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ABSTRACT

Involving a wireless power transmission system, the invention discloses a multimode frequency modulated wireless power transmission system based on artificial magnetic conductor, which comprises an artificial magnetic conductor (AMC), a non-resonant exciting coil and a non-resonant receiving coil. Sequentially arranged above the AMC, the non-resonant exciting coil and the non-resonant receiving coil transmit wireless power through near-magnetic field coupling. The AMC consists of multiplayer ceramic chip capacitors, square copper patches, copper plating holes, dielectric plate and copper base. The chip capacitors are loaded on the gap between two adjacent square copper patches, and a dielectric plate is laid between the copper base and the square copper patches. There are a plurality of modes in the invention corresponding to a plurality of operating frequencies of the whole wireless power transmission system. Therefore, the wireless power transmission system can have multiple high-efficiency operating frequencies, which means that wireless power transmission system can work with multiple frequencies and frequency modulation.

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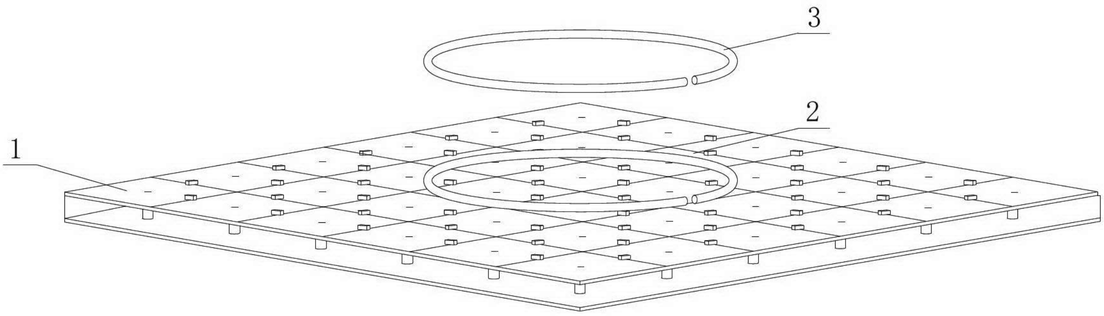


Figure 1
A schematic structural diagram of the present invention

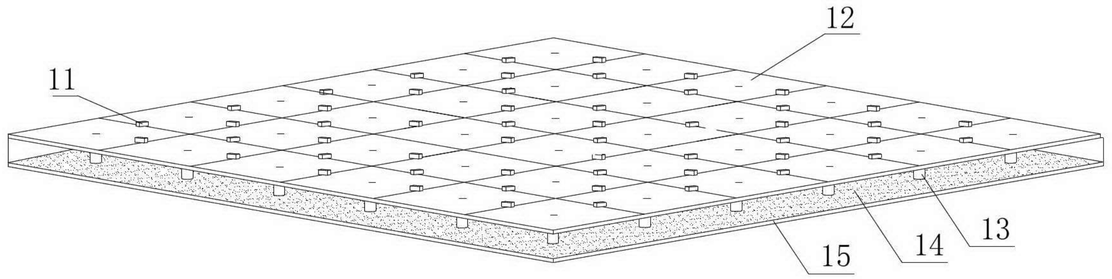
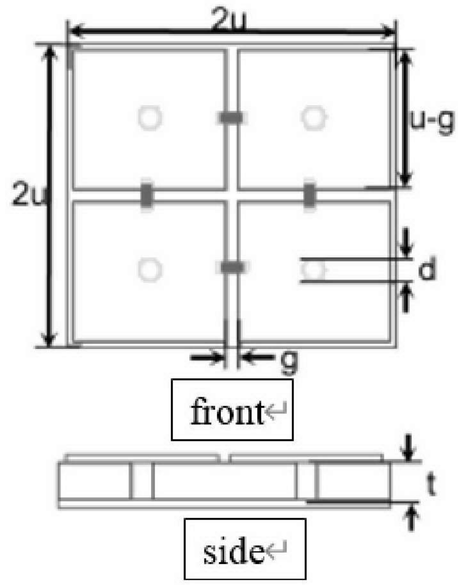


Figure 2
A schematic structural diagram of the AMC in the present invention



Name	Unit(mm)
u	58
g	1
d	1
t	5

Figure 3
A schematic diagram of the unit structure of the AMC in the present invention

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Wireless power transmission device

TECHNICAL FIELD

[01] The invention relates to a wireless power transmission system, in particular to a multimode frequency modulated wireless power transmission system based on an AMC.

