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Microwave absorption by CNM decorated with nickel nano particles.

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Abstract*:Decorated or doped carbon nano materials composites have been a material of choice for its use in telecommunication and in RADAR application, using mostly petroleum based carbon precursor. In the present work, as-obtained carbon nano materials prepared from cotton, decorated with nickel nano particles were found to be excellent absorbent for microwave (Reflection Loss of 99%) at thickness of 3mm and at frequency range of 2-8 GHz.The material shows -15 to -20 dB loss. The carbon sample prepared has a "Tap-density" of 0.04 g.cm^{-3}.The apparent lightness of the material and the optimal thickness used is very significant for its application in telecommunication as well as a microwave protective material.*

***Keywords*:** *microwave absorption, nickel nano particle, reflection loss, cotton fibers, tap-density.*

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I. INTRODUCTION

Carbon NanoMaterials (CNM) decorated or doped with metal nano particles, as composites have been found to be excellent candidate as microwave absorbing material by different researchers. Most of the microwave absorber developed are by using resources like fossil fuel which are depleting rapidly. Several microwave absorbing materials have been developed with renewable sources like plant base materials like oil, fiber, comb, stem etc. [1,2,3].There is a demand to fabricate light weight material, which facilitates microwave absorption in broad band frequency ranges 2-24 GHz, the common range for RADAR and other telecommunication application.Sharon *et. al.*[4] study of microwave absorption by Carbon Nano Fiber (CNF)in frequency ranges 2-8 GHz using a mixture of Ni+Co oxide at various thickness between 3-10mm showed reflection loss of 94% for 3mm thickness at 6-8 GHz and 96% for 6mm thickness at 4-6 GHz. Composite of CNF:Melamine (1:5) of thicknesses of 4.5mm and 6 mm showed the best flat reflection loss of 99.88% for frequencies 6-8 GHz. Sharon *et. al.* studied microwave absorption by CNM prepared from *Camphor*($C_{10}H_{16}O$)and reported that, the carbon prepared under certain synthetic condition can absorb microwave of either specific wavelengths or the entire range of 8-12 GHz[5]. Most research groups have studiedmicrowave absorption by CNM as composite. Ting Zhang *et.al.*studiedFe_3O_4 composites of CNF prepared by electrospinning of polyacrylonitrile (PAN)/ acetylacetone iron (AAI)/ dimethylformamide (DMF) solution[6].Microwave absorption property of polyaniline (PANI) functionalized Ni-doped ordered mesoporous carbon (OMC) $Ni_{0.15}$/PANI exhibits an effective absorption bandwidth (*i.e.*, reflection loss(RL) ≤ −10 dB) of 4.7 GHz and an absorption peak of −51 dB at 9.0 GHz [7].In the present work,as obtained CNM prepared from cotton decorated with nickel nano particles without composite formation have been found to be very effective material for microwave absorption in the thickness range of 2-5 mm and frequency range of 2-8 GHz.

II. EXPERIMENTALS

Cotton fibers were suspended in nickel nitrate solution, dried and pyrolysedat a temperature of 700^{o}C in inert atmosphere of argon. Pyrolysis was carried out in an academically assembledLyndberzhorizontal furnace (Fig. 1). The metal decorated carbon were characterized by SEM, Raman spectra, XRD to study its morphology and the specific surface area (SSA) were studied by BET method. The carbon samples were then studied for their microwave absorption properties at 2 to 8 GHz and thickness range of 2-5 mm.

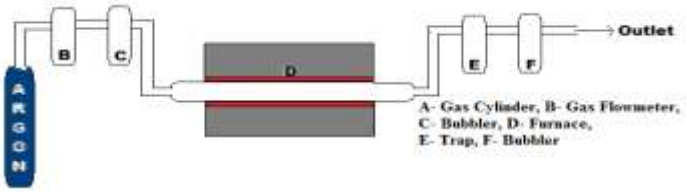


Fig. 1: Schematic representation of academically assembled Lyndberz Horizontal Furnace

III. RESULT AND DISCUSSION

Scanning electron micrograph(Fig.2) of sample showspeculiar designs on the surface of carbon obtained and the surface is evenly decorated with nickel nano particles having size of 50 nm. The thickness of the carbon sheets were found to be in the range 80to 120nm.

Raman spectrograph (Fig.3) showstwo peaks at 1350 cm^{-1} of D band and at 1580 cm^{-1} of G band indicating the presence of disorder in sp^2-hybridized carbon systems as well as presence of crystalline graphene in sp^2-hybridized [8]. Thus, the sample is a mixture of graphitic and amorphous carbon material.

