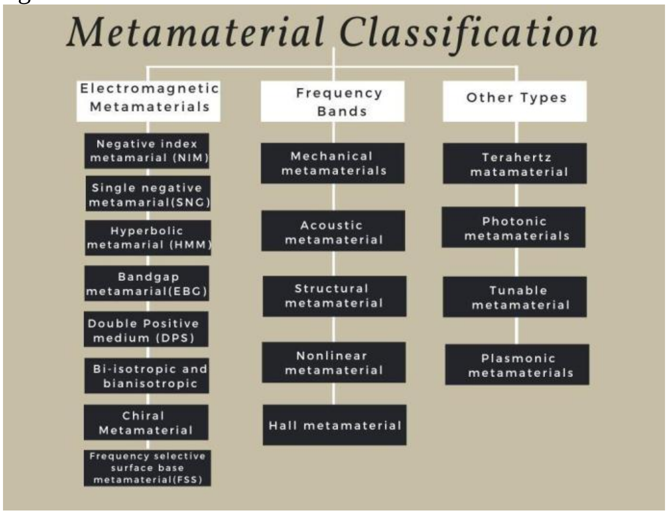

Figure 1:- Classification of metamaterials

Passive Metamaterial

Metasurfaces are planar super-thin singular nanostructures comprised of subwavelength dielectric or metallic components that may be constructed to regulate light characteristics including polarization, scattering, amplitude, and phase. The effective 2□-phase controlling capacity with the advantage of high transmittance makes

Characteristics	Wavelength(nm)	Transmission Efficiency	Deflection Efficiency	Deflection Angle	Ref
a-Si based larger supercell(15 unit cells)	715	83%	71%	8.40°	7
a-Si based shorter supercell (8 unit cells)	680	57%	43%	15.50°	7
a-Si based larger supercell (15 unit cells with 3π phase)	633	43%	10%, 22%	8.0°	7
a-Si based circular nanodisk(8 unit cells)	705	-	45%	10.3°	31
c-Si based circular nanodisk(8 unit cells)	532	71%	67%	19.27°	32
Liquid crystal based circular nanodisks (6 unitcells)	745	-	50%	12.0°	11

A. *Table1 :- Performance comparison*

The author concentrated on the Mie-resonance Huygens dielectric metasurface in his paper [7], which arises as a result of the interference of electric dipole (ED) and magnetic dipole (MD) resonance. They used phase control to develop and build a silicon metasurface with good transmission and excellent beam deflection capabilities. Its metasurface is made up of circular nanodisk-based large cells made of amorphous silicon. They react with the phase delay of the electromagnetic wave by altering the diameter of the disks. They proved that the transmitted beam direction could be adjusted considerably by adjusting the size of the supercell using the near-unit and phase-discrete transmittance capabilities of the insulating nanodisks. Furthermore, they have developed a mechanism for combining waves from two separate supercells, which results in excitations of greater diffraction orders