BACKGROUND

[02] In recent years, the wireless communication industry has developed rapidly. Mobile communication can directly transmit a large amount of data for us through wireless transmission when we use computers and smart devices. Based on existing information and communication technology, computer technology, internet technology and big data applications, the Internet of Things and artificial intelligence will become potential applications in the future. However, the Internet of Things and artificial intelligence cannot be separated from energy supply and put forward higher requirements for the convenience of power supply. The Internet of Things and artificial intelligence that we need is not that the device takes the plug to charge itself and requires us to wait or backup more devices. The ideal state is that they can supplement energy in time without space limitation. Wireless power transmission is undoubtedly a practical and suitable solution to realize timely energy supplement without space limitation. Compared with the traditional power supply by wire, wireless power transmission has many advantages, such as convenience, expansibility of power supply capacity and unique security in some aspects. Convenience is the most prominent characteristic. Free from the time and space constraints, such as wire length and number, battery capacity and battery charging time, the use of electrical equipment will be flexible and convenient. With regard to the expansibility of power supply capacity, it is too expensive, inconvenient or difficult to supply power in traditional ways, but wireless power supply can be a good solution, for example, the implantation of medical electronic treatment equipment and a large number of distributed wireless sensing micro-devices. The security is mainly reflected in that it can avoid the electric spark of exposed wires and interfaces when they are electrified.

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[03] There are various ways of wireless power transmission. According to the wireless transmission medium, they can be divided into magnetic field coupling type, electric field coupling type, electromagnetic wave coupling type and mechanical wave coupling type. Electric field coupling and magnetic field coupling are mainly used for short-distance wireless power transmission. Generally, with the same field strength, magnetic field is much safer than electric field, and non-radiation field is safer than radiation field. Therefore, wireless power transmission with magnetic field coupling has a wide range of related contents. Electromagnetic wave coupling, with microwave, laser and other wireless power transmission modes, is mainly used in long-distance wireless power transmission. Mechanical wave coupling wireless power transmission is mainly used when the first three methods are not suitable. Nowadays, wireless power transmission with magnetic resonant coupling is the most suitable wireless power transmission technology to be applied. The application of wireless power transmission technology should consider many factors such as transmission efficiency, transmission distance, transmission power, security risks, cost and so on, while more technical support is needed for specific application details. For example, it is do convenient when wireless power can be transmitted, but the ownership and permission of energy should be considered. For example, if there are many magnetically coupled wireless power transmission under resonance conditions, it should be noted that the objects in working environment should not have metal rings. Especially, when the resonant frequency of some unexpected objects is equal to the frequency of wireless power transmission system, we need to make protective measures with relevant technologies so as to avoid accidental resonance damage, waste of energy, or overheating causing fire.

SUMMARY

[04] The purpose of the invention is to provide a multimode frequency modulated wireless power transmission system based on AMC. There are multiple modes that can work or switch to work simultaneously, so as to cope with the unexpected resonance object entering the wireless power supply area to avoid accidental loss and solve the problems raised in the above background technology.

[05] To achieve the above purpose, the present invention provides the following technical scheme.

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[06] The multimode frequency modulated wireless power transmission system based on AMC, comprises an AMC, a non-resonant exciting coil and a non-resonant receiving coil, wherein the non-resonant exciting coil and the non-resonant receiving coil are sequentially arranged above the AMC and transmit wireless power through near-magnetic field coupling.

[07] The AMC consists of multiplayer ceramic chip capacitors, square copper patches, copper plating holes, dielectric plate and copper base. Square copper patches are arranged with each other to form a square block. Between square block and copper base, there are copper plating holes arranged. The chip capacitors are loaded on the gap between two adjacent square copper patches and a dielectric plate is laid between the copper base and the square copper patches.

[08] Further, the size of AMC is 348 mm×348mm, which can be adjusted according to the required size and frequency band for specific applications.

[09] Further, the capacitance value of the multiplayer ceramic chip capacitors in embodiment is 4.7nf, and for specific applications, capacitors with other capacitance values can be selected according to the required operating frequency band of the wireless power transmission system.

