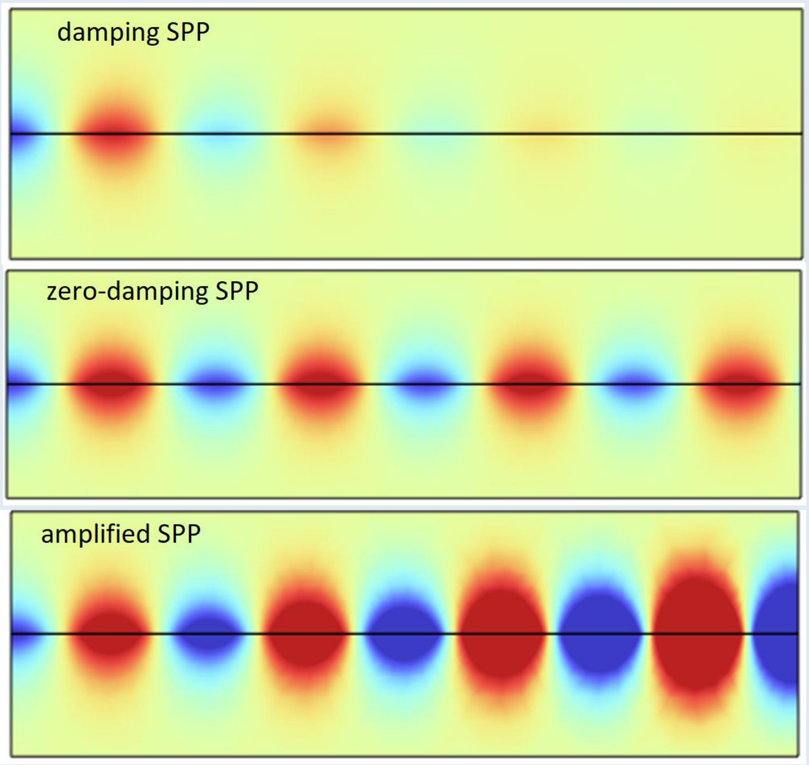
Propagation of Amplified Surface Plasmon Polaritons in AB-stacked Bilayer Graphene



The numerical COMSOL® simulation confirmed that surface plasmon polaritons with gain. They were observed using 2D model for the AB-stacked bilayer graphene layer between two air semiplanes and there is a good agreement with the theoretical data.

Z. Eremenko [1,2], A. Charnukha[1]

1. Leibniz Institute for Solid State and Materials Research, Dresden, Germany
2. O.Ya. Usykov Institute for Radiophysics and Electronics National Academy of Sciences of Ukraine, Kharkiv, Ukraine

Introduction & Goals

Surface plasmon polaritons (SPPs) are electromagnetic waves that travel along a metal–dielectric or metal–air interface in the infrared or visible-frequency. The SPPs term explains that the wave involves both charge motion in the metal ("surface plasmon") and electromagnetic waves in the air or dielectric ("polariton") [1]. Due to the short-lived nature of graphene inverted state, experimental evidence of active plasmons in graphene has so far been elusive [2]. In [2] the existence of a resonant optical gain at frequencies around the energy gap due to a singularity in its joint optical density of states has been predicted theoretically. Thus, the task is to find the physical and COMSOL® modeling gain condition of AB-stacked bilayer graphene SPPs simulation.

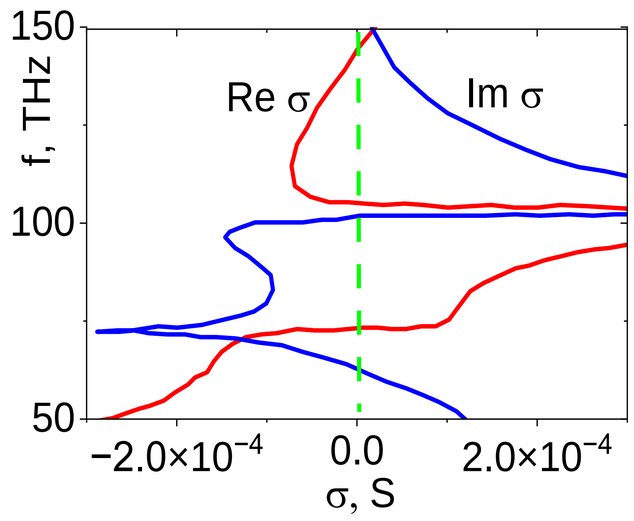


FIGURE 1. Frequency dependence of the real and imaginary part of the optical conductivity of AB-stacked bilayer graphene [2].

Methodology

We used the COMSOL Multiphysics® Wave Optics Module to setup AB-stacked bilayer graphene model at THz frequency band. We took a 2D model structure as the initial model from Application Libraries site file such as graphene_spp.mph. Our studied structure consists of two air layers and a thin AB-stacked bilayer graphene layer between of them.

Using the frequency dependence of real and imaginary part of electric conductivity of the AB-stacked bilayer graphene presented in [2] we have calculated the frequency dispersion dependences of real and imaginary parts of wave number for AB-stacked bilayer graphene SPPs and obtained electromagnetic filed distribution.

Results

The numerical COMSOL® simulation confirmed that SPPs with gain were observed for the AB-stacked bilayer graphene layer between air areas and there is a good agreement with the theoretical data. We have estimated SSPs propagation length and have obtained that the propagation length has more than zero absolute values in the band of 103-114 THz. Thus, the damping, zero-damping and gain SPPs can be exist in studied graphene only in this band. The obtained modelling evidence of the gain SPPs in graphene existence gives the opportunities to greatly increase the SPPs propagation length using AB-stacked bilayer graphene layers. It can be used in designing and fabricating nanostructures with desired optical properties.

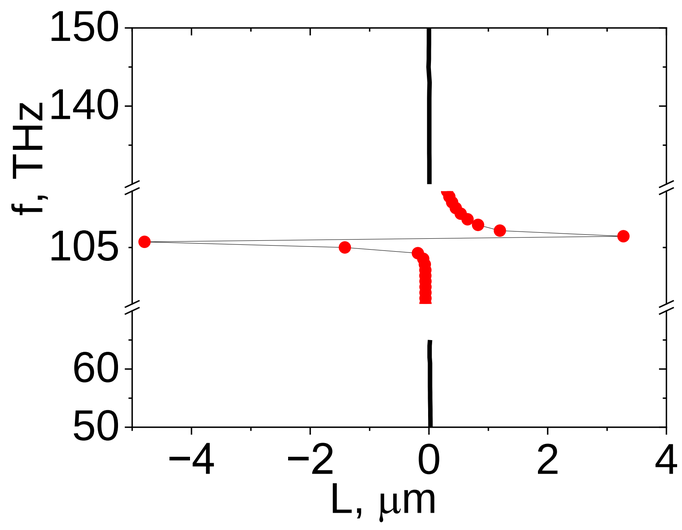


FIGURE 2. SPPs frequency dependence on its propagation length *L* in the bilayer graphene around the gain/loss area with large propagation length shown as red points.

REFERENCES

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Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

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