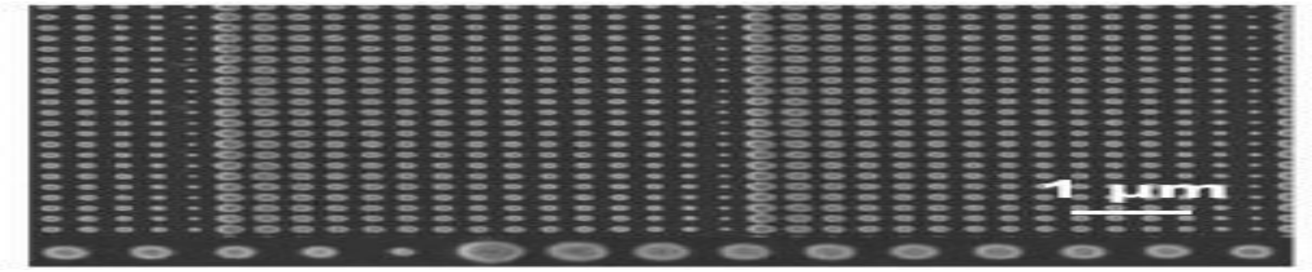

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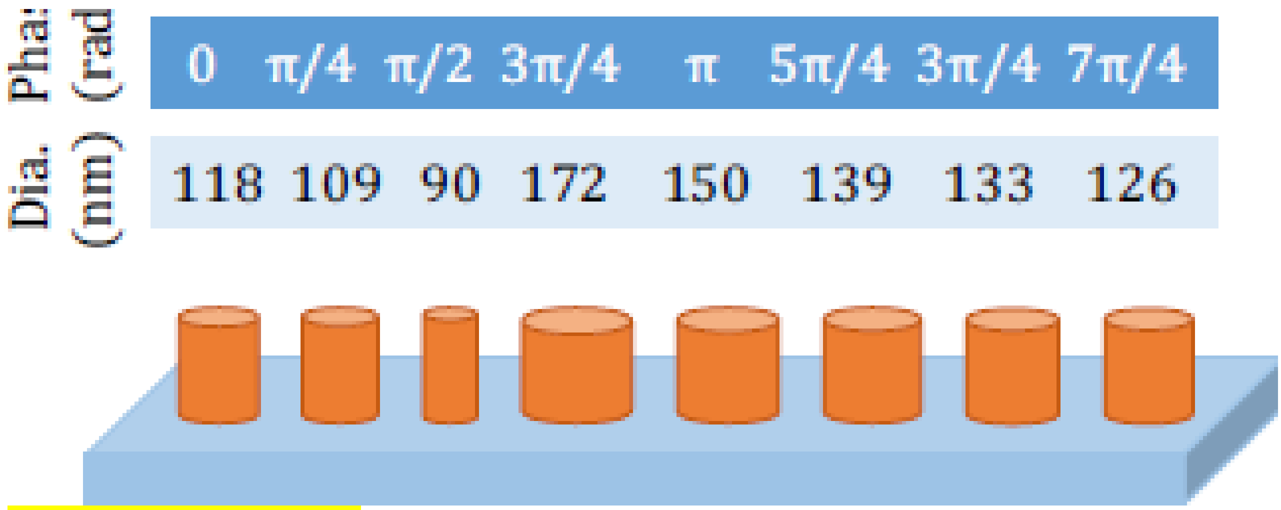
Figure 2(a)- Scanning electron microscopy (SEM)view of 15-disk supercell dependent metasurfaces with a physical length of 90 × 90 μm_2 [7].

Figure 2(b): Representation of the smaller supercell,which is made up of eight nanodisks, all of which are accountable for phase shifting between 0 to 2π in$1/4\pi$ increments [7].



Pha: (rad	0	π/4	π/2	3π/4	π	5π/4	3π/4	7π/4
Dia. (nm)	118	109	90	172	150	139	133	126

They created three distinct gradient metasurfaces with fifteen (2π phase response), eight (2π phase response), and fifteen (3π phase response) a-Si nanodisks that can accurately capture propagating wave angles. The disks are 80–192 nm in diameter at fifteen (2π phase response), as illustrated in Figure 2(a)[7]. The disks in eight (2π phase response) havediameters ranging from 90 to 172 nm, as indicated in Figure 2. (b). And in fifteen (3π phase response), alternating 8-disk unit cell and 7-disk unit cell placement to construct the multi- order 3π supercell metasurfaces[7]. It consists of an 8-disk unit cell metasurface dual-beam reflector with a deflection angle of θ1 and a 7-disk unit cell concealed surface beam reflector with a deflection angle of θ2.

As a result, the paper's author determined that the operating wavelength of a 15-disk supercell (2π phase) based gradient metasurface is 715 nm, as shown in Table 1[7].

- The numerically and experimentally realized deflection angles are 8.66° and 8.40°,respectively.
- The maximum transmission efficiency achieved numerically and experimentally is95% and 83%, respectively.
- The deviation efficiencies achieved numerically and empirically were 95% and 71%,respectively.

By shortening the supercell, we were able to reach an experimental deflection angle of 15.50°[7]. Waves from two separate supercells can be merged to efficiently bend the propagating wave. This also demonstrates that the optical signal could be modified using this approach, however only at a fixed angle, which is a drawback for devices in motion.

II. ACTIVE METAMATERIAL

The processes of digital tunable units have been reported to be controlled by an external direct supply (DC) and a series of interconnected wires, which may increase the complexity of the entire system and lead to challenges with controlling and moving metamaterials or digital coding metamaterials. The suggested light-controllable digital metasurface is made up of an array of controllable digital unit particles arranged in the x and y directions, as well as an array of photodiodes that provide light-controllable DC bias for the varactor diodes integrated in the digital particles, as seen in Figure 3, and it represents as an alternative solution to controlling EM waves in real-time and introduces new opportunities. The suggested digital particle's reflection phase may be dynamically adjusted by varying the intensity of the illuminating light [2].

