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MANIPULATING RESONANT MODES AT THE SUB-WAVELENGTH SCALE ON A SEMICONDUCTOR MATERIAL

B. BOUHAFS and M. BENATTALLAH
Laboratoire de Physique Théorique, Faculté des Sciences, Université Aboubekr Belkaïd – Tlemcen, B.P. 119, Algeria
E-mail : bouhafs_ben@yahoo.fr ; benatallah.mohammed@yahoo.fr

ABSTRACT: The study of resonant modes near material-dielectric interfaces is of fundamental importance to a wide range of sciences and technologies. The first experimental potential offered by the surface resonant modes has been to measure the optical properties of thin layers in a nanometric scale. Several applications have been conducted to probe surface effects, detection of molecular fluorescence, bio-molecular sensors, and wave guides.

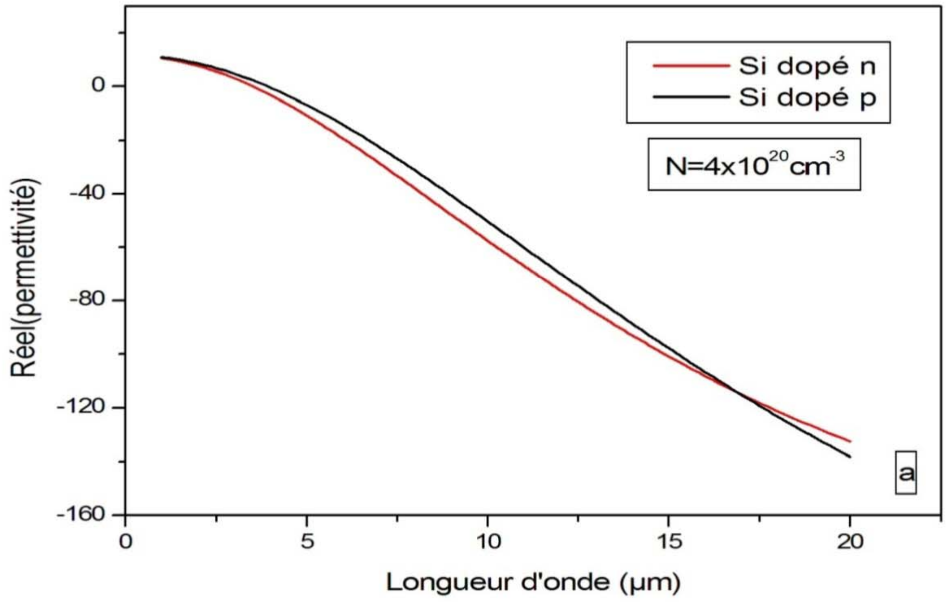
In the present work, we study resonant modes excited on a doped silicon-dielectric interface. For this typical material, it is included the contribution of charge carrier concentrations, N in the range $3x10^{19}$ - $5x10^{20}cm^{-3}$. In this way, the interaction produced between matter and light is controlled differently than silver, gold which are commonly used in plasmonic field. In Barnes work, it has been considered silver-ambient air interface where resonant modes are excited in the visible spectrum and for which the metallic absorption being much smaller than the dispersive, i.e., a low loss metal. In the following results, we were focused to describe resonant modes associated to the contribution of two optical effects of the implied material excited in the wavelength range $\lambda = 1\text{-}20\ \mu m$. In this spectral range, the silicon admits similar optic features to those of the metals cited above were the profile dielectric permittivity describes Debye's transition, but it can be possible to modify the excitation of collective modes in a reduced scale.

In this proposal, relatively to the p- and n-doping of the semiconductor surface, we can play on the charge carriers' concentration which modifies the optical properties via the conductivity. On the analysis of surface plasmon-polariton modes (SPPs) on doped silicon, we report their propagation length versus the free space wavelength. For example, the large propagation length denoted $\delta_{SPP} = 263\ \mu m$ towards $20\ \mu m$ at high concentration is connected to a complex permittivity, – 188 + i210. If we want to control the metallic character on the doped silicon, it is important to give a limit concentration relative to the order of δ_{SPP} as the contribution of the imaginary part of the above permittivity is much small. In photonic field based on SPPs the propagation length (as an example parameter) represents an upper limit on the size of the structures one can contemplate using.

Through this short discussion we can conclude that charge carrier concentration play an important role in modifying SPPs properties which are investigated in the aim to develop sub-wavelength optical components.

KEYWORDS: resonant modes, material-dielectric interface, doped silicon, sub-wavelength scale

