Tabletop sources of high-field terahertz (THz) pulses are currently a hot topic, which is being pursued by many groups around the world [1]. While the favourite method for intense THz generation is optical rectification in nonlinear crystals [2], research on using other novel methods have shown promising results, including those using air-plasmas [3], relativistic laser-solid interactions [4], and large aperture photoconductive antennas [5]. At the Canadian Advanced Laser Light Source, we have built an array of intense THz sources with different central frequencies, with peak THz electric fields ranging from few 100 kV/cm to few MV/cm [6]. In parallel, we have used these sources to study the nonlinear THz response of various materials [7]. In this talk, I will first quickly review the various components of the "intense THz rainbow" at ALLS, and then describe some recent results on intense THz generation from relativistic laser-plasma interactions. I will then describe one application of such intense THz sources, more specifically on the study of hot carrier dynamics in graphene.

To study the effects of the carrier density on the nonlinear response of graphene to intense THz radiation, we studied the response of epitaxial graphene using the Optical-Pump / THz-Probe (OPTP) technique [7,8], followed by similar studies using gated graphene, where the carrier concentration (Fermi energy) was controlled by electrochemical doping [9]. By comparing the results of these nonlinear THz spectroscopy experiments with simulations, we now have a good understanding of the physics behind the nonlinear THz effects in graphene. In short, the change in the photoconductivity of graphene $\Delta \sigma$ is found to be a delicate balance between the Drude weight $D$ and the scattering rate $\Gamma$, with an increase in $D$ increasing $\sigma$, while an increase in $\Gamma$ decreasing $\sigma$. Our studies have also shown sufficient correlation between the Fermi energy and mobility of the graphene sample and its nonlinear THz response. For example, Fig. 1 shows the THz transmission through gated graphene with different Fermi energy, for THz fields from 1.5 kV/cm to 70 kV/cm. One can see from this figure that the Fermi energy of the graphene under investigation can be estimated from the variation in the THz transmission as a function of the THz peak electric field.

References


