A Method for Producing a Polymer-Carbon Composite Shielding Material for Electromagnetic Radiation and Its Applications

The essence of the solution (what it concerns):

The invention relates to the use of a polymer-carbon composite containing carbon nanostructures as a shielding material for electromagnetic radiation in the sub-terahertz and terahertz ranges. The composite serves as a protective layer for electronic components or devices, shielding them from electromagnetic interference. The material combines selective electromagnetic shielding properties with transparency to microwave radiation and electrical non-conductivity in the DC range.

PROBLEM:

The growing prevalence of electronic devices in various environments has increased the need for efficient shielding against electromagnetic interference, especially in the terahertz (THz) range. Current materials often lack selectivity, leading to undesired attenuation of microwave signals or electrical conductivity that could interfere with device performance. Moreover, achieving homogeneity in composites has been the focus of prior solutions, which has inadvertently hindered the development of non-conductive and selectively shielding materials. This has created a gap in the availability of cost-effective, easy-to-produce materials for selective THz shielding.

SOLUTION:

The invention presents a polymer-carbon composite where thermoplastic polymers, elastomers, or siloxanes act as the matrix. Dispersed within the matrix are carbon nanostructures, including graphene, nanographite, graphene oxide, reduced graphene oxide, or carbon nanotubes. These nanostructures are present in amounts ranging from 0.1% to 10% by weight and are introduced directly without pre-processing into suspensions or emulsions.

Key aspects of the solution include:

1. **Selective Shielding Efficiency:** The composite provides shielding performance exceeding 10 dB in the 0.1–10 THz range (and > 30 dB for frequencies above 0.5 THz), making it highly effective for targeted electromagnetic radiation attenuation.
2. **Electrical Non-Conductivity:** Unlike traditional composites that form conductive pathways, this material is non-conductive in the DC range (>200MΩ), achieved by preventing homogenous dispersion of the nanostructures.
3. **Scalable Manufacturing Process:** The composite is produced using ultrasonic mixing of polymers with carbon nanostructures, eliminating the need for pre-prepared suspensions, reducing complexity, and enhancing scalability.

APPLICATION:

The polymer-carbon composite has a broad range of applications, including:

1. **Electronics Protection:** Shielding sensitive components from electromagnetic interference in consumer electronics, industrial systems, and communication devices.
2. **Scientific Equipment:** Ensuring precise operation of instruments by minimizing THz interference.
3. **Flexible Shielding Materials:** As coatings, paints, or flexible films in devices requiring customized shapes and thicknesses.
4. **Automotive and Aerospace:** Integration into sensors or onboard systems to reduce electromagnetic interference.

TECHNOLOGY:

The innovation lies in the unique combination of material properties and processing techniques:

1. **Composite Design:** The composite consists of a polymer matrix such as polydimethylsiloxane, polyethylene terephthalate, polystyrene, polyester, polymethyl methacrylate, or natural rubber. The matrix incorporates carbon nanostructures such as graphene (thickness below 30 nm and diameter above 100 nm) or carbon nanotubes (diameter below 30 nm and length above 1 µm).
2. **Production Method:** Direct ultrasonic mixing of the polymer with the nanostructures ensures uneven dispersion, resulting in non-conductive behavior while maintaining electromagnetic shielding efficiency.
3. **Material Versatility:** The composite can be produced as emulsions, suspensions, or paints, which are then formed into layers with varying thicknesses and shapes.

SOLUTION ADVANTAGES:

1. **Selective THz Shielding:** Efficiently attenuates electromagnetic radiation in the terahertz range without interfering with microwave signals.
2. **Non-Conductive Properties:** Ensures no electrical conductivity in the DC range, enhancing safety and compatibility with sensitive electronic systems.
3. **Low-Cost Manufacturing:** Simplified production process eliminates the need for pre-prepared suspensions or emulsions, reducing costs.
4. **Easy Integration:** Flexible material properties and versatile production techniques allow seamless application to existing products.
5. **Durability and Adaptability:** Provides long-lasting shielding performance with good plasticity, enabling use in diverse environments and applications.