Fluorescence of laser-created electron-hole plasma in graphene

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We present an experimental study of non-linear up- and down-converted luminescence of graphene subject to continuous-wave (cw), pico- and femotsecond laser excitation in the visible and the near infrared [1].

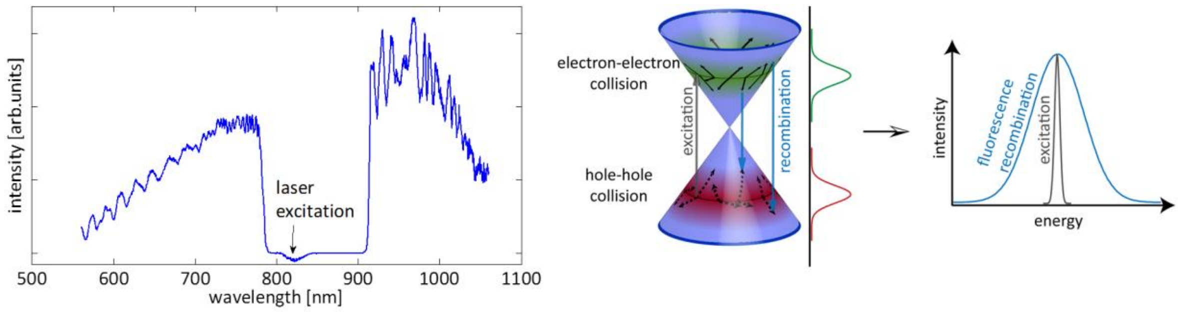
In case of cw visible excitation a spectrally broad down-converted fluorescence can be observed. We attribute this phenomenon to electron hole recombination after thermal equilibration with phonons. However, in the pulsed regime, graphene shows a non-linear luminescence which does not only extend to lower energies but which also reaches to energies higher than the laser excitation energy. This up- and down-converted luminescence originates from the recombination of a high density electron-hole plasma. Since excited charge carries can efficiently exchange energy due to scattering in momentum space the recombination of the resulting non-equilibrium electron-hole pairs yields the observed white light luminescence.

Furthermore, studying the luminescence intensity as a function of layer thickness gives additional insight into its nature and provides a new tool for substrate independent thickness determination of multilayer flakes.

Suspending graphene vertically (perpendicular to the substrate) and measuring the out-of-plane polarization dependence shows that this luminescence can only be excited with the laser beam electric field being parallel to the graphene plane. From this, the matrix elements for the electronic inter-band transitions can be determined.

References

[1] R.J. Stoehr, R. Kolesov, J. Pflaum and J. Wrachtrup, Phys. Rev. B, **82** (2010) 121408(R).



Left: Emission spectrum of a single graphene layer under picosecond excitation of 820 nm wavelength. Right: schematic representation of the 2D dispersion relation of graphene. The gray arrow shows the optical excitation of initially monoenergetic electron-hole pairs. Collisions lead to a broadening of the energy distribution as shown by the green and red curves. Recombination of shifted electron-hole pairs leads a broad fluorescence centered around the excitation energy.