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SHIELDING POLYMER-BASED COMPOSITES REINFORCED BY FIBERS WITH METAMATERIAL STRUCTURE

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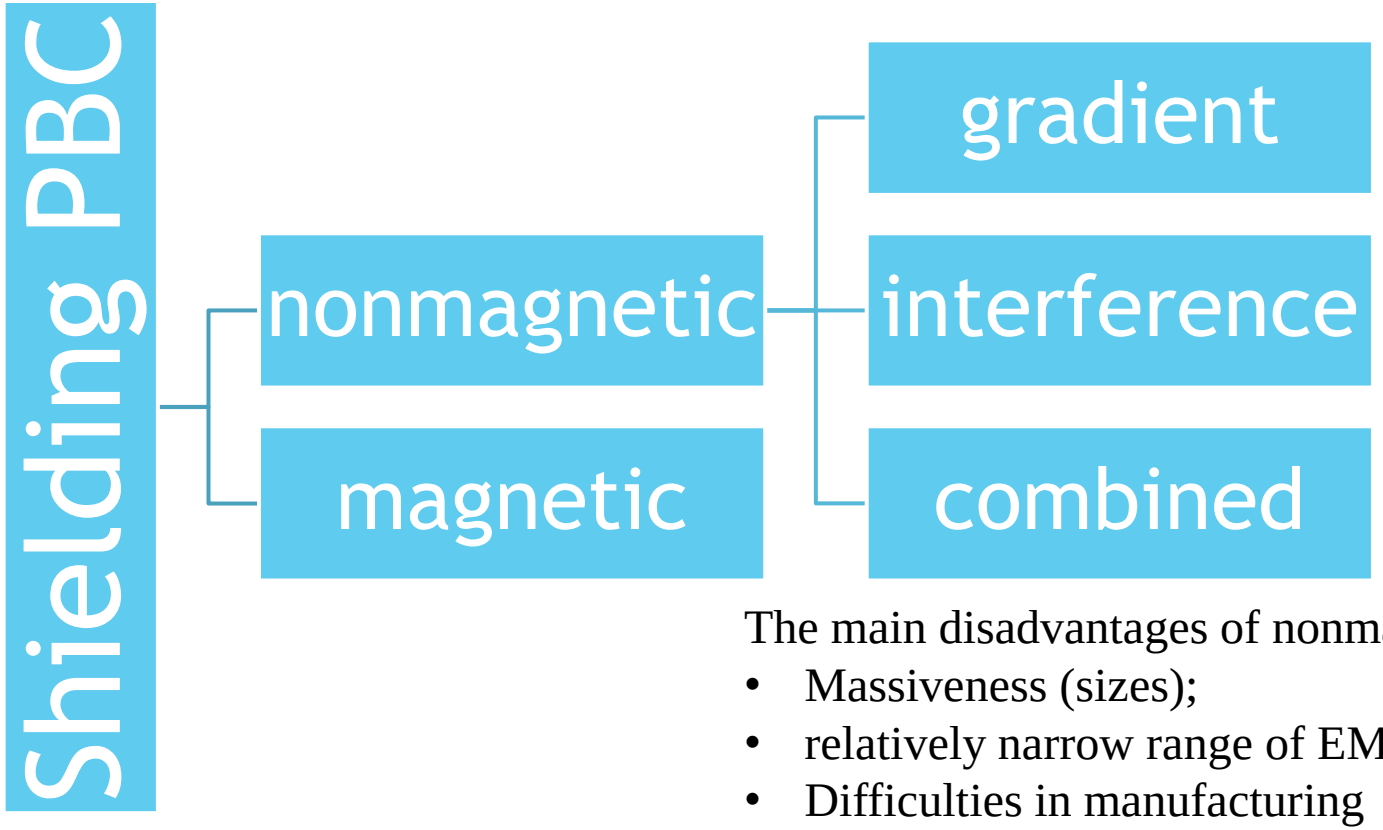
OUTLINE

- Introduction
- Metamaterial concept
- Knitted fabrics as a base for metamaterial filler
- Electroconductive properties of fillers and polymer-based composites
- Absorbing properties of PBCs and their advantages

