Nonlocal effects in heavily doped semiconductor

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The Drude model is the most adapted model to describe the optical properties of metal and nano-antennas. Unfortunately, it starts to fail when the size of the nanostructures becomes small enough, that is a few nanometers for noble metals or a few tens of nanometers in the case of heavily doped semiconductors. It is then necessary to consider a nonlocal susceptibility tensor to describe accurately the optical properties of these metallic nanostructures. The best-suited approaches are the semi-classical quantum model [1] or the hydrodynamic Drude model (HDM). HDM can describe accurately the ultra-confined light of the plasmonic mode by the introduction of an electron quantum pressure in the equation of motion of the free electron gas.[2] It is particularly well adapted to be implemented in electromagnetic modeling. In this work, we compared experimental measurements of the volume plasmon modes with HDM. Figure 1 shows volume plasmon modes measured by attenuated total reflectance (Diamonds) on heavily Si-doped InAsSb layers with thickness varying between 20 nm and 200 nm. InAsSb:Si is grown by solid source MBE on GaSb substrate.[3] HDM is represented in Fig. 1 by the gray map. The light gray curves show the volume plasmon modes introduced by the nonlocal effect. Modeling is in good agreement with the experimental data.

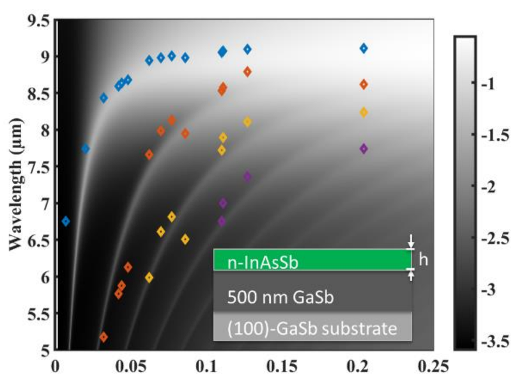

Figure 1 Optical resonances of InAsSb:Si layers of varying thicknesses measured by attenuated total reflectance (ATR). The gray map corresponds to the HDM simulations, and the diamonds are the modes measured by ATR for different layer thicknesses.

[1] L. Wendler and E. Kändler, Phys. Status Solidi B 177, 9 (1993).
[2] E. Sakat, A. Moreau and J.-P. Hugonin, Phys. Rev. B 103, 235422 (2021).
[3] M. J. Milla, *et al.* Nanotechnology 27, 425201 (2016).

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