Graphene Perfect Absorber Based on Silicon Huygens' Metasurface

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Abstract— The high mobility and transparency of a monolayer graphene, combined with its flexibility and environmental stability, make it suitable not only for ultrafast electron devices, but also for transparent photonic devices. Graphene is also the best saturable absorber, and its fast relaxation time and nonlinearity are expected to be applied to ultrafast nonlinear optical devices. However, a problem is the weak interaction between light and a monolayer graphene, where Dirac electrons in graphene have a universal absorptivity of 2.3% for any wavelength. For this reason, graphene photonics has been developed in a "horizontal" form based on plasmonic waveguides to increase interaction length. However, this method has the problem of high loss due to the use of metal.

If the interaction of vertically incident light with the graphene can be enhanced in a "vertical" manner, it will contribute to the miniaturization and energy saving of a wide range of photonic devices. All-dielectric metasurfaces significantly enhance the coupling between the graphene and light by Mie resonance.

In this talk, I will talk about our recent studies about metasurface perfect absorbers (PAs) based on Silicon (Si) Huygens' metasurface (HMS). At first, I review multipole engineering of PAs in visible region based on degenerate critical coupling (DCC) of electric dipole (ED) and magnetic dipole (MD) [1], electric quadrupole (EQ) and magnetic quadrupole (MQ) [2] etc. Then, I demonstrate all-optical switching in Si HMS PA by photothermal effect [3]. Finally, I propose monolayer graphene PA based on DCC between toroidal electric dipoles (TED) and magnetic dipole (MD) (Fig. 1) [4]. Those devices are expected to be applied to low energy consumption and ultrafast all-optical switching devices.

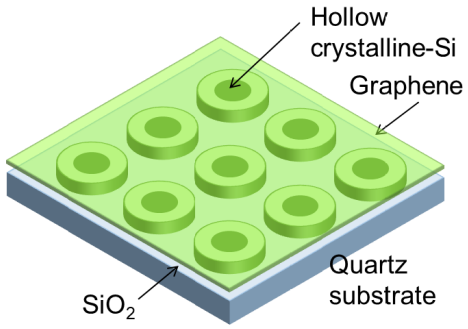

Figure 1: A monolayer graphene PA based on DCC of TED/MD in Si metasurface.

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