Results



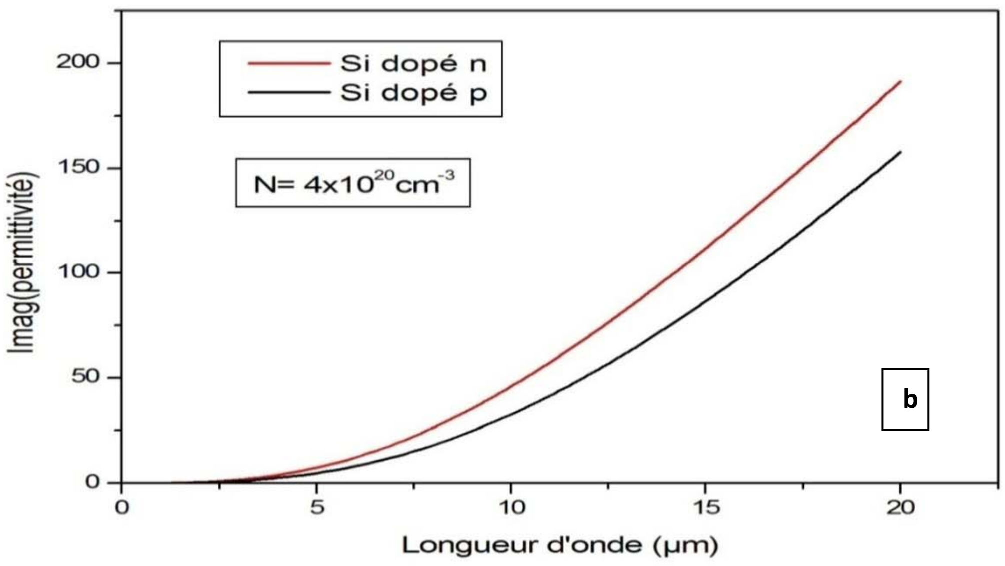
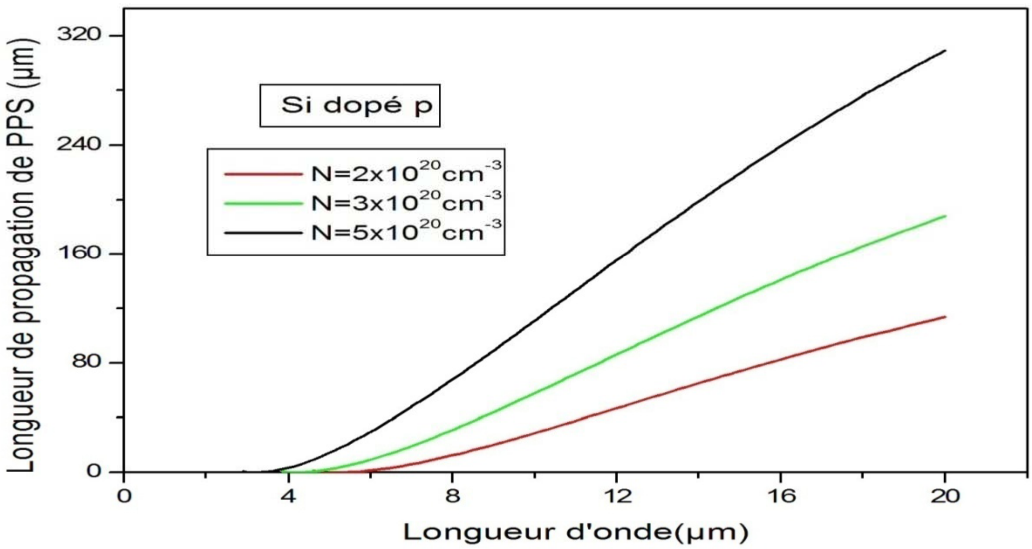


Fig.1 **:** Real and imaginary parts of dielectric permittivity of doped silicon versus the wavelength**,** for different conditions in charge carrier concentrations.



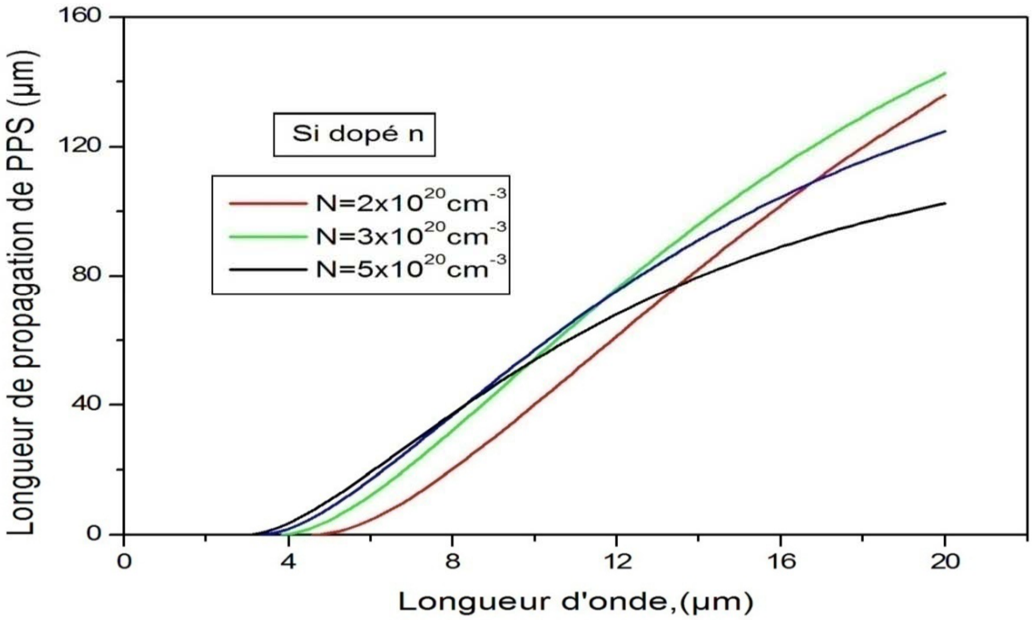


Fig. 2 :. Propagation length, δ_{SPP} of surface resonant modes into doped-silicon at different conditions in charge carrier concentrations N= $2x10^{20}$, $3\ x10^{20}$, $4\ x10^{\ 20}$, and $5\ x10^{20}$ cm^{-3}. Note that in calculating these data we have assumed that there is radiative damping.

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