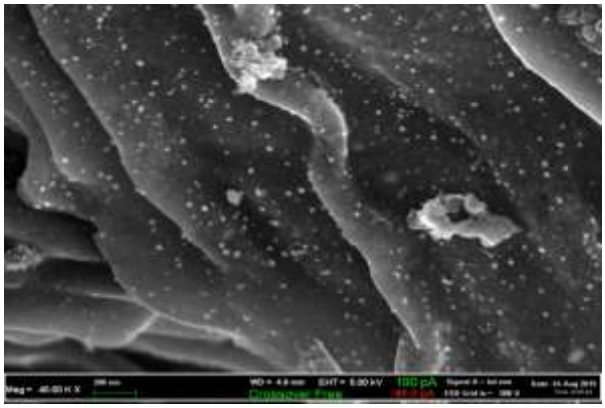


Fig. 2: SEMimage of CNM with decorated nickel

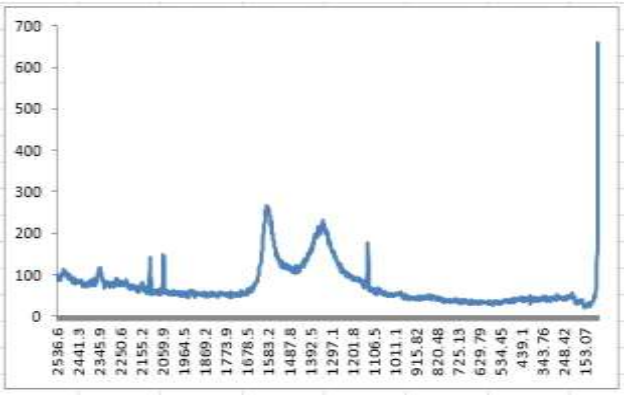


Fig. 3: Raman spectra

XRD of activated CNM sheet(Fig.4) shows broad peak at $2\theta = 23.5^0$ indicating presence of amorphous carbon, while sharp peakat $2\theta = 28.66^0$ and 44.5^0 indicating presence of graphitic carbon with possibility of graphene oxide.Thus, it is a mixture of crystalline and amorphous nano carbon sheets. The specific surface areaobtained was found to be 642 $m^2.g^{-1}$ by BET method.

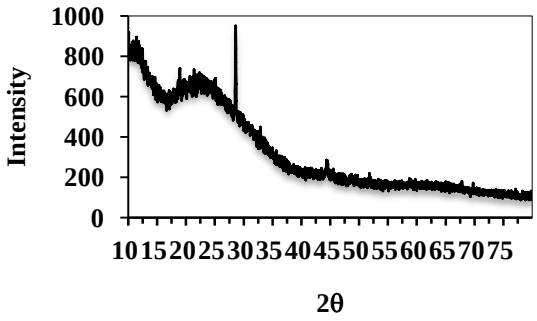
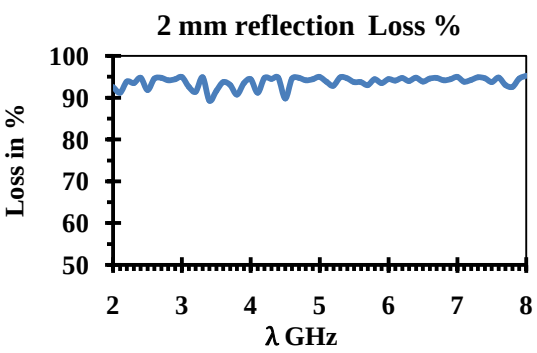


Fig. 4:XRD spectrograph of CNMwith decorated nickel

Thesamples were analyzedat various thickness for microwave absorption from 2- 5mm (Figures 5-9). The CNMof 2 mm thicknessshows microwave absorption between 90-95% at the frequency range of 2-

8GHz.Absorption by 3mm thickness of CNM shows almost constant at 97-99% at the frequency range of 2- 8 GHz. While for thicknesses 4 and 5 mm at the frequency range of 2-8 GHz, a marginal decrease in absorption was observed, within the limits of error. The sample also showed -15 to -20dBloss at thickness of 3mm while for thickness of 2, 4 and 5 mmthe dB losses were between -8 to -15 % (Fig. 10).The "Tap density" of the material was observed to be 0.04 g.cm^{-3}, indicating the lightness of the material and its use as a protective layer for microwave absorption.The ferromagnetic behavior of nickel and its ability of absorbing microwave is extensively documented in the literature,albeit the thickness and the material on which it is loaded remains a topic of research. Thus, the as-obtained carbon nanomaterial proves to be a better material absorption of microwave than the composites which require greater thickness for nearly similar or lesser extent of absorption.