Ref	Year	Frequency	Deflection angle/efficiency	bits
27	2012	3.06 GHz	11°	1-Bit
2	2018	3.75Hz	000000: ~10.2° 010101: ~8.4°	1-Bit
26	2020	5.6 GHz	00001111: ±45° 0000011111: ± 31° 00000000001111111111: ±15°	1-Bit

Table 2:- Comparision of parameters

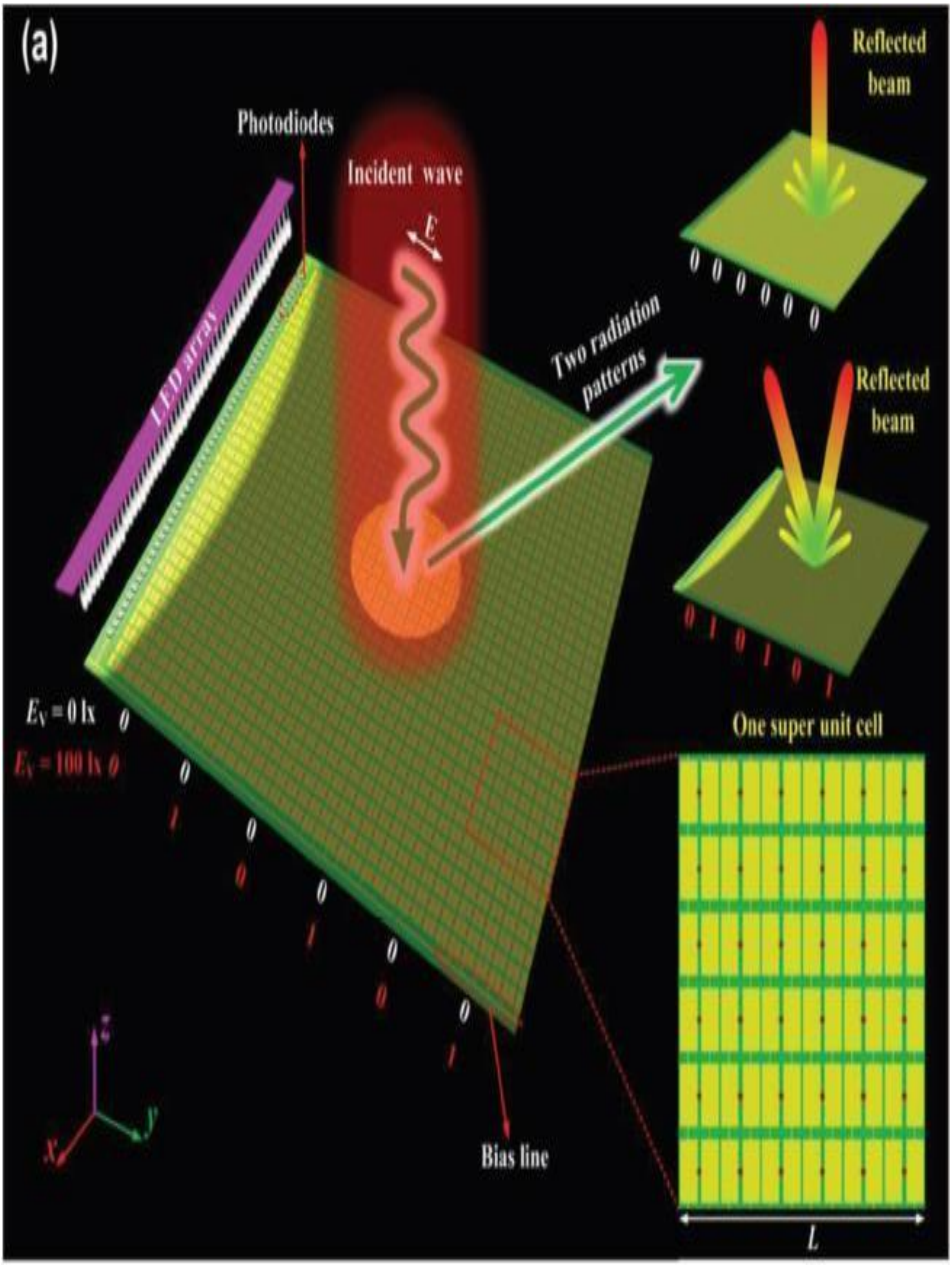


Figure 3:- The planned light-controlled digital coding metasurface is demonstrated. The voltage created by the photodiodes may be dynamically changed by remotely altering the intensity of the illuminating light. Whenever the luminous source intensity EV = 0 lx, it reflects rays of the light-controlled digital metasurface with the coding sequence "000000" are shown in the upper-right inset. When the luminous source intensity EV = 100 lx, it reflects rays of the light-controlled digital metasurface with the coding sequence "010101" are shown in the middle-right inset. Lower-right inset: a super unit cell built out of 6 × 6 digital particles. [2].