SHIELDING PBC CAPABLE TO ABSORB ELECTROMAGNETIC WAVES IN ULTRA-HIGH FREQUENCY RANGE



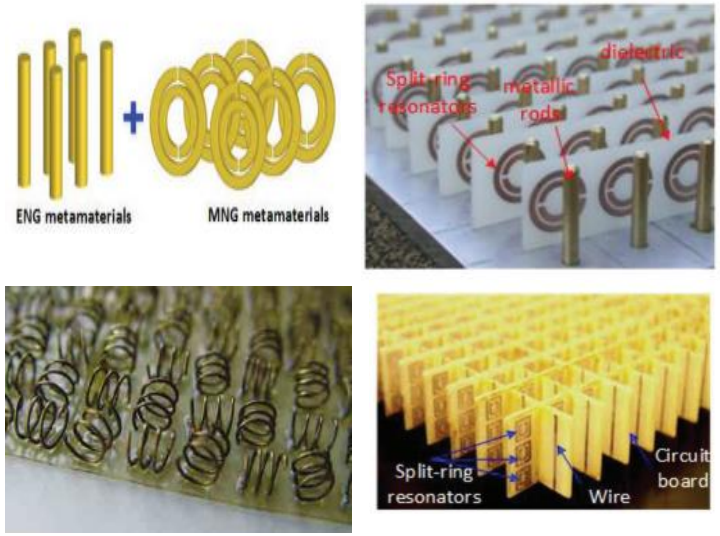
multilayered structure with a smooth or stepwise change in the complex dielectric and magnetic permeability in thickness

structure from the dielectric and electroconductive layers thickness should be equal one quarter wavelength ($\lambda/4$)

The main disadvantages of nonmagnetic PBC :

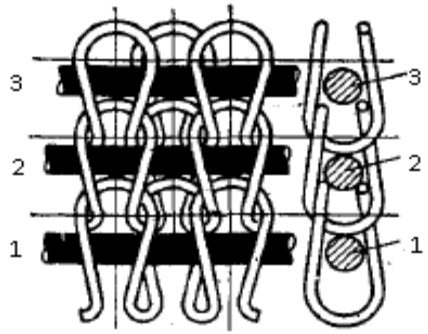
- Massiveness (sizes);
- relatively narrow range of EMR;
- Difficulties in manufacturing

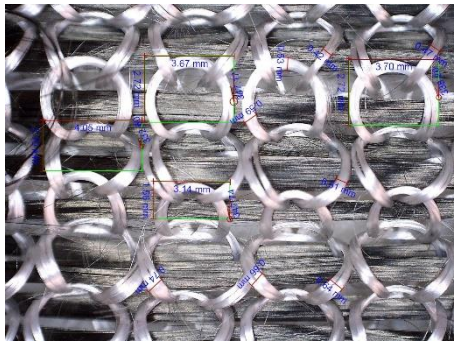
METAMATERIALS



- Metamaterials are the composites with the properties to be determined in essential degree not by the physical properties of the components but by the composite structure, in particular size, shape and periodicity of the composite component location.
- Metamaterials can have a negative refractive index, anomalous magnetic and dielectric constant, and other unique properties.
- The development of metamaterials involves the choice of various structure parameters (size, form, constant or variable period of element location in composite).

KNITTED FABRICS FROM CARBON FIBERS





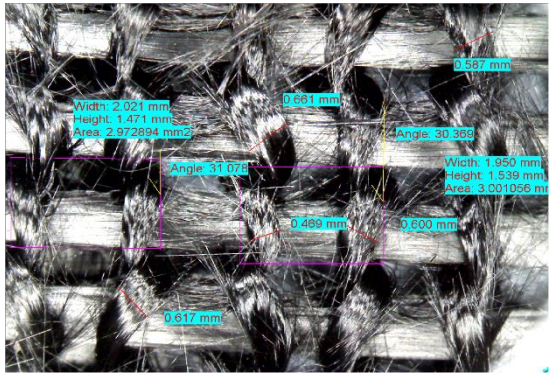
Thus, it is possible to include fibrous functional filler in PBC in the form of regular periodic structure consisting from straight or circular elements from electroconductive fibers with given orientation and quantity in the volume of the polymer matrix.
Using of weft knitted technology (lastic with weft) allows the followings:

