Improving the Radiation Characteristics of an Antipodal Vivaldi Antenna using a Spatially Variant Metamaterial Lens

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An anisotropic dielectric material can offer a different permittivity depending on the orientation of the electric fields. Here a macroscopically homogeneous anisotropic dielectric metamaterial is designed using a high permittivity particle material embedded in a low permittivity host material. The geometric positioning of the particle material compared to the host material creates a shielding effect in the directions of low permittivity, whereas there is no shielding effect in the direction of high permittivity (D. E. Aspens, Am. J. Phys., 50, 704-709, 1982). The resulting permittivity tensor is diagonal, with two low permittivity directions and one high permittivity direction. Spatially varying the unit cell geometry leads to a permittivity which varies as a function of position and so permits a degree of wave guiding, employed here to improve the gain of an antipodal Vivaldi antenna (R. C. Rumpf et al, PIER, 142, 243-260, 2013).

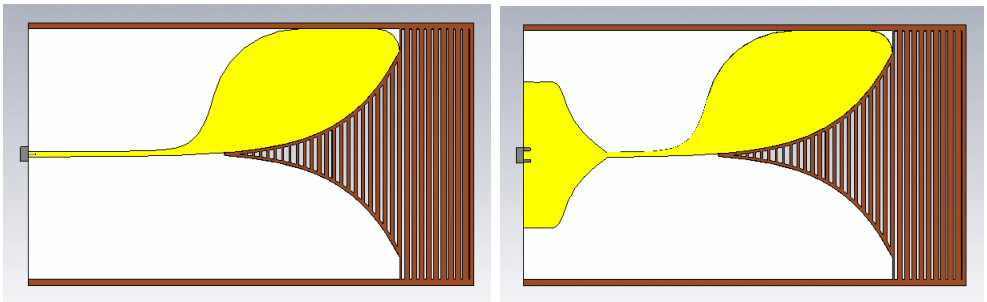

Fig. 1: CST MWS Model of Vivaldi Antenna with an Anisotropic Lens

The preferred high-permittivity path is used to improve the realized gain of the antenna by orienting the electric flux parallel to the conducting and ground planes and perpendicular to the desired direction of wave propagation. The spatially variant metamaterial lens also reduces beam tilting and cross polarization by creating low permittivity paths orthogonal to the desired polarization. The antenna exhibits higher realized gain with the spatially variant metamaterial lens as compared to the lenses of the same size but made of only one dielectric. The improved Vivaldi gain and radiation characteristics would be useful for various UWB applications including sensing, radar imaging and communications. The performance of the improved Vivaldi antenna is demonstrated via numerical simulation and measurement.