The coding sequence must be pre-designed before the signal is transmitted by the transmitted light array. The coding sequence is received by the photodiode array and subsequently transferred to the concealed surface, resulting in dynamic control of the incident waves through the digital coding interface with in microwave area. They propose and develop a digital particle, seen in Fig. 4, to create the desired light-controlled digital metasurface, whichconsists of two identical metallic areas on top and a metal ground on the bottom. Either metalareas includes two stubs at each end that act as bias lines. A varactor diode is put in the gap between the two symmetrical areas to realize adjustable features. We employ an array of silicon positive-intrinsic-negative (PIN) photodiodes working in photovoltaic function to supply DC reverse voltage (VR) to adjust the capacitance (CT) of the integrated varactor withlight[2].

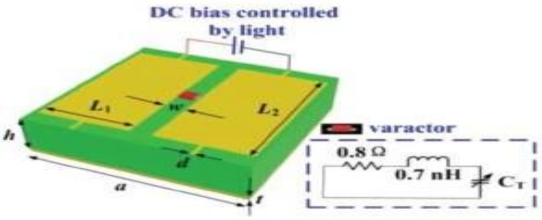


Figure 4:- The light-controllable digital metasurface's unit cell. The photodiodes, who were operated by an LED array system, provide the DC bias only for varactor. The equivalent analog circuits model of the varactor is illustrated in the inset. [2].

The light-dependent digital metasurface may be partitioned into 6 × 6 super unit cells, as illustrated in the inset of Figure 3. Every super unit cell is made up of 6 x 6 sub-particles. The numbers '0' and '1' can be used to describe the states of super unit cells. The sub-particle with a capacitor CT = 2.67 pF signifies the "0" unit in this simulation, while the sub-particle with a capacitor CT = 0.95 pF signifies the "1" unit [2]. An array of low-power light-emitting diodes (LEDs) is employed as the light source to stimulate the photodiodes. The voltage produced by photodiodes may be dynamically regulated by adjusting the intensity of light emitted, as shown in Figure 4.

To actualize the coding sequences '000000' and '010101,' the author links photodiode strings 2nd, 4th, and 6th to varactor diodes. As a result, the metasurface will behave as the sequence ‘000000' when the light intensity is 0 lx, resulting in a bias voltage of 0V, and as the sequence “010101” when the light intensity is 100 lx, resulting in a bias voltage of 10V [2]. As a result, the suggested approach may overcome the complex biased wired structure that is employed to control individual particle in the digital metasurface [2]. This is another convenient method for wireless communication using optical source with hassle-free designing.

III. DIGITAL METAMATERIAL

The current metamaterials are generally characterized by effective permeability and permittivity of continuous microscopic media by homogenous or inhomogeneous having periodic or non-periodic structures. The above feature of metamaterial is also known as ‘Analog metamaterials.' Whereas in a digital metamaterial, a particular material is responsible for achieving distinctly different functionalities when it is digitally controlled. For coding metamaterial, two types of the unit cell are introduced, i.e., 0 and π phase response for ‘0’ and ‘1’ element respectively for 1-bit digitally controlled technology. . The EM wave is manipulated by designing a coding sequence of elements "0" and "1" to obtain different functions. This idea can extend to 2 bits, 3 bits, or more.

The author of the presented work proposes coding metamaterials. They show their capacity to alter EM waves by applying unique coding sequences of '0' and '1' components of metamaterial particles [12]. They also proposed a biased diode for controlling either the '0' or '1' element to create a one-of-a-kind metamaterial particle. They build a digital metamaterial with a unique state of particle ‘0' or ‘1' that is controlled digitally using Field Programmable Gate Array (FPGA) circuitry. The author successfully illustrates a 'Programmable Metamaterial' through numerical simulations and tests, illustrating how the FPGA program can control a single digital metamaterial with a particular capacity for EM wave manipulation.

As shown in **Figure 5a**, an exclusive metasurface of 1-bit coding is composed of a binary element of ‘0’ or ‘1’ having a maximum phase difference of π (or 180⁰). As a result, they created ‘0’ element as a metamaterial having 0 phase response and ‘1’ element having π phase response in metamaterial particle[12].

