Study of silicon carbide/graphite double coating polyester woven fabric EMW absorbing property

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Abstract. In this paper, polyester woven fabric was selected as the base fabric. Silicon carbide and graphite were the underlying and surface layer absorbing agents, respectively. The influence of coating thickness of the silicon carbide and graphite absorbents on the dielectric constant was discussed.

1. Introduction
Microwave absorptive fabrics are widely studied not only in the military field for stealth technology, but also in civilian sphere, with regards to pollution by EM radiation deriving from various electronic apparatuses [1-3]. In past years, the properties of intrinsic conductive fabrics or fabrics coated with absorbers, such as carbon fiber fabric, nonwoven polyacrylonitrile and poly (ethylene terephthalate) impregnated with polyaniline, glass fibers coated with multi-walled carbon nanotubes, microwave absorptive fabrics, epoxycotton fabric coated with barium ferrite, doped polyaniline, etc. have been investigated [4-10].

In this paper, silicon carbide and graphite with high absorption and low-cost production were the underlying and surface layer absorbing agents, respectively. The influence of coating thickness on the dielectric constant was discussed. Silicon carbide/graphite carbide double coating polyester woven fabric absorbing materials with the best wave absorption performance were prepared.

2. Experimental procedure

2.1. Materials and instruments
Polyester woven cotton fabrics (weave fabrics) used for this work were provided by the YOUNGOR Co., Ltd. (Zhejiang, China). All other reagents were purchased from Tianjin Chemical Reagent Co., Ltd. (Tianjin, China).

2.2. Fabric coating preparation process
- Add a weighed amount of ethanol, the diluent, to the beaker with the epoxy resin, and then stir continuously with the electric mixer for 30 min until the mixture is uniformly mixed;
- Add the absorbing agent powder and curing agent to the mixture; stirring for 15 min to ensure the mixture is uniformly mixed.
Fix the plain weave fabric woven onto the coating machine, then pour the prepared coating liquid on the fabric, making the first layer (bottom layer).

After completion of the underlying coating, dry for 0.5 hours at 60°C until the coating is slightly dry, and then repeat (4) for the second layer (surface layer) coating; place the coated fabric in the oven to dry at 60°C for 3 hours to obtain double layer absorbing coating fabric. The absorbing coating fabric structure model is shown in figure 1.

![Absorbing coating fabric structure model.](image)

**Figure 1.** Absorbing coating fabric structure model.

### 2.3. Measurement of the permittivity

The composites were die-pressed to form cylindrical toroidal specimens with a 7.0 mm outer diameter and a 3.0 mm inner diameter. The measurements of EMW loss property for the specimens were carried out using a PNA 3629D vector network analyzer in the 30–6000 MHz range. The \( \varepsilon' \) and \( \varepsilon'' \) of complex permittivity correlate polarization and loss.

### 3. Results and discussion

#### 3.1. The influence of silicon carbide coating thickness on the dielectric constant

In order to explore the influence of silicon carbide coating thickness on the dielectric constant, the woven fabrics had been selected as fundamental fabric, a series of different coating thicknesses of silicon carbide of the silicon carbide /graphite layer coating woven fabric were made. Sample specifications are shown in table 1.

| Number | Under layer thickness (mm) | Surface layer thickness (mm) |
|--------|---------------------------|-----------------------------|
| 1      | 0.25                      | 0.50                        |
| 2      | 0.50                      | 0.50                        |
| 3      | 0.75                      | 0.50                        |
| 4      | 1.00                      | 0.50                        |
| 5      | 1.25                      | 0.50                        |

Figures 2-4 show the influence of different silicon carbide coating thicknesses on the dielectric constant with frequency change. When the content of the absorbent is constant, the coating thickness determines the amount of absorbent contained in the coating, thereby affecting the extent of the absorption of the electromagnetic wave into the coated fabric. As seen from the figure, the real part of the dielectric constant decreases with increasing frequency from the figure 2. At \( f > 10^4 \) Hz, when the silicon carbide coating thickness increases, the real part of the dielectric constant of the coated fabric increases, at 10 Hz \( \leq f < 10^5 \) Hz; when the silicon carbide coating thickness is 1.00mm, the dielectric constant has the largest real part, so polarization is strongest. Over the entire frequency range, when the silicon carbide coating thickness is 1.00 mm, the loss tangent and the imaginary part of the dielectric constant is maximum, so the loss is strongest. The loss tangent and permittivity imaginary part curves of other thickness nearly coincide, at \( f > 10^5 \) Hz. Thus, when silicon carbide coating
thickness is 1.00mm, the coated fabrics have the best absorbing properties.

**Figure 2.** The influence of silicon carbide coating thickness on the real part of the dielectric constant.

**Figure 3.** The influence of silicon carbide coating thickness on the imaginary part of permittivity.
Figure 4. The influence of silicon carbide coating thickness on the loss tangent.

3.2. The influence on the graphite coating thickness of the dielectric constant

In order to explore the influence of graphite coating thickness on the dielectric constant, the woven fabrics had been selected as fundamental fabric, a range of different graphite coating thickness weave fabrics of silicon carbide/graphite were prepared. Sample specifications are shown in table 2.

| Number | Under layer thickness (mm) | Surface layer thickness (mm) |
|--------|---------------------------|----------------------------|
| 1      | 1.00                      | 0.25                       |
| 2      | 1.00                      | 0.50                       |
| 3      | 1.00                      | 0.75                       |
| 4      | 1.00                      | 1.00                       |
| 5      | 1.00                      | 1.25                       |

Figures 5-7 reflect the dielectric constant of different graphite coating thicknesses with frequency change. When the content of the absorbent is constant, the coating thickness determines the amount of absorbent contained in the coating, thereby affecting the extent of the absorption of the electromagnetic wave into the coated fabric. As can be seen from the figure, when frequency increases, the real part of the dielectric constant decreases. At $f > 10$ Hz, as graphite coating thickness increases, the real part of the dielectric constant of the coated fabric showed an increased fluctuation trend. When the graphite coating thickness is 0.25 mm, the coated fabrics have the minimum real part of the dielectric constant. When the graphite coating thickness of 1.25 mm, the coated fabrics have the largest real part of the dielectric constant. When the graphite coating thickness is 1.00 mm, the loss tangent and the imaginary part of the dielectric constant are maximum, so the loss is strongest. The curves of other graphite coating thicknesses coincide approximately at $f > 10^3$ Hz. The curve of several different thicknesses of the permittivity imaginary part and the loss tangent nearly coincide and change slowly; the value trend is a constant. Thus, a graphite coating thickness of 1.00 mm has the best absorbing property.
Figure 5. The influence of graphite coating thickness on the real part of the dielectric constant.

Figure 6. The influence of graphite coating thickness on the imaginary part of permittivity.
Figure 7. The influence of graphite coating thickness on the loss tangent.

4. Conclusions
At lower frequency bands ($f < 10^3$ Hz), coating thickness has a great influence on the dielectric constant. At higher frequencies ($10^3$ Hz < $f < 10^6$ Hz), the curves of the loss tangent and the imaginary part of the dielectric constant show a gentle trend, almost a constant. When the silicon carbide coating layer (under layer) has a thickness of 1.00 mm and the graphite coating (surface layer) has a thickness of 1.00 mm, the coated fabrics have the best absorbing performance.

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