Applications Of Ferromagnetic Nanowires And Carbon Nanotubes In The Design Of Microwave Devices And Materials

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As wireless communication systems are flourishing and as operating frequencies are progressively increasing, there exists nowadays a strong demand for microwave devices at millimeter wavelengths. Nonmetallic ferromagnetic materials, also called ferrites, have found wide application in radio frequency (RF) technology because they possess the combined properties of a magnetic material and an electrical insulator. For applications requiring nonreciprocal operation, as in circulators and isolators, there is no alternative to magnetic devices. The remarkable flexibility in tailoring the magnetic properties, the very high resistivity, price and performance considerations make ferrites the first choice materials for microwave applications. However, the frequency range of operation, the bandwidth, and the aptitude to be integrated in monolithic microwave integrated circuits (MMICs) should be improved.

In this paper, a new class of magnetic materials which can overcome the main disadvantages encountered when using ferrites in RF devices operating at millimeter wavelengths is presented. This material, called magnetic nanowired substrate (MNWS), is composed of an array of parallel ferromagnetic nanowires embedded in a polymer dielectric substrate. First, the ferromagnetic nature of nanowires yields very high saturation magnetizations, thus expected operating frequencies higher than 40 GHz, close to those of pure ferromagnetic metals used for the nanowire formation. Next, the nanometric wire diameter, obtained using advanced technologies developed at UCL, allows an easy penetration of electromagnetic waves inside the MNWS and enables to conserve the insulating nature of the polymer. Moreover, due to the high aspect ratio of nanowires (>500) the desired magnetic properties for microwave devices are obtained without a biasing static magnetic field. This leads to a considerable potential increase of the compactness and ease of integration in MMICs. Various potential applications of this new material are presented.

In parallel, the coexistence of a huge number of RF instruments functioning in various frequency bands requires the development of new protection measures against electromagnetic radiations and interferences, not only between different instruments but also the instrument and its user. The particular conducting properties of carbon nanotubes offer innovating solutions to reduce the fabrication cost and to design broadband electromagnetic shielding and/or absorbing materials.