Giant Field and Radiative Emission Enhancement in Anisotropic Epsilon-Near-Zero Slabs

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We investigate anisotropic epsilon-near-zero (AENZ) films under TM-polarized plane wave incidence and found they possess peculiar properties. In particular we studied uniaxially anisotropic films where either the permittivity along the surface normal or along the transverse plane tends to zero while the other one does not. Previously, numerous applications of isotropic epsilon-near-zero (ENZ) films including radiation pattern tailoring, energy squeezing and enhanced harmonic generation have been studied. A notable property of these materials is the capability of enhancing electric field. In this paper the capability of AENZ films in local electric field enhancement has been quantified and several AENZ conditions are reported with superior performance in comparison to (isotropic) ENZ films. Specifically, sensitivity to film thickness and losses, and the range of angles of incidence have been elaborated with the aim of achieving large electric field enhancement in the film. It has been proved that in comparison to the (isotropic) ENZ case the AENZ film's field enhancement is not only much larger but it also occurs for a wider range of angles of incidence. Furthermore the field enhancement in AENZ does not exhibit significant dependence on the film thickness unlike the isotropic case. The effect of loss on the value of the field enhancement is also investigated emphasizing the advantages of AENZ versus ENZ. Moreover, due to this giant field enhancement in AENZ films and using reciprocity, we show that a dipole located at the E-field hotspot radiates very strong far-fields over a wide angular range. Realization of AENZ materials can be done, depending on the desired operating wavelength, using a multilayered media made of a stack of conductive and insulator layers or by stacking semiconductor layers.