[010] Further, there are 36 square copper patches with side length of 57mm and copper foil thickness of 0.035, besides, the gap width between two adjacent square copper patches is 1mm.

[011] Further, the diameter of the copper plating hole is 1mm and the thickness is 0.0175 mm.

[012] Further, the dielectric plate can be any kind of dielectric plate in the market, and the dielectric plate in embodiment is F4B250.

[013] Further, the size of copper base is 348 mm×348mm, and the thickness of copper foil is 0.035 mm.

[014] Further, the non-resonant exciting coil and the non-resonant receiving coil are both non-resonant circular metal copper rings.

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[015] Compared with the prior art, the invention has following beneficial effects.

[016] 1. The multimode frequency modulated wireless power transmission system based on AMC comprises an AMC equipping multiplayer ceramic chip capacitors. Under the excitation of non-resonant exciting coil emitting near-magnetic field, each resonance unit of AMC will vibrate and then they will be coupled with each other, and multiple modes will be obtained after coupling. These modes correspond to multiple operating frequencies of the whole wireless power transmission system. The system of the present invention can have multiple wireless power supply modes to work at the same time, thereby multiple devices can access different modes to receive electric energy, so as to avoid inefficient work caused by multiple devices sharing one operating frequency. Therefore, the wireless power transmission system can have multiple high-efficiency operating frequencies, which means that the wireless power transmission system can work with multiple frequencies and frequency modulation.

[017] 2. There are multiple resonant modes for the multimode frequency modulated wireless power transmission system based on AMC. Based on this, objects having the same accidental resonance frequency with operating frequency can pass through by switching operating frequency of the system, thus avoid accidental resonance damage, waste of energy, or overheating causing fire.

[018] 3. The invention can be combined with application of magnetic coupling wireless power transmission system with simple technological process.

BRIEF DESCRIPTION OF THE FIGURES

[019] Figure. 1 is a schematic structural diagram of the present invention.

[020] Figure. 2 is a schematic structural diagram of the AMC in the present invention.

[021] Figure. 3 is a schematic diagram of the unit structure of the AMC in the present invention.

[022] Figure. 4 is a physical diagram of the AMC in the present invention.

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[023] Figure. 5 is a reflection coefficient diagram of special materials obtained by simulation calculation and experimental test of the present invention.

[024] Figure. 6 is a transmission coefficient diagram of special materials obtained by simulation calculation and experimental test of the present invention.

[025] Figure. 7 is a simulation diagram of AMC surface magnetic field intensity distribution under different modes of the present invention.

[026] Figure. 8 is an experimental diagram of AMC surface magnetic field intensity distribution under different modes of the present invention.

[027] Figure. 9 is a simulation diagram of magnetic field intensity distribution on AMC side under different modes of the present invention.

[028] In figures, 1- AMC, 11- multiplayer ceramic chip capacitors, 12- square copper patches, 13- copper plating hole, 14- dielectric plate, 15- copper base, 2- non-resonant exciting coil, 3- non-resonant receiving coil.

DESCRIPTION OF THE INVENTION

[029] The technical scheme in the embodiments of the present invention will be described clearly and completely with reference to the drawings in the embodiments of the present invention. Obviously, the described embodiments are only parts of the embodiments of the present invention, not all of them. Based on the embodiments of the present invention, all other embodiments obtained by ordinary technicians in the field without creative labour belong to the scope of protection of the present invention.

[030] Referring to Figs. 1-4, a multimode frequency modulated wireless power transmission system based on AMC comprises an AMC (1), a non-resonant exciting coil (2) and a non-resonant receiving coil (3). Wherein, the non-resonant exciting coil (2) and the non-resonant receiving coil (3) are sequentially arranged above the AMC (1), and the non-resonant exciting coil (2) is closer to AMC (1). The non-resonant exciting coil (2) and the non-resonant receiving coil (3) are both non-resonant circular metal copper rings, with the same size of 150mm ring diameter and 2mm copper diameter. The size of AMC (1) in embodiment is 348 mm×348mm, which can be adjusted according to the required size and frequency band for specific applications.

