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Comparison of Frequency Selective Surfaces and Metamaterials

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Abstract:
This paper makes a clear comparison between frequency selective surfaces (FSS) and metamaterials. The characteristics of both FSS and metamaterial are discussed in this paper. Various applications and uses of both structures has been discussed. Both of them are used in the application of antennas. They are used to provide desired frequency responses. FSS and metamaterials show properties which can be used to manipulate the wave fronts. Usually structures are designed using metamaterials and FSS to work in electromagnetic spectrum. Amplitude, frequency and phase of the electromagnetic waves can be manipulated by metamaterials. Metamaterials show properties that are not usually found in nature. FSS is an assembly of identical planar structures which behave as an EM filter. FSS are frequency selective in nature. Different design and orientation of both FSS and metamaterials gives different properties and phenomena's. The main difference between FSS and metamaterials arise from the structure of FSS and elements of metamaterials. The selection of FSS and metamaterials depends upon the type of applications such as reflection or transmission in a particular frequency range or absorption in a particular frequency range. This paper aims at highlighting the major differences between FSS and metamaterials based on their different applications in different fields.

Keywords: electromagnetic spectrum**,** FSS, metamaterials, planar structures, wave fronts

I. INTRODUCTION

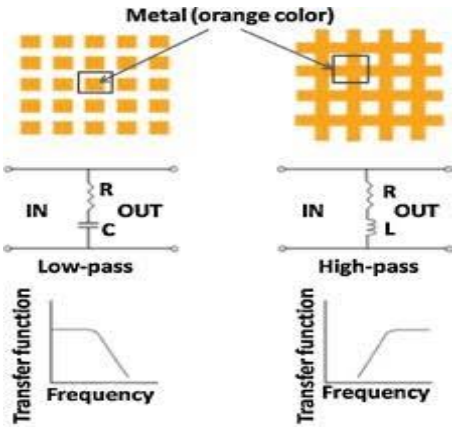
Frequency selective surfaces or FSS are planar periodic structures that repeats either in one dimension or in two dimensions. It consists of elements which are called unit cells that repeats in a uniform manner. The size, shape and the spacing between the elements determine the resonance of FSS structures. They can reflect transmit or absorb the electromagnetic radiations that are incident on them. The resonance also depends on the angle of incidence and polarization. The dielectric which is used to support the FSS structures also affect the resonance. There are mainly two types of FSS which are the slot type and patch type FSS.

Properties which are not seen naturally can be obtained by using metamaterials. Metamaterials enables people to construct devices that can manipulate wave fronts. Thus, desired properties can be obtained. Properties like negative refraction (negative permeability and permittivity) can be obtained. Perfect lens and invisibility cloaking are the major advantages of metamaterials. Metamaterials are three dimensional materials that have negligible layer thickness.

II. STRUCTURE OF FSS

FSS are two dimensional structures. The slot type and patch type FSS shows different resonance characteristics. The slot type FSS shows the opposite resonance of its complementary patch type FSS. the patch type FSS act as a low pass filter while its complementary slot type act as a high pass filter. when both effects are combined it gives a flat response. FSS act as a band pass or band stop filter depending on the shape of elements. Different shapes of element give different resonance. Figure 1(a) shows the patch type FSS and figure 1(b) shows the slot type FSS and their frequency response.

FSS are usually fabricated by etching the elements on to a dielectric for a patch type FSS. The elements are usually a highly conducting metal like gold. The elements are supported by a dielectric material like Teflon or f4-B2. For slot type FSS, the corresponding shape of the FSS is cut out from a metallic sheet.



(A) (B)

FIGURE 1. STRUCTURE OF FSS (A) PATCH TYPE FSS (B) SLOT TYPE FSS

III. APPLICATIONS OF FSS

There are different fields of FSS application. Mainly its application comes in design of antenna. FSS helps in operating antenna's in their desired frequency range by selectively trans mitting or reflecting the electromagnetic waves by using the frequency selectivity property of FSS. FSS are used in radomes, which are structures used to protect satellites or stations. The FSS structures on radomes reflect all the undesired frequencies and only pass the desired frequency. Another major application is in stealth technology which is used to make aircrafts or warships less visible to the radar signal by reducing the radar cross sectional area of the aircraft. FSS are usually used at the front door of microwave oven for preventing the harmful waves from coming out of the oven but the same time allowing visible light to go into the oven.

IV. STRUCTURE OF METAMATERIAL

Metamaterials are three dimensional periodic structures composed of structures called unit cell. Unit cell is combination of split ring resonators (SRR) and wire structure.

An array of unit cell is used to create a metasurface. Figure 2 shows the combination of wires and SRR.

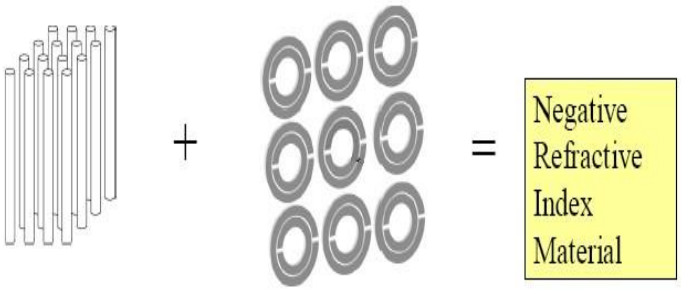


FIGURE 2: COMBINATION OF THIN WIRES AND SRR

SRR has two concentric metallic rings, with gap in each ring. Gap between inner and outer ring acts as capacitor. The rings act as inductor. This results in LC resonant circuit.

FIGURE 3: STRUCTURE ARRAY

V. APPLICATIONS OF METAMATERIALS

The main applications of metamaterials include invisibility cloaking, phase compensation, negative refraction.

Cloaking is achieved by guiding the electromagnetic waves around an object thus making the object inside invisible. Figure 4 shows the invisibility cloaking.

Phase compensation is achieved by passing wave through double positive surface (DSP) and then through double negative surface (DNG).DSP has positive phase shift while DNG has negative phase shift. This gives zero phase difference.

Metamaterial are also used for manufacturing antennas with enhanced power reduced size and high directivity. They are also used in absorber, sound filters and sensors for variety of applications.

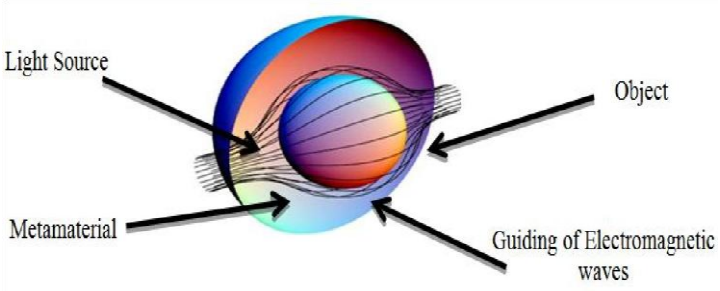


FIGURE 4: INVISIBILITY CLOAKING

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