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Graphene, superconductors, and metals: What is a good conductor for metamaterials and plasmonics?[1]

PHILIPPE TASSIN, Vrije Univ. Brussel and Ames Lab/Iowa State Univ.

Recent developments in the field of metamaterials and plasmonics have promised a number of exciting applications, in particular at terahertz and optical frequencies. Most metamaterials consist of carefully designed metallic structures that replace atoms in their role as the basic unit of interaction with electromagnetic radiation. Unfortunately, the noble metals are not particularly good conductors at optical frequencies, resulting in significant dissipative loss in metamaterials. In this communication, we address the question of what is a good conductor for use in metamaterials and in plasmonics. We develop a model based on the quasistatic response of the metamaterial constituents to an incident electromagnetic field in order to derive a figure of merit for conductors. We find (1) it is the resistivity of the material-rather than the conductivity or permittivity-that provides direct information on the dissipative loss in the metamaterial, and (2) the dissipative loss depends on certain geometric aspects of the system, such as the layer thickness. Subsequently, we apply the model to graphene, to superconductors (Nb and YBCO), to several noble and transition metals, and to some conducting oxides (like ITO).

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