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The non-resonant exciting coil (2) and the non-resonant receiving coil (3) transmit wireless power through near-magnetic field coupling. The magnetic field generated by the non-resonant exciting coil (2) excites the resonance of one unit in the AMC (1), which can control the distribution area and intensity of the near-magnetic field, so as to realize multimode frequency modulated wireless power transmission. As each resonant unit of the AMC is subject to electromagnetic vibration, the resonance elements are coupled with each other, and the distribution of magnetic field varies with the coupling results at different frequencies. Some frequency bands with very similar magnetic field distribution belong to a mode, besides, the operating frequency used in wireless power transmission system is the frequency corresponding to the highest transmission efficiency in one mode. The frequency band refers to a band with a very similar magnetic field in the same mode. The frequency corresponds to a frequency with the highest wireless power transmission in the same mode. It is necessary to point out that there are multiple modes corresponding to different magnetic field distributions, meanwhile, the efficiency of wireless power transmission is different according to the different operating frequency.

[031] The AMC (1) consists of multiplayer ceramic chip capacitors (11), square copper patches (12), copper plating holes (13), dielectric plate (14) and copper base (15). The size of copper base (15) is 348 mm×348mm, and the thickness of copper foil is 0.035 mm. With double-faced copper-clad plate and single side etching, the square copper patches (12) are periodic arrangement in one side and they are arranged with each other to form a square block in the same size as copper base (15). There are 36 square copper patches (12) with side length of 57mm and copper foil thickness of 0.035, besides, the gap width between two adjacent square copper patches (12) is 1mm. Chip capacitors (11) are loaded on these gaps, with capacitance value of 4.7nf in embodiment, and for specific applications, capacitors with other capacitance values can be selected according to the required operating frequency band of the wireless power transmission system. Between square block and copper base (15), there are copper plating holes (13) with diameter of 1mm and thickness of 0.0175mm. A dielectric plate (14) is laid between the copper base (15) and the square copper patches (12), which can be any kind of dielectric plate in the market. The function of dielectric plate is to be a medium. There is no need to make specific requirements for its permittivity, and the

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actual selection is based on the principle of low cost. In embodiment of this invent, the dielectric plate is F4B250, with permittivity of 2.5.

[032] The reflection curve and transmission curve of the system obtained by CST simulation and experimental tests are shown in Fig. 5 and Fig. 6 respectively. The frequency range of simulation and experiment is 20-40MHz. It can be seen from the reflection curve that there are five valleys corresponding to five mode frequency bands. When chose the frequency corresponding to the lowest valley value of each mode as the operating frequency of wireless power transmission, the energy fed into the source is the most. From the transmission curve, it can be seen that the transmission coefficient corresponding to the frequency with the largest feeding energy is not the highest among the corresponding modes, but the overall trend is that the reflection coefficient corresponding to the frequency with low reflection curve value will be larger, and the maximum transmission coefficient value will be deviated due to the specific magnetic field distribution. In practical application, the frequency with the highest transmission coefficient in each mode is the operating frequency of the corresponding mode of wireless power transmission.

[033] There are multiple wireless power transmission modes and it can be noted from Fig.7, Fig.8 and Fig.9 that the distribution of AMC front surface field is different in different modes, wherein in the same mode, the corresponding field distribution is very similar, and in different modes the difference of field distribution is obviously larger.

[034] The corresponding frequency in each wireless power transmission mode of the present invention is the resonant frequency generated by the coupling of the units of the AMC. The wireless power transmission system operating at these resonance frequencies can improve the transmission efficiency and extend the transmission distance. For each of these modes, wireless power transmission can be effectively carried out.

[035] In conclusion， the multimode frequency modulated wireless power transmission system based on AMC comprises an AMC (1) equipping multiplayer ceramic chip capacitors (11). Under the excitation of non-resonant exciting coil emitting near-magnetic field, each resonance unit of AMC (1) will vibrate and then they

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will be coupled with each other, and multiple modes will be obtained after coupling. These modes correspond to multiple operating frequencies of the whole wireless power transmission system. The system of the present invention can have multiple wireless power supply modes to work at the same time, thereby multiple devices can access different modes to receive electric energy, so as to avoid inefficient work caused by multiple devices sharing one operating frequency. Therefore, the wireless power transmission system can have multiple high-efficiency operating frequencies, which means that the wireless power transmission system can work with multiple frequencies and frequency modulation. There are multiple resonant modes for the multimode frequency modulated wireless power transmission system based on AMC. Based on this, objects having the same accidental resonance frequency with operating frequency can pass through by switching operating frequency of the system, thus avoid accidental resonance damage, waste of energy, or overheating causing fire. The invention can be combined with application of magnetic coupling wireless power transmission system with simple technological process and low cost.

