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Name of Deparetment: Physics
Topic: Synthesis, Characterization and Application of Carbon nanotubes and their nanocomposites

Findings

As a part of my PhD research work, in the present thesis I have mainly focused on synthesis of carbon nanotubes and other carbon nanostructures for their applications in field emission, sensing and supercapacitor. The growth of MWCNTs and graphene was carried out using LPCVD while SWCNTs were grown via PECVD methods. Mostly for the synthesis of CNTs through CVD method requires a metal catalyst deposited substrate. For this we have used sputtering method as well as we have spin coated nanoparticles on the substartes. We have also studied growth of CNTs and other carbon nanostructures on different substrate with and without metal catalyst. We successfully grown MWCNTs and SWCNTs on Fe nanopraticles sputtered silicon substrate. We also spin coated Fe nanoparticles on copper and Fe, Ni nanopraticles on stainless steel substrtate to observe the growth of MWCNTs. Apart from this CNTs were grown directly on copper substrate and graphene on inconel substrate.

Here are the brief outcomes of each chapters of the thesis:

Chapter-1 Basic Introduction of carbon based nanostructures such as Carbon Nanotubes (CNTs) and graphene nanoplatelets along with their structure and properties have been discussed in this chapter. This chapter gives detailed analysis of different synthesis techniques for the growth along with their limitations and scope of improvement in the synthesis mechanism. Apart from this the aims and objectives of the thesis and motivation behind the present work has also been included in this chapter.

Chapter-2 In this chapter synthesis techniques used for the preparation of MWCNTs, SWCNTs and grapheme nanoplatelets have been discussed. A detailed overview of the experimental setup of Low Pressure Chemical Vapour Deposition (LPCVD) and Plasma Enhanced Chemical Vapor Deposition (PECVD) along with sputtering setup has been discussed in detail. **Chapter-3** In this chapter we have reported that the field emission properties of multiwall carbon nanotubes (MWCNTs) were significantly increased by

decorating their surface by iron oxide nanoparticles. A significant change in current density, stability and turn on voltage has been observed in iron oxide coated MWCNT films. Decoration of iron oxide nanoparticles reduces turn on voltage from 4 V/μm to 3.4 V/μm, while current density increases from 10.15to 33.26mA/cm^2.For practical MWCNT based field emission devices, it is necessary to improve the emission current density and stability. **Chapter-4** This chapter presents the most effective and novel approach to fabricate a three-dimensional (3D) Surface-Enhanced Raman Scattering (SERS) substrate for detection of heavy metal ions in the environment. Firstly, Single Wall Carbon Nanotubes (SWCNTs) were synthesized by Plasma Enhanced Chemical Vapor Deposition (PECVD) technique at low temperature. Then, the surface of SWCNTs was functionalized by Zinc Oxide nanoparticles (ZnO NPs) using thermal evaporation technique to achieve ZnO@SWCNTsnanocomposite film as a SERS substrate. For detection of heavy metal ions, the Raman spectra were recorded for samples of different metal ions- Pb^{2+}, Hg^{2+}, Cd^{2+}, Cu^{2+}, and As^{2+}. The proposed substrate demonstrates high sensitivity, selectivity and very low Limit of detection of the order of 0.225 nM with high stability and repeatability for Pb^{2+}. Therefore, the proposed ZnO@SWCNTs nanocomposite SERS substrate can be used as a powerful tool for the detection of heavy metal ion- Pb^{2+} in aqueous solutions for a green environment.

Chapter-5 In this chapter we have reported a simple approach to synthesize graphene directly on Inconel substrate without the requirement of catalyst through low pressure chemical vapour deposition technique. In this approach, the substrate works as both the catalyst and support for the growth of graphene. The graphene nanosheets have an average thickness of 10-20 nm and consist of a few graphene layers. The electrochemical behaviour of graphene as a supercapacitor electrode is characterized by cyclic voltammetry, galvanostatic charge/discharge and electrochemical impedance spectroscopy. The prepared graphene shows specific capacitance of 2.5 mF/cm^2 at current density 1 mA/cm^2 in three electrodes setup. In addition, it shows good cyclic stability even after 1000 cycles. Graphene-Inconel substrate shows good electrochemical behaviour due to its unique nanostructured configuration, large specific area of graphene layer and good conductivity. This highlights the use of graphene as electrode in many high-performance energy storage devices.