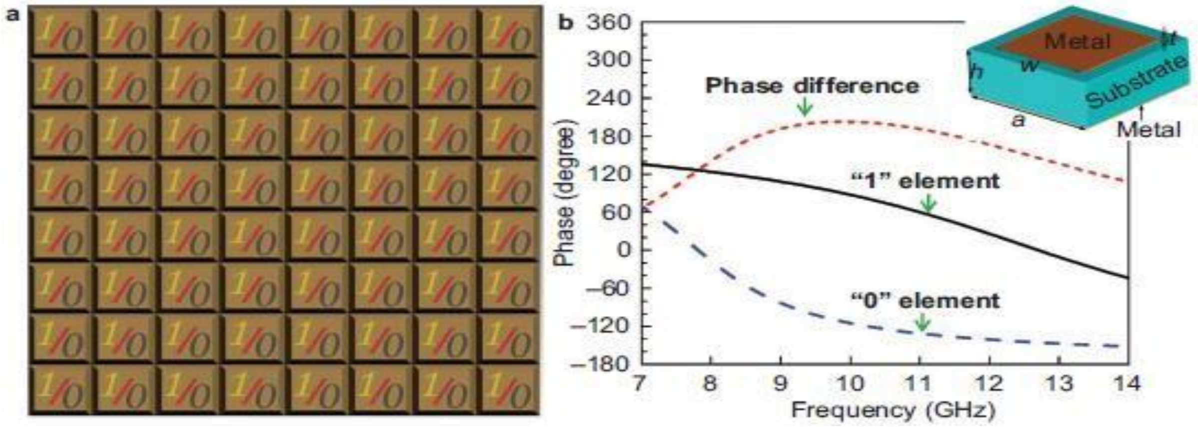


Figure5:- The 1-bit digital and coding metasurfaces. (a) The 1-bit digital metasurface is made up of just two kinds of elements: '0' and '1'. (b) A square metallic areas unit construction (inset) to implement the ‘0' and ‘1' components, as well as the accompanying phase responses throughout a wide frequency range[12].

As shown in **Figure 6a**, they proposed a unique metamaterial surface to control '0' and '1' responses digitally. The biased voltage is guided by DC voltage because the diode is 'ON' when the biased voltage is 3.3 V and 'OFF' when there is no biased voltage. As a result, whenthe diode is turned on, the metamaterial particle response is the ‘1' element, and when the diode is turned off, the response is the ‘0' element.