[036] The above is only a better specific embodiment of the invention, but the protection scope of the invention is not limited to this. On the premise of not departing from the design spirit of the invention, various modifications and improvements made to the technical scheme of the invention by technical personnel familiar with the technical field shall fall within the protection scope of the invention.

[037] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms, in keeping with the broad principles and the spirit of the invention described herein.

[038] The present invention and the described embodiments specifically include the best method known to the applicant of performing the invention. The present invention and the described preferred embodiments specifically include at least one feature that is industrially applicable

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Based on AMC, a multimode frequency modulated wireless power transmission system comprising an AMC (1), a non-resonant exciting coil (2) and a non-resonant receiving coil (3), characterized in that the non-resonant exciting coil (2) and the non-resonant receiving coil (3) are sequentially arranged above the AMC (1) and transmit wireless power through near-magnetic field coupling.

The AMC (1) consists of multiplayer ceramic chip capacitors (11), square copper patches (12), copper plating holes (13), dielectric plate (14) and copper base (15). Square copper patches (12) are arranged with each other to form a square block. Between square block and copper base (15), there are copper plating holes (13) arranged. The chip capacitors (11) are loaded on the gap between two adjacent square copper patches (12) and a dielectric plate (14) is laid between the copper base (15) and the square copper patches (12).

2. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that the size of AMC (1) is 348 mm×348mm, which can be adjusted according to the required size and frequency band for specific applications.

3. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that the capacitance value of the multiplayer ceramic chip capacitors (11) in embodiment is 4.7nf, and for specific applications, capacitors with other capacitance values can be selected according to the required operating frequency band of the wireless power transmission system.

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4. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that there are 36 square copper patches (12) with side length of 57mm and copper foil thickness of 0.035, besides, the gap width between two adjacent square copper patches (12) is 1mm.

5. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that the diameter of the copper plating hole (13) is 1mm and the thickness is 0.0175 mm.

6. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that the dielectric plate (14) can be any kind of dielectric plate in the market, and the dielectric plate in embodiment is F4B250.

7. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that the size of copper base (15) is 348 mm×348mm, and the thickness of copper foil is 0.035 mm.

8. The multimode frequency modulated wireless power transmission system based on AMC according to claim 1, characterized in that the non-resonant exciting coil (2) and the non-resonant receiving coil (3) are both non-resonant circular metal copper rings.

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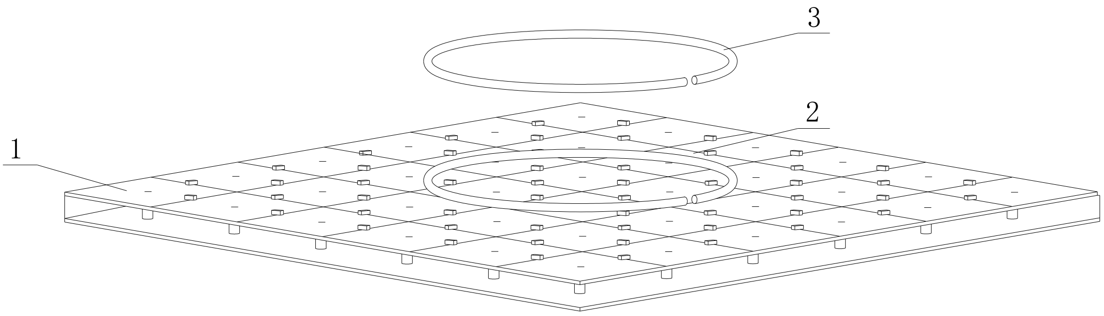