- creating of unidirectional structure consisting of straight weft high-strength and high-modulus carbon fibers;
- the surface density of the knitted fibrous filler in unidirectional PBC can be adjusted smoothly and in a wide range, using threads and wisps of different linear densities and changing the step of their distribution in the fabrics;
- it is possible to include fibrous functional filler in PBC in the form of regular periodic structure

FIBROUS KNITTED FILLERS FOR POLYMER BASED SHIELDING MATERIALS

ELECTRICALLY CONDUCTIVE MATERIALS

The unit for the measurement of round electrical conductivity of carbon fabric



TohoTenax-Ural 100

According to the value of specific electrical conductivity and its nature carbon graphite materials including fibrous ones may be referred to semiconductors. By the nature of conductivity carbonized fibers can be referred to semiconductors, but at the same time graphitized fibers cover the range from semiconductors to conductors.

Measurements using this unit with the following mathematic processing of the results allow not only evaluate the value of fabric electroconductivity but also to determine the recommended angle of orientation of the layers from weft-knitted fabrics in the whole composite taking into account the coefficient of anisotropy. And the mean value of average circular electrical resistivity of fabric should be the same for all surface of weft knitted fabrics. So it can be the base of the method of nondestructive quality control for such kind of functional materials

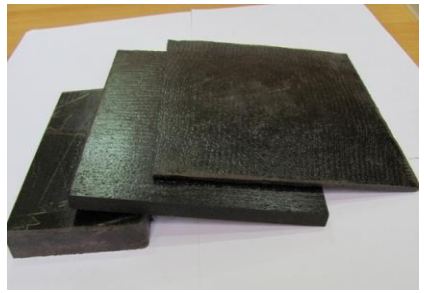
Medium-circular volumetric electrical resistance of carbon knitted fabrics:
UKN 5000-Ural 100 - 1,1-1,3 Ohm
Toho Tenax (1 thread 400 tex) -Ural 100 - 1.35 -1.46 Ohm
Toho Tenax (2 strands 400 tex) -Ural 100 - 0,8-0,9 Ohm

ABSORBING POLYMER-BASED COMPOSITES REINFORCED BY FIBROUS FILLERS WITH METAMATERIAL STRUCTURE

Studies of EMR shielding and absorption parameters of composite material were determined by the reflectometric method on the base of the EMR energy reflection and attenuation coefficients in the frequency range 8-12 GHz.

- Absorbent polymer-based composites reinforced by fibrous fillers with a structure of metamaterials can reduce the modulus of reflection of the radar signal till -10 ÷ -20DB, which corresponds to an absorption coefficient of 60-80%.
- At the same time such materials have a much smaller thickness (2-5 mm) compared to known materials of interference and gradient types. The thickness of such materials should be equal to a quarter of the wavelength ($\lambda / 4$), which is, for example, for the range 8-12 GHz is about 9-11mm.

POLYMER BASED COMPOSITES REINFORCED BY KNITTED FILLERS



- Polymer based composite materials reinforced by carbon fibers with the ability to absorb EMR can be used to create effective shielding structures in the form of layers in structural materials or protective elements (screens), where the required level of electromagnetic wave absorption is achieved by considering possible dielectric and magnetic losses, multiple internal reflections, energy scattering on inhomogeneous elements, etc.
- The specific weight of polymer-based composites reinforced by fibrous fillers is about 1.6-1.9 g / cm3 depending on the fibers used (carbon, aramid, glass, etc.), It allows to reduce the weight of the additional protective coating by 2-3 times compared to known interference coatings using metal (ferromagnetic) or ceramic filler.
- The cost and manufacturability of the developed polymer-based composites or protective panels based on them is comparable with corresponding values for traditional carbon plastics.

THANK YOU FOR ATTENTION!

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