Abstract

Electromagnetic interference (EMI) is a serious issue. Lightweight, flexible polymer nanocomposite materials have been a key interest for EMI shielding and microwave absorption due to many advantages over traditionally used metal sheets. This work is about design and tailoring of polymer composites and its film for absorption of predominant EMI shielding. It consists of four major parts, viz., (i) materials tuning, (ii) morphology tuning, (iii) electromagnetic (EM) property study of polymer composite and (iv) EM simulation. In case of materials tuning, the base material is taken as fly ash cenosphere (FAC) which is an industrial waste, whereas weather resistive PVB is taken as the base polymer matrix.

In **Chapter 1**, the motivation for the thesis is established, based on literature and current challenges in EMI shielding materials. The issues of polymer composite for real time EMI shielding application are addressed and discussed. These issues are mainly lightweight, thickness, processing, flexibility, weather resistivity, morphology and most importantly coat ability. This is the reason for attraction towards ultra-thin polymer composite film for EMI shielding.

In **Chapter 2**, the polymer composite design approach, EMI shielding measurement technique and simulation procedures adopted in the thesis are detailed. The EMI shielding effectiveness measurement through waveguide method by using vector network analyzer (VNA) is discussed here, along with details of the EM characterization methods employed. Secondly, the basic mechanism of EMI shielding and reflection loss in the materials and films are discussed. The EM simulation methodologies used are also discussed. These simulations concern the complex *S*-parameters and absorption power, which are common across a large portion of the thesis. Simulation which are specific to a particular portion are explained in the appropriate places in the corresponding chapters.

Chapter 3 is the most important chapter of this thesis. In this chapter, the utilization of industrial waste FAC based polymer composites and its film for EM applications is studied. Both experimental and simulated results are discussed. FAC is metal and metal oxide coated by chemical and electroless method and dielectrics/absorption property is studied. The coating thickness is optimized based on the absorption property. Further, *in situ* conducting polymer (Polyaniline or PANI) composite synthesis is carried out and solution processed to prepare ultra-thin films. Two case studies are considered here. In the first case, PANI/FAC based composites were used as a filler in PVB, Secondly, PANI/FAC composites are directly solution processed. The EMI SE of these ultra-thin films are investigated with shielding mechanism. Based on the understanding of this chapter, morphology tuning of the polymer composites was considered in the next chapter.

In **Chapter 4**, the morphology tuning of polymer nanocomposite for EMI shielding and absorption was studied. As a case study, the manganese di-oxide (MnO_2) was taken and morphologically different nanostructures were synthesized using standard chemical methods and polymer nanocomposite is prepared. Based on obtained reflection loss (RL), *in situ* conducting polymer-MnO_2 nanorod composite was synthesized and free standing ultra-thin film was prepared by solution processing. The EMI SE and shielding mechanism of these films were investigated. Based on the understanding of this chapter, PVB-conducting polymer nanocomposite films were designed for EMI shielding, which is discussed in the next chapter.

In **Chapter 5**, EMI SE of PVB–PANI nanofiber composite film was studied. PANI nanofiber was synthesized by standard chemical procedure at low temperature and characterized. PVBPANI nanofiber composites were prepared by simple solution casting and characterized. The results indicate that the PVB-PANI nanofiber composite film has better EMI shielding and shielding due to absorption property, as compared to PVB-PANI composite films. Thus, based on this understanding, another conducting polymer, PEDOT:PSS, based novel PVBPEDOT:PSS hybrid composite films were synthesized and discussed in the next chapter.
In **Chapter 6**, novel hybrid PVB-PEDOT:PSS based ultra-thin composite films for EMI shielding were designed. Initially, PVB-PEDOT:PSS ratio was optimized with a potential shielding effectiveness. Secondly, EMI SE of this PVB-PEDOT:PSS film was enhanced by introducing conducting, optimized nickel coated glass fabric. Finally, for more specific EMI shielding applications, optically transparent PVB-PEDOT:PSS-ITO ultra-thin hybrid film was prepared with an appreciable shielding effectiveness.

In summary, this thesis has made contribution towards design and tailoring of absorption predominant EMI shielding enhancement of polymer composites based on industrial waste, metal, metal oxide, conducting polymer and conducting glass fabric, and its ultra-thin film having large area coat ability. All the properties were optimized keeping in mind the final polymer composite should be used as a coated film rather than a thick pellet. In a nutshell, in these studies more than 99 % of EMI shielding was demonstrated.