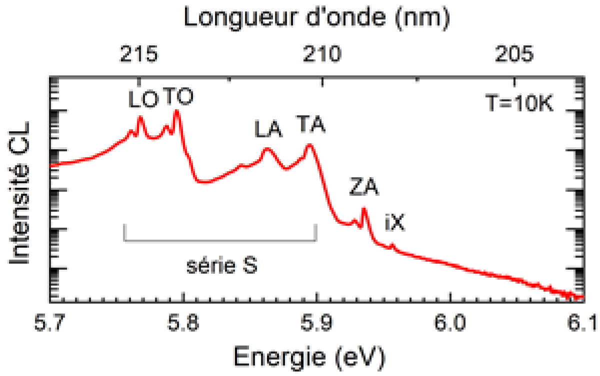
GEMaC
Groupe d'Étude
de la Matière Condensée

2D SEMICONDUCTORS

The research activity on boron nitride materials has been carried out in the DIAM team since 2006. Like diamond, hexagonal boron nitride hBN has a wide band gap (6.25 eV) but is part of the 2D semiconductor family whose original properties were highlighted in 2010 shortly after graphene discovery.

Excitons



Cathodoluminescence spectrum of the free exciton in hBN

The spectroscopic tools initially developed for diamond have contributed to build an expertise on the optical properties of 2D semiconductors. Pioneering studies on 3D hexagonal boron nitride hBN, its 2D atomic layers and 1D nanotubes have been carried out at GEMaC. In these crystalline structures under sp2 hybridization, the optical properties are governed by very stable excitons (binding energy of 300 meV in hBN and 2 eV in the BN monolayer). The theoretical description of these 2D excitons defeats the usual approaches of semiconductor physics and is a matter of collaboration.

At the European level, the team was asked to join the Graphene Flagship project in 2018 for developing optical characterizations of the 2D materials synthesized in Europe. The aim is to exploit graphene in industrial scale components.

Highly sensitive to their environment, the atomic layers give the best of their optoelectronic properties in devices when they are sandwiched in hBN crystals. The van der Walls heterostructures are the subject of intense research worldwide, extending the physics of semiconductor quantum wells by offering new degrees of freedom in the interactions between atomic layers. At the heart of these stacks currently being studied in the laboratory, hBN alternates with graphene, transition metal dichalcogenides (e.g. MoS2) or black phosphorus (BP).