Seminar

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Institute for Plasma Research

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Title: Multicomponent-Based Nanocomposites for Wide-Band, Thin, and Lightweight Microwave Absorbing Materials

Speaker: Dr. Salim Hassan Siddiki
Indian Institute of Technology (ISM), Dhanbad

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Venue: Online

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Abstract:

In the pursuit of wide-band, thin, and lightweight microwave absorbing materials (MAMs) for stealth technology, this study successfully synthesized and characterized a series of novel composite materials with impressive microwave shielding and electromagnetic properties. The composites were designed by incorporating various functional nanofillers into polymer matrices, leading to the development of cadmium-substituted nickel ferrite-coated multi-walled carbon nanotube (MWCNT)/polyvinylidene fluoride (PVDF)/epoxy-based nanocomposites. Among these, the 3 mm thick NiF-150_10PV nanocomposite exhibited remarkable microwave absorption performance, with a minimum reflection loss (RL_{min}) of approximately -35 dB at 8.5 GHz and -37 dB at 10.5 GHz, coupled with a wide effective absorption bandwidth (EAB) of 3.9 GHz. On the other hand, the 3 mm thick CdNiF-150_10PV nanocomposite demonstrated an RL_{min} of -25 dB at 9.9 GHz with an EAB of 3.6 GHz, underscoring its potential for radar applications.

It is already known that HfO_2 has multiple defect sites due to the coexistence of +3 and +4 oxidation within the HfO_2 crystal structure. The subsequent study focused on the synthesis of a hybrid material, HfO_2-$Ti_3C_2T_x$/$NiFe_2O_4$/epoxy-resin-based composite, with HfO_2 nanoparticles uniformly distributed on MXene nanosheets. The resulting 3 mm thick MXHf-30_NiF sample exhibited robust microwave absorption characteristics, showcasing an impressive RL_{min} of -20.9 dB at 10.40 GHz, supported by an EAB of 2.32 GHz. This composite holds great promise for applications in microwave absorption materials.

Furthermore, the study expanded its scope to investigate exfoliated hexagonal boron nitride (h-BN)/nickel ferrite/MWCNT/epoxy-based composites. The 15-NiFBN-0.75_2mm composite demonstrated exceptional microwave absorption properties, with an astounding RLmin of -59.38 dB in just 2 mm of thickness. Remarkably, these exceptional absorption properties were achieved with a relatively low loading of 17.18 wt%. This composite offers a cost-effective and efficient solution for microwave absorption, making it highly attractive for practical radar applications.

The results from this study signify significant progress in the development of advanced MAMs, showcasing the potential for enhanced radar performance. The wide frequency coverage, high absorption capability, and low loading requirements of these novel composites hold promise for various applications, including radar cross-section reduction and telecommunication interference reduction, where electromagnetic interference and radar detection are crucial

factors. These findings open the door for further research and development in advanced nanocomposites for microwave absorption and suggest exciting possibilities for the next generation of radar technologies.

1. ***Salim Hassan Siddiki et al.*** *"Substituted nickel ferrite coated MWCNT/PVDF based epoxy nanocomposite for microwave absorption."* ***Ceramics International****, 48 (2022) 30260–30271,*
2. ***Salim Hassan Siddiki* et al****. "Defect Dipole-Induced HfO2-Coated T3C2Tx MXene/Nickel Ferrite Nanocomposites for Enhanced Microwave Absorption."* ***ACS Applied Nano Materials****.*
3. ***Salim Hassan Siddiki* et al.*** *"Influence of Exfoliated Boron Nitride for Fabrication of a Lightweight Wide-band Microwave Absorbing Material''.* ***ACS Applied Engineering Materials.***
4. *G C Nayak,* ***Salim Hassan Siddiki****, Sukanta Das, Sukanta Das, N K Patra. "DEVELOPMENT OF HYBRID NANOCOMPOSITES BASED WIDE BAND RADAR ABSORBING MATERIALS (1-12 GHz) AND PROCESS OF PREPARATION THEREOF". Indian patent application number-202111034760 (Published).*