Figure 1
A schematic structural diagram of the present invention

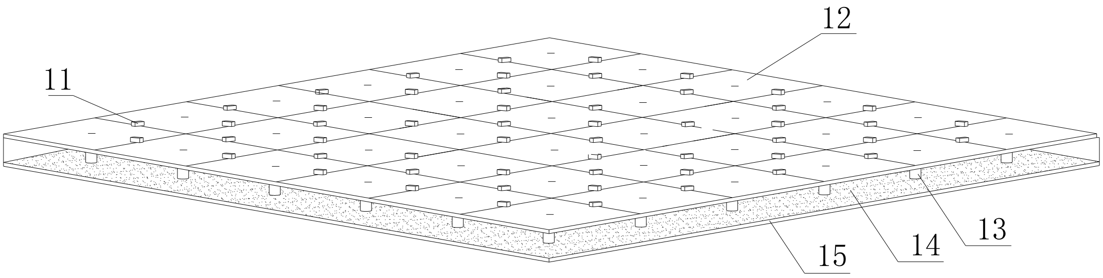
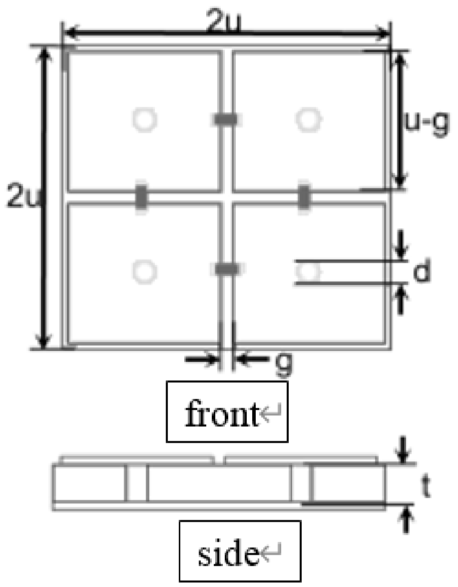


Figure 2
A schematic structural diagram of the AMC in the present invention



Name	Unit(mm)
u	58
g	1
d	1
t	5

Figure 3
A schematic diagram of the unit structure of the AMC in the present invention

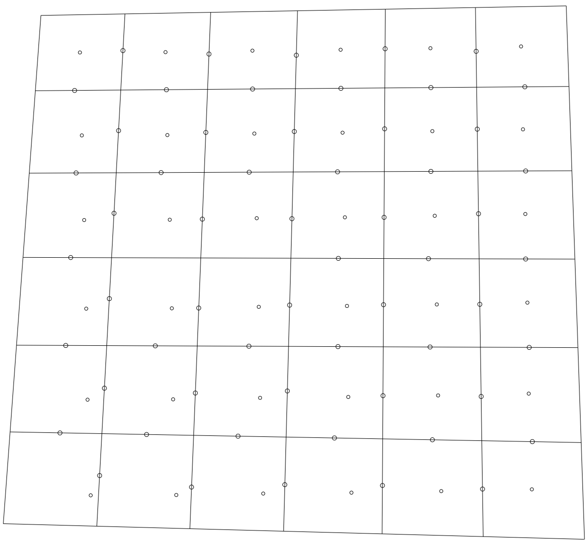


Figure 4
A physical diagram of the AMC in the present invention

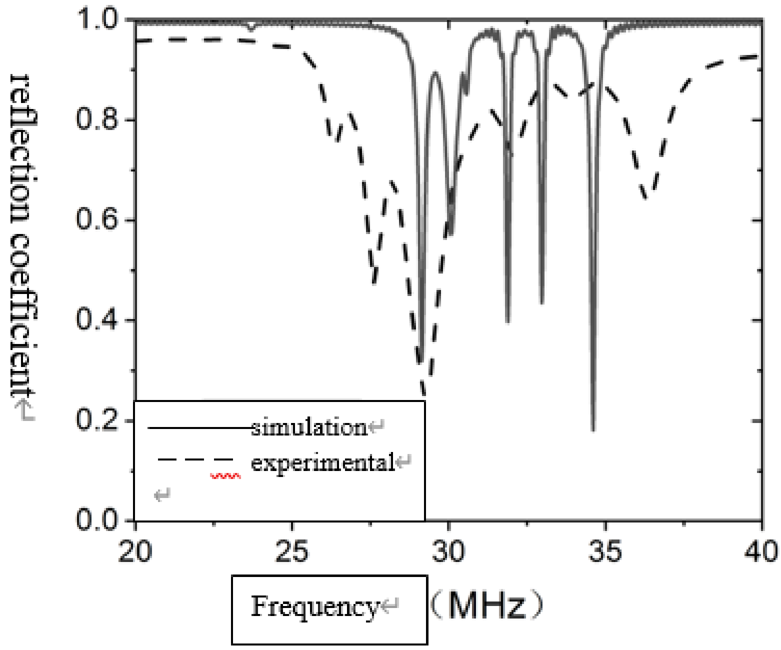


Figure 5
A reflection coefficient diagram of special materials obtained by simulation calculation and experimental test of the present invention