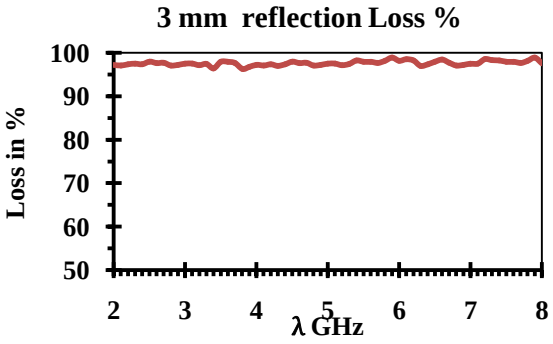
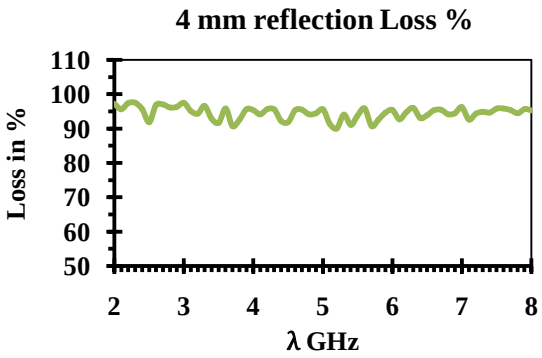


Fig. 5: Reflection Loss in %of 2mm thickness **Fig. 6:** Reflection Loss in %of 3mm thickness



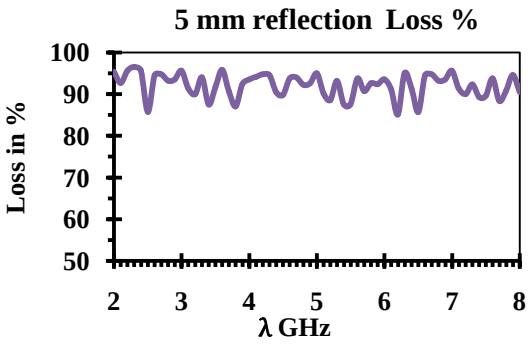
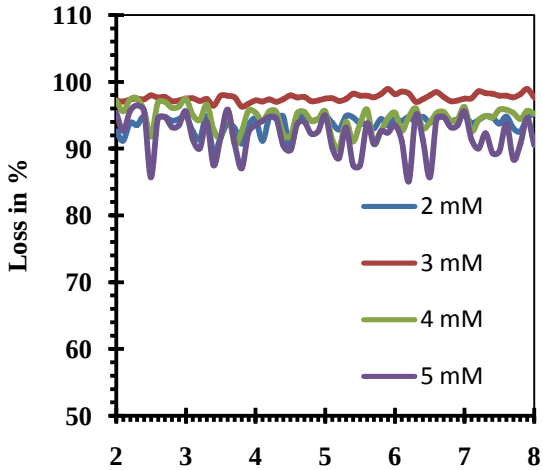


Fig. 7: Reflection Loss in %of 4mm thickness**Fig. 8:** Reflection Loss in %of 5mm thickness



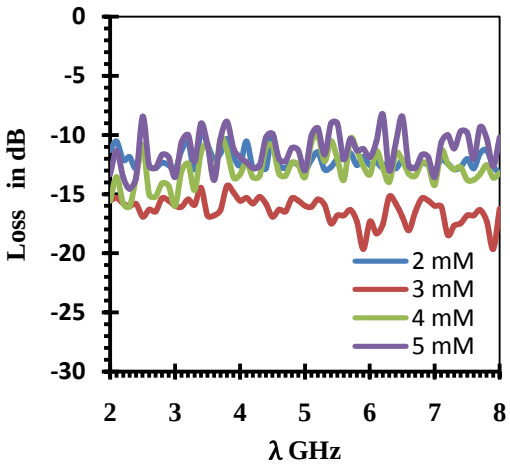


Fig. 9: Reflection Loss in % **Fig. 10**: Loss in dB

IV. CONCLUSION

The as-obtained carbon nano materials, decorated with nickel nano particles prepared from cotton showed excellent absorption of microwave at very thin layer of 3 mm and due to its lightness, makes it a good candidate for telecommunication system as well as a microwave protective material.

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