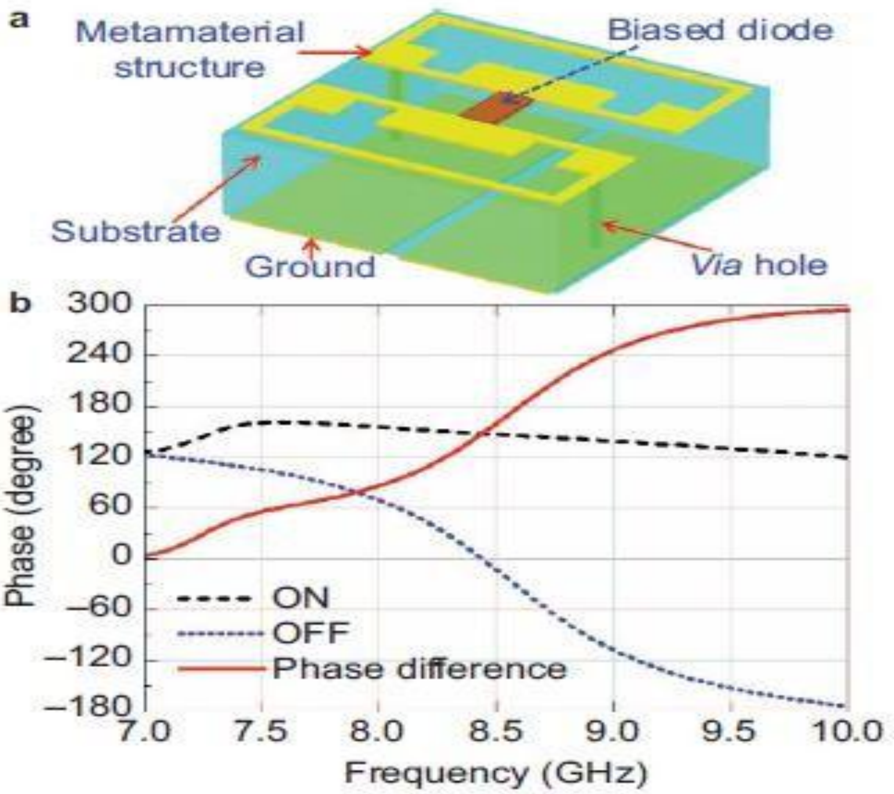


Figure 6:- A metamaterial particle utilized to construct the digital metasurface and its related phase responses. (a) The metamaterial particle structure, which acts as ‘0' and ‘1' elements whenever the biased diode is switched ‘OFF' and ‘ON', respectively. (b) The output responses of the metamaterial particle whenever the biased diode is switched between ‘OFF' and ‘ON' across a frequency range. [12].

The author used four coding sequences to verify the concepts: 000000, 111111, 010101, and001011. Figure 7 demonstrates the flow of the programmable metasurface induced by an FPGA. To validate the modified EM waves utilizing a single metasurface with numerous abilities, the experiment is carried out by activating a coding sequence of 000000, 111111, 010101, and 001011 with FPGA and measuring the scattering pattern of the 1D digital metasurface[12].

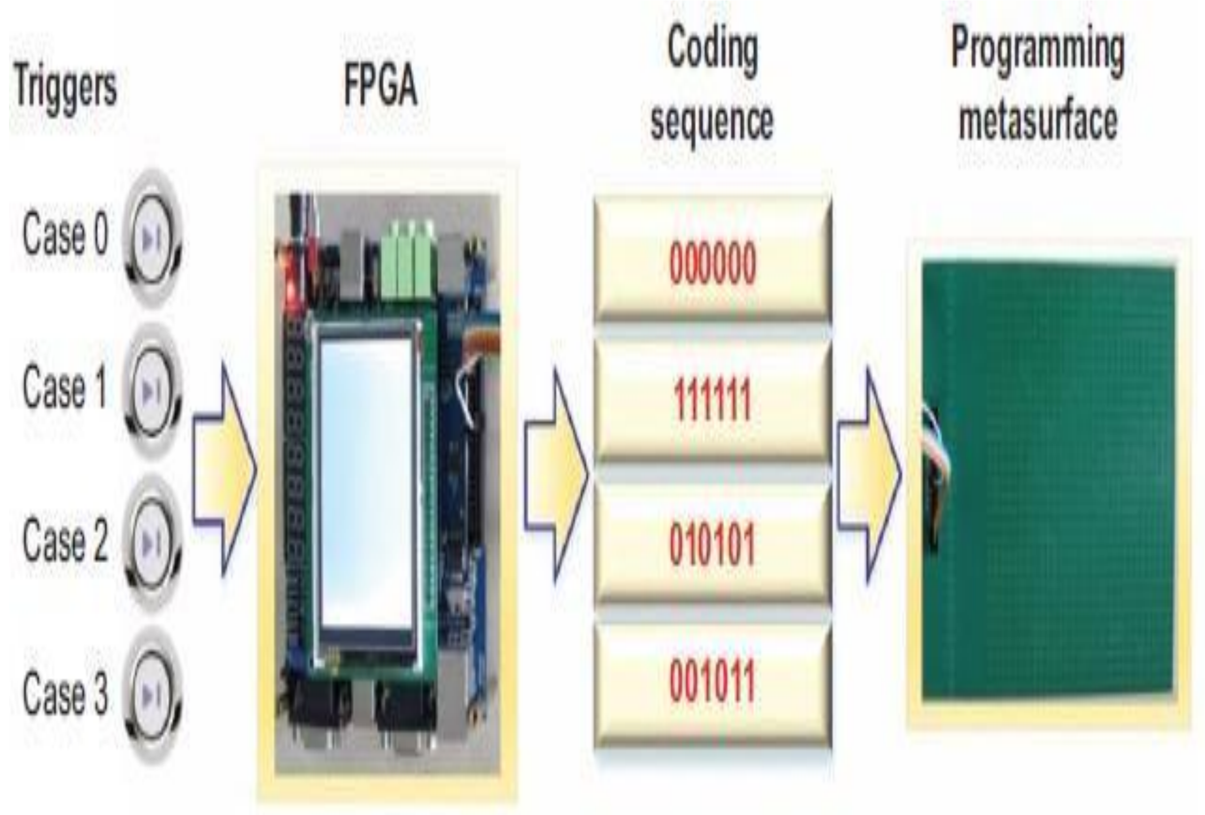


Figure 7:- A schematic for implementing a programmable metasurface using FPGA hardware. 1D is for one-dimensional; FPGA stands for field-programmable gate array. [12].

