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基于电阻膜的雷达吸波超材料设计和宽频隐身研究

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Summary. *Resistive film is a class of films with resistive properties, which can be used in the manufacture of wave-absorbing metamaterials. The resistive film metamaterial absorber has the advantages of wide absorption frequency band and thin absorber thickness [1]. It has broad application prospects.*

Indium tin oxide (ITO) is a displacement solid solution with electrical conduction and other properties, mostly used in electronic components, its thin film can be deposited to the surface of the dielectric layer by sputtering deposition technology. It can be used for the design of absorbers of resistive film metamaterials. The indium tin oxide (ITO) thin film metamaterial absorber consists of an indium tin oxide (ITO) film periodic array pattern layer, a dielectric substrate, and a metal base plate multilayer structure coated on the substrate surface. Indium tin oxide resistive film widens the absorbing frequency band through resistive loss and resonance, and realizes the broadband absorption of electromagnetic waves. In the case of multilayer structure composite, as shown in fig. 1(a), the absorption band of indium tin oxide (ITO) thin film metamaterial absorber can reach 3.16~51.6 GHz. The maximum relative absorption bandwidth can even reach 176.9 %. Compared with traditional absorbing materials, indium tin oxide (ITO) thin film metamaterial absorbers have the advantages of absorption frequency bandwidth and insensitivity to polarization, with strong practicality.

Graphene conductive ink is a material with resistance film characteristics, with high conductivity, high toughness, high strength and other characteristics, which is also used in the design of metamaterial absorbers. This type of metamaterial absorber is composed of a graphene conductive ink resonant unit, a dielectric layer and a reflective backplane printed on the dielectric isolation layer, and the structure is the same Indium tin oxide (ITO) resistive film type metamaterial absorbers are similar.

The main advantage of metamaterial absorbers based on graphene conductive ink is that they can be applied to flexible structures, as shown in fig. 1(b), under the bending shape test, the absorption performance of the absorber is not greatly affected. Broadband absorption and polarization insensitivity can still be achieved. Compared with indium tin oxide (ITO) thin film structure absorbing metamaterials, graphene conductive ink absorbing metamaterials not only have broadband electromagnetic absorption, but also polarization insensitivity and other excellent performance [4], but also has the characteristics of light and thin and bendable, in various fields have broad application prospects.

Conductive plastic film is a new type of organic resistance film material, the biggest advantage of the metamaterial absorber based on it is that the resonant structure of the conductive plastic film in the middle layer and the dielectric substrate can be processed independently, this building block building processing scheme not only saves preparation time, but also makes the choice of substrate material no longer restricted by resistance film processing. Compared with the resistive film structure based on conductive ink, the conductive plastic film metamaterial absorber can not only overcome the influence of uneven ink thickness and counterimpedance during processing, but also be compatible with laser etching process and improve the processing accuracy of the resonant structure. As shown in fig. 1(c), its relative absorption bandwidth can reach 106.8 %, which can achieve efficient absorption in the 5~25 GHz band, and It is not sensitive to the polarization characteristics of incident waves, and can still achieve broadband absorption for wide- angle incident electromagnetic waves. In addition, the conductive plastic film can be compatible with the laser etching process, and its easy-forming properties make the preparation more accurate, improve the processing accuracy of the resonant structure, and also achieve the same thinness and light structure as other materials and other advantages, which provide new ideas for the development of broadband metamaterial absorbers.

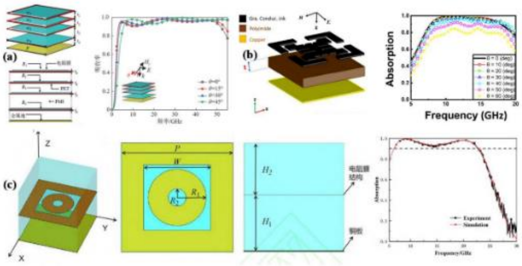

Figure 1 – relative absorption bandwidth: a – Indium tin oxide (ITO) thin film metamaterial absorber [2]; b – Graphene ink metamaterial absorber [3]; c – Conductive plastic film metamaterial absorber [5]

Since the emergence of electromagnetic absorbing materials, the research of various electromagnetic absorbing materials has made great progress, and the research and design have become increasingly mature. From the original traditional absorbing materials based on inorganic substances such as ferrite to metamaterial absorbers based on artificial resonant structures, researchers have continuously improved the performance of absorbing metamaterials through the improvement of materials and the perfection of processes. However, in terms of large-area radar stealth, there are still some shortcomings of absorbing metamaterials, such as insufficient absorption band, difficult to achieve wide incidence angles, etc. It is necessary to further improve the design of metamaterial absorbers by improving the structure of metamaterials absorbers and selecting more efficient processes, and its research prospects are still very broad.

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Summary. *In this paper, a radar absorbing metamaterial structure is designed, which consists of an upper layer of resistance film and a bottom layer of metal base plate, and the middle dielectric layer is omitted. The thickness of the resistance film is 100 nm, and the thickness of the metal plate is 1mm. The calculation results of CST Microwave Studio 2021 electromagnetic simulation software show that the absorption ratio is more than 99 % in the frequency range of 2~18 GHz, and the relative bandwidth reaches 100 %.*

In the national defense and military affairs, in order to realize the long-distance camouflage of weapons, wave absorbing materials are widely used in stealth technology of aircraft, tanks, ships,