Application Case Study

SYNOPSYS® Silicon to Software™

RSoft Application: Graphene-Based Electro-Optic Nano-Modulator

Overview

A leading electro-optical company in Japan needed to design a graphene-based modulator. Graphene, which has a high modulation efficiency, is a promising material choice for nanoscale modulators.

The Challenge

Graphene consists of a planar atomic layer of carbon atoms bonded in a hexagonal structure. It has unique optical constant properties that are highly dependent on its environment, including temperature, conductivity, and other properties. The simulation of an extremely thin layer requires special treatment, especially since graphene is anisotropic with different in-plane and out-of-plane properties. The RSoft™ Photonic Component Design Suite provides ideal solutions for this simulation challenge.

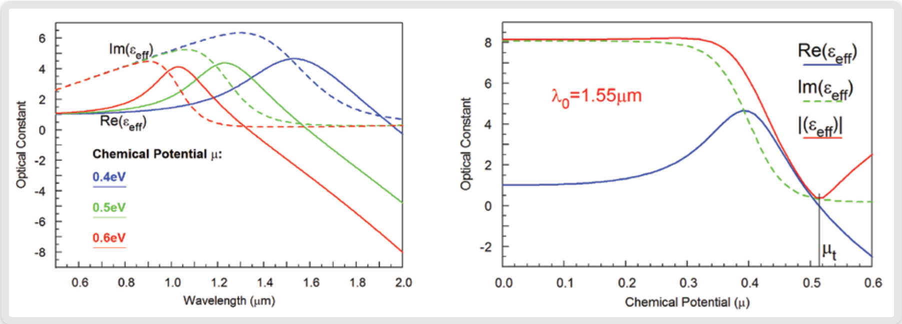

Figure 1. Graphene optical constant versus wavelength and chemical potentials computed in the RSoft tools

The Solution

Graphene is implemented as a special material in The RSoft CAD Environment™. The required material properties can be easily set, including the chemical potential, temperature, and scattering factor. The anisotropic properties are included. Multiple instances of graphene with different properties can be combined in a single simulation.

In addition, a non-uniform mesh can be used to accurately simulate a thin graphene layer in the RSoft FemSIM™, FullWAVE™, DiffractMOD™ and ModePROP™ simulation packages.

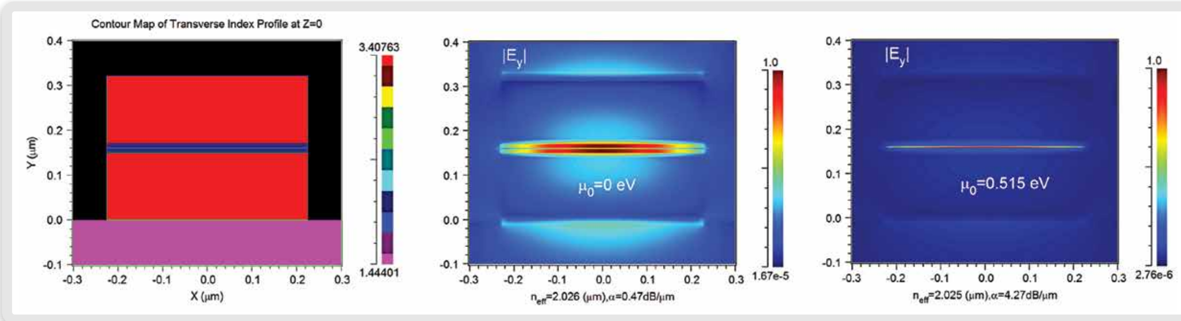

Figure 2. Fundamental optical mode of a waveguide composed of a thin graphene layer between Si and SiN4 layers computed with FemSIM

The Result

Graphene's computed optical constant vs. wavelength and chemical potentials are shown in Figure 1. The plasmonic point µt = 5.15 eV is marked where graphene behaves like a metallic material. The fundamental optical mode of a waveguide composed of a thin graphene layer between Si and SiN4 layers was computed with FemSIM. Modes at a chemical potential of 0 and 5.15 eV (µt) are shown in Figure 2. A FullWAVE FDTD simulation propagated light along the graphene waveguide for 0.8 µm. A 3dB modulation can be achieved by applying voltage to change chemical potential from 0 to 0.515eV, as shown in Figure 3.

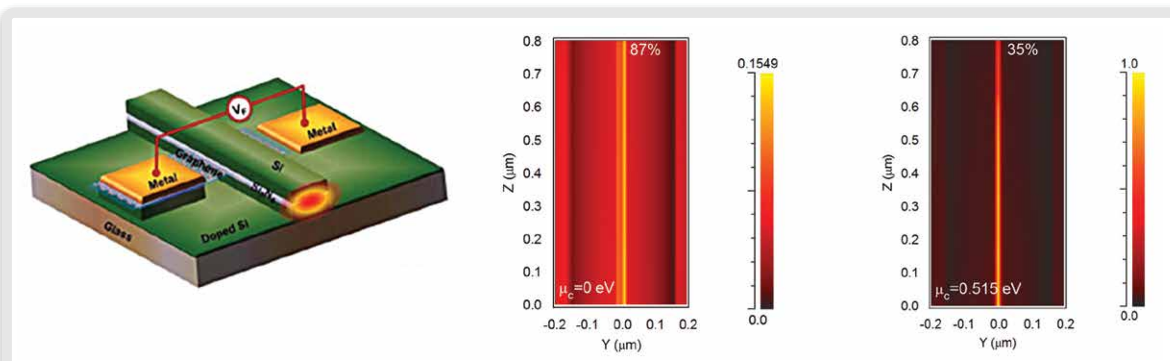

Figure 3. Graphene waveguide (left); FullWAVE FDTD simulation propagating light along the graphene waveguide (right). Waveguide image source: J. Opt. Soc. Am. B/Vol. 29, No. 6/June 2012

For more information, please contact Synopsys' Optical Solutions Group at (626) 795-9101, visit http://optics.synopsys.com/rsoft/, or send an e-mail to rsoft_sales@synopsys.com.

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