The computed and observed scattering patterns for the sequences 000000 and 111111 demonstrate that the reflected energy is focused on the central beam since they mimic precisely electric and magnetic conductors, respectively. Sequence 010101 successfully reflects incoming energy into two symmetric orientations, however sequence 001011 reflects energy in several directions, resulting in a decreased radar cross-section (RCS) (RCS). The per-stored intended coding pattern in FPGA with switching devices mounted on the metamaterial assists in attaining the needed coding pattern's rapid and programmable control flexible trigger.

The Field Programmable is the biggest advance in metamaterials development because to the following characteristics:

- A singular programmable metamaterial may execute numerous extremely different operations (e.g. single-beam radiation, variable multi-beam radiation, beam scanning, wave propagation, vortex beam generation) [6].

- FPGAs can perform real-time operations by altering the digital state and delivering instructions [6].

- Digital metamaterial links the physical and digital worlds, contributing in the creation of new information technology and driving metamaterials towards system-wide applications [6].

IV. SOFTWARE INTELLIGENT METAMATERIAL

To overcome the problems caused by the physical environment like signal absorption, free- space path loss, refractions, reflections, and diffractions, the HyperSurface tiles are introduced to control EM wave behavior over software in a wireless environment. The HyperSurface tile is a coating object in the indoor or outdoor environment in such as walls, furniture, etc., which can control EM waves routing in any desired direction, including polarization manipulation, full absorption, and more. It combines the network-controlled element with adaptive metasurface to attain the desired macroscopic behavior of EM wave also has connectivity capabilities for allowing it to get into control loops for adapting its performance.

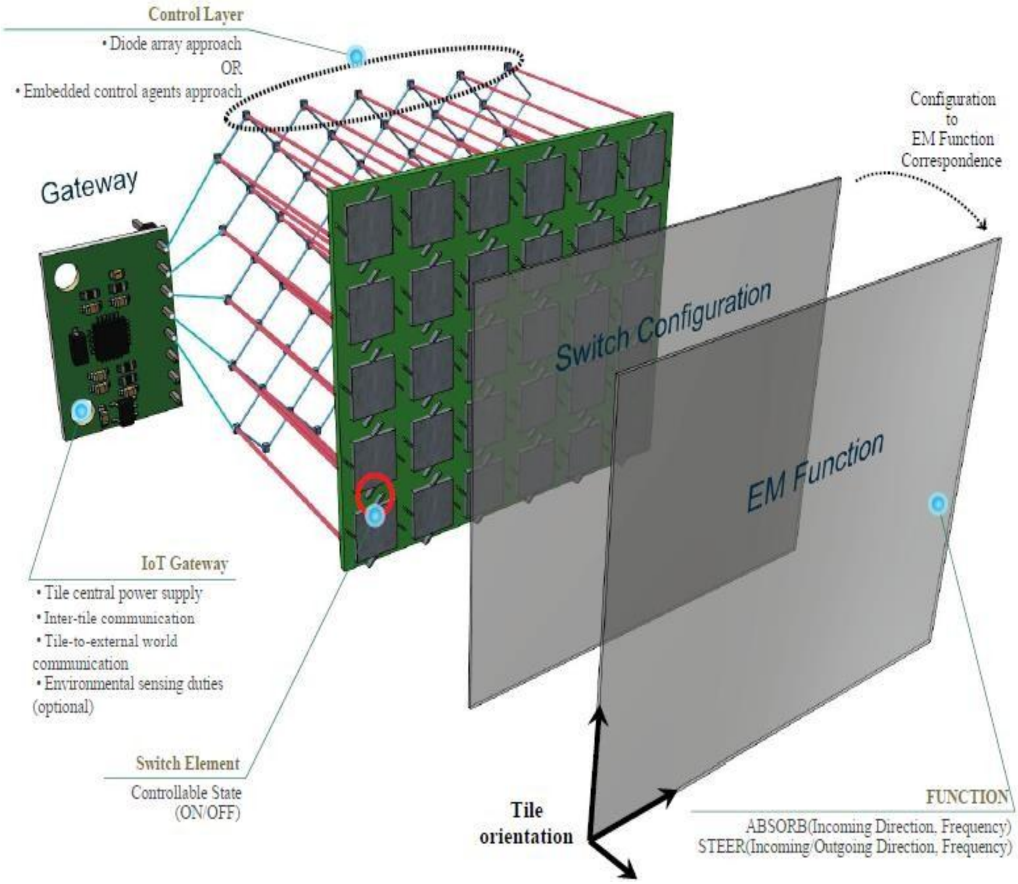


Figure 8:- A single HyperSurface tile's functional and physical design. A switch state configuration arrangement achieves a desired and supported EM function. Standard gateway hardware handles inter-tile and external communication. [3].

