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Terahertz properties and applications of graphene

Promising applications in many diverse areas of human endeavor, including medicine, biology, communications, security, astronomy, and so on, terahertz technology has recently turned into a very active area of scientific research. The terahertz frequency band, usually defined in the 0.1-30 THz range, was for decades one of the least explored regions of the electromagnetic spectrum, mainly due to the lack of materials and devices responding to these frequencies in a controllable manner. Even today, there exists a need for devices efficiently manipulating terahertz waves. In this talk I will discuss the properties of graphene at terahertz frequencies, in particular how these can give insight into the materials quality. Moreover, graphene will be also discussed as a material for terahertz device applications and how its unique physical properties can be harnessed to develop active terahertz devices and systems. Several recently proposed terahertz reconfigurable terahertz optoelectronic devices based on graphene will be discussed, in particular plasmonic and metamaterial structures. By employing graphene as the active material, device design with unprecedented degrees of freedom, low-cost, and ease of fabrication is possible, thus leading to a substantial improvement with respect to the existing art in terms of controllability of terahertz waves. Although in the infrared/visible range the optical absorption of graphene is only a few percent and scarcely controllable, its optical conductivity dramatically increases in the terahertz range, closely following the DC one, leading thus to the possibility of efficient electrical control of terahertz absorption. Moreover, by combining active graphene layers with other passive structures augmenting the intensity of the electric field in graphene, i.e. in hybrid metamaterial topologies, the control over terahertz waves can be greatly enhanced with respect to that in graphene-alone structures. These devices can be employed as the building blocks for novel terahertz systems; for instance single detector terahertz cameras can be developed employing arrays of graphene electro-absorption modulators as electrically reconfigurable spatial light modulators.

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