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The goal of this research is to develop novel polymer nanocomposites with improved shape-flexibility, ease in processing, and high ratio of magnetic permeability (μr) to dielectric permittivity (εr) for smaller physical size, wider bandwidth, and higher power efficiency antenna systems. The research effort consisted of: 1) investigation of the influence of nanoparticle dimension, chemical composition, and orientation within polymer matrices on magneto-dielectric properties, 2) synthesis of polymer compatible, low energy loss nickel zinc iron oxide magnetic nanoparticles with various particle sizes, 3) polymer antenna construction and evaluation of performance.

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FINAL REPORT **PI Kofinas University of Maryland**

The goal of this research is to develop novel polymer nanocomposites with improved shape-flexibility, ease in processing, and high ratio of magnetic permeability (μ_r) to dielectric permittivity (ε_r) for smaller physical size, wider bandwidth, and higher power efficiency antenna systems. The research effort consisted of: 1) investigation of the influence of nanoparticle dimension, chemical composition, and orientation within polymer matrices on magneto-dielectric properties, 2) synthesis of polymer compatible, low energy loss nickel zinc iron oxide magnetic nanoparticles with various particle sizes, 3) polymer antenna construction and evaluation of performance.

Key Accomplishments

1. Understanding nanoparticle magnetic domain wall movement and its effect on polymer composite properties. Hard ferrite nanoparticles exhibited lower magnetic permeability than soft ferrites due to difficulty in domain wall movement. Magnetic nanoparticles with multi-domains showed lower permeability compared to single domain particles due to domain wall re-arrangement.

2. Synthesis of high resistivity soft ferrite nanoparticles for low loss RF polymer composites. Highly crystalline, surface-modified $Ni_xZn_{1-x}Fe_2O_4$ nanoparticles of various chemical compositions were successfully synthesized. We managed to tailor a specific size (ranging from 5nm to 30nm) and shape (spherical or irregular) of these nanoparticles by a seed-mediated growth method. The permittivity (ε_r) and permeability (μ_r) of the polymer composites were optimized for $Ni_xZn_{1-x}Fe_2O_4$ nanoparticle doping. The dielectric loss (tan δ) of the nanocomposites was less than 0.010.

3. Development of a procedure for fabrication and processing of polymer nanoparticle composites. Polymer composites, applicable to conformal antenna installations, including thin sheets and bulky bars were prepared by a low-cost solution-casting method.

4. Understanding the influence of magnetic particle orientation within polymer matrices on the magnetic permeability of the nanocomposite. Polymer composites with layered nanoparticles showed higher magnetic permeability compared to randomly dispersed nanoparticles. This promising improvement, resulted from the easily-magnetized structure of layered nanoparticles and by the reduction of adverse eddy currents.

5. Construction and evaluation of nanocomposite antenna performance. An inverted F antenna (IFA) was fabricated using polymer nanocomposites. A quality factor of $Q \approx 50$ at 433 MHz ($\lambda = 69.28$ cm) and 868 MHz ($\lambda = 34.56$ cm) was measured.