Environment Configuration Service Workflow:- In traditional networking, the EM waves propagation similar to routing can handle by a HyperSurface-enveloped environment. The key challenge with wireless devices is determining a path for two connected devices across HyperSurface tiles that have software commands that are merged and transmitted to suitable tile gateways that allow absorbing, guiding, and focusing them on altering EM emissions. The network embedding challenge is determining the best air routes to construct a continuous loop with a device location detection system that gets the updated position of the user's device and alters the wireless environment's behavior appropriately [3]. If the device is determined to be unauthorized, a "block" target is created for it. Authorized devices which are familier of the programmable environment can make a request to setup the service to specify their specific targets[3]. When the environment creation service receives the command to gateway tile, it builds a corresponding air route and has control over theinfrastructure access points' beamforming capabilities. [3] Formal imitation On the user's device, beamforming automatically adapts by examining and choosing the optimal beam the ideal beam direction using the device's usual method [3].

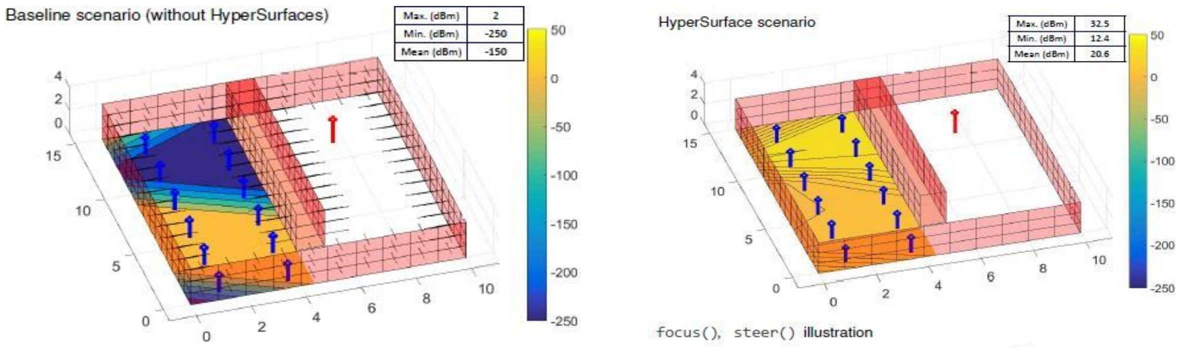


Figure 9:- Simulation findings for a research on wireless environment optimization at 60GHz. The coverage in the non-HyperSurface configuration is insufficient (top). The addition of HyperSurfaces (middle) considerably enhances total signal coverage and received power. [3].

The current work allowed programmatic control of the wireless environment's electromagnetic behavior. A HyperSurface tile, which is a planer material that can interact with collision waves in a programmed fashion, is covered in large items such as walls and furniture, both indoor and outdoor. After integrating it with a programmable wireless environment, tiles with qualities such as wave absorption and orientation in assigned directions are linked and managed by an external service, which builds and publishes a layoutthat assists end users [3]. It is possible to analyze it through simulation, demonstrating the remarkable potential of this novel concept.

V. CONCLUSION

To accomplish the criteria of increased signal strength, maximum coverage, very low power and cost, amazing dependability, enormous connection, and low latency for wireless communication, we must control the environment or the signal. For many years,metamaterials have been developed for a wide range of applications in both 3D and 2D environments, as well as in a number of frequency bands such as microwave, terahertz, infrared, and optical. We examined the most current metasurface research and applications at optical frequency. This article discusses electromagnetic wave modification at optical frequencies to improve data rate and coverage, low power and cost, high dependability, wide connection, and low latency for wireless communication. Because it operates over a wide frequency range, is simple to fabricate, and is light in weight, we discovered that a metamaterial classified into four phases, namely passive metamaterials, active metamaterials, digital materials, and intelligent metamaterials, successfully processed EM waves in thedesired path using optical frequency range foe wireless communication.

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