BOR-FDTD Analysis of Guided Modes in Sub-edwavelength Coaxial Metallic Waveguides

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Bozhevolnyi *et al.* recently show that a simple groove with V shape engraved on a metallic film can play the role of a surface plasmon waveguide [1]. These authors proposed also some features on effective connections in integrated optical circuits using surface plasmons [2]. Waveguides made of real metals are not currently used in the optical region because of the metal losses. In this paper, we demonstrate that for coaxial waveguide in silver, optical signals can be guided without losses. A Body-Of-Revolution Finite Difference Time Domain (BOR-FDTD) code is implemented and used to simulate this effect.

The BOR-FDTD is based on the time and space discretization of Maxwell equations written in cylindrical coordinates. The azimuth and axial dependences are analytically expressed leading to one dimensional calculation. In fact, only the radial coordinate should be considered. In addition, to enhance the accuracy of the numerical results, a non uniform meshing is incorporated into the BOR-FDTD code. Thus, fine details of the structure are described by a small spatial step (□=0.1nm), whereas □= 25nm for the rest of the calculation window. In order to validate our code, we have calculated cut-off frequencies for a coaxial aperture in perfect metal and we have compared the result to the well-known analytical calculations (Fig. 1).

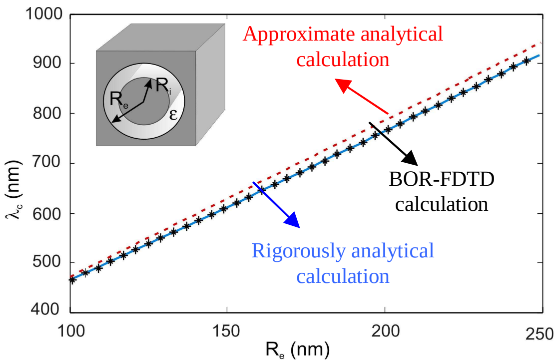

Fig.1: Modes of coaxial perfect metallic waveguide, Mode TE_{11}, R_i=75 nm.

Numerical results of Fig. 2 show the existence of unexpected modes when the external radius tends to the inner one. These modes have a large decay length, which provides their use in the domain of nano-optics. Theoretical results seem to show that plasmonic guided modes are at the origin of this phenomenon. These modes were pointed out in the case of a rectangular waveguide [3], but they do not exist for cylindrical ones. We demonstrate here that for coaxial waveguide in silver, optical signals can be guided with very small waveguides i.e., coaxial waveguides with external radius of around 75nm.

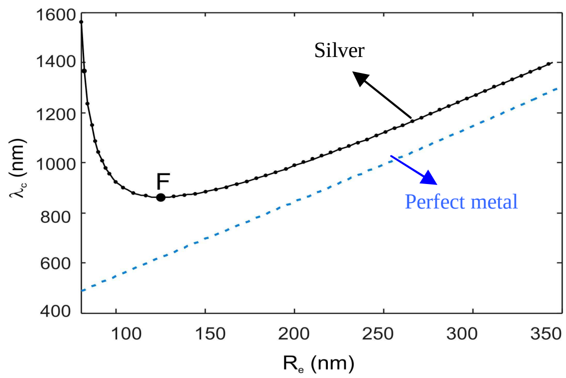

Fig.2: Modes of coaxial waveguide in silver, Mode TE_{11}, R_i=75 nm.

References

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[3] R. Gordon and A. G. Brolo, Optics Express **13**, 1933 (2005).