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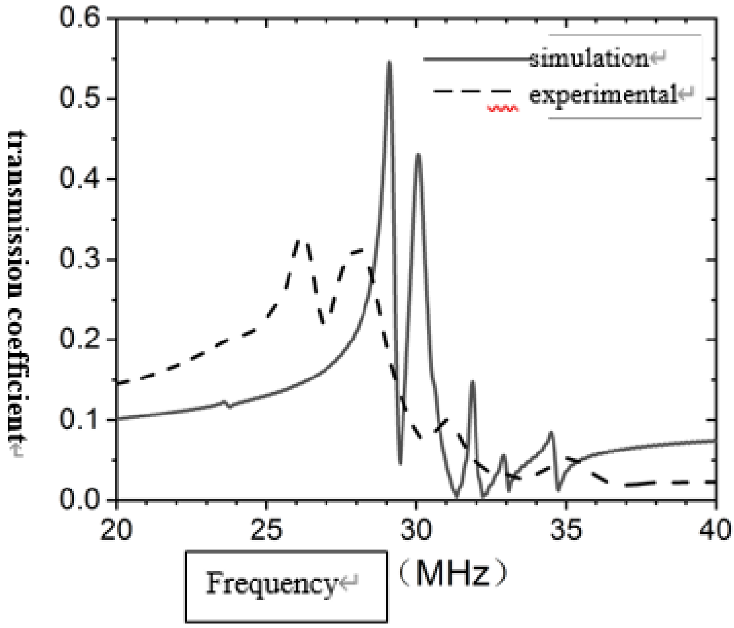

Figure 6
A diagram of special materials obtained by simulation calculation and experimental test of the present invention

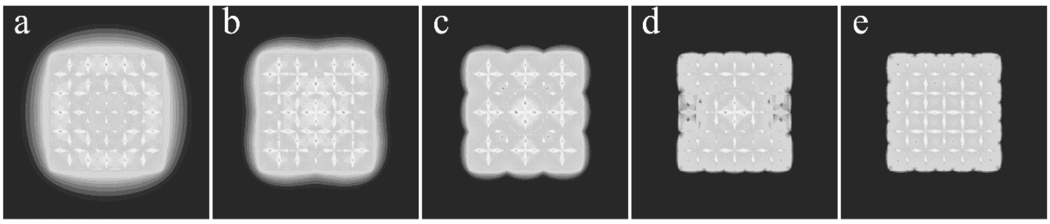

Figure 7
A simulation diagram of AMC surface magnetic field intensity distribution under different modes of the present invention

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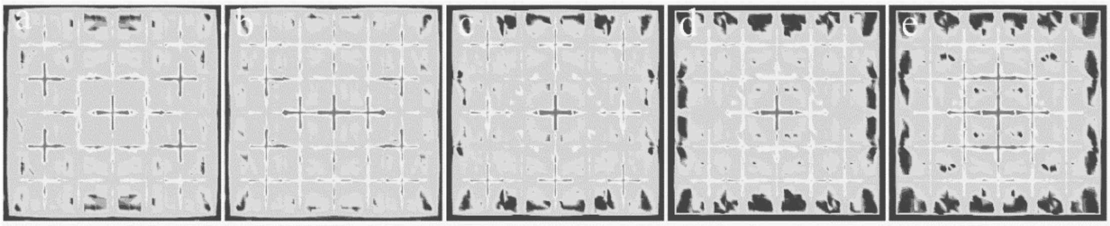

Figure 8
An experimental diagram of AMC surface magnetic field intensity distribution under different modes of the present invention

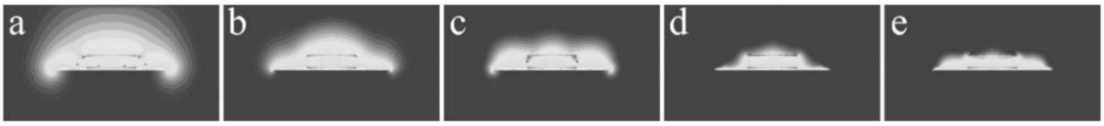

Figure 9
A simulation diagram of magnetic field intensity distribution on AMC side under different modes of the present invention