SELF-ASSEMBLY OF COLLOIDAL NANOMONOLAYERS FOR CHARGE-TRANSFER EXCITONS OBSERVATION

LABORATORY : Institut Lumière Matière

LEVEL : M2
TEAM(S) : LUMINESCENCE

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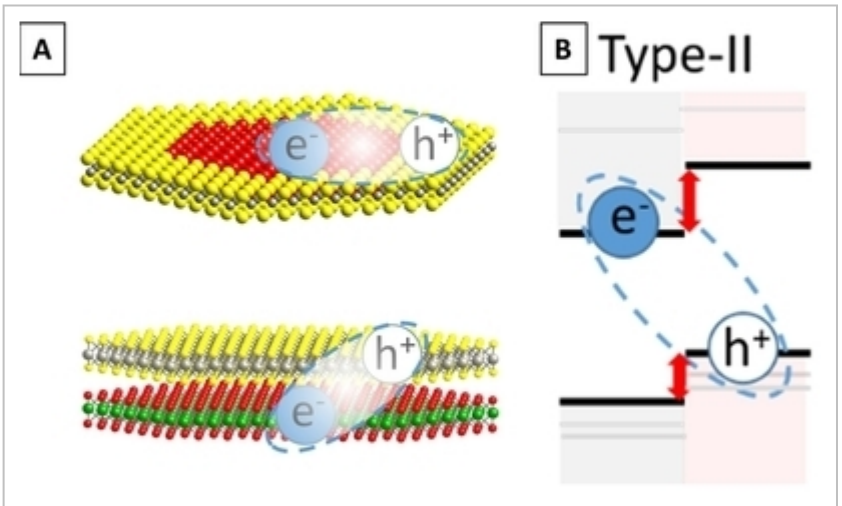
KEYWORD(S) : single particle spectroscopy / colloidal synthesis / TMDCs

SCIENTIFIC CONTEXT :

Transition metal dichalcogenides are lamellar van der Waals materials that can be – similarly to graphene– prepared as atomically thin monolayers. Some of them, particularly molybdenum and tungsten dichalcogenides become direct band gap semiconductors at this scale, opening numerous applications in optics, electronics and energy conversion.[1]



Schematics of NMLs heterostructures (A) presenting a type-II band alignment (B)

Over the past ten years, we developed ways to directly synthesize these materials in solution as colloidal nanomonolayers,[2,3] allowing us to control their size, composition and crystal structure. It would be now possible to create heterostructures (fig. A) either by direct colloidal synthesis (top, in-plane heterostructure) or by assembly (bottom, out of plane heterostructure). The particular electronic structure of these materials induce then a type-II band alignment, efficiently able to separate electrons and holes after photoexcitation (fig. B), creating a charge-transfer exciton. Such state is observable through optical spectroscopy, and is of utmost importance in light conversion devices such as LEDs, solar cells and photocatalysts.

MISSIONS :

During the project, the student will explore different ways to create these heterostructures by direct colloidal synthesis and by assembly. The obtained monolayers and heterostructures will first be observed using transmission electron microscopy. After surface ligands modification and annealing, the nanostructures will be characterized in depth using diverse spectroscopy techniques: Raman scattering for phase determination, absorbance for band gap determination and photoluminescence for identification of the charge transfer exciton state. These last experiment will be conducted down to cryogenic temperatures (4K) in a confocal microscope able to resolve and identify single photons emitters.

Environment:

At the Light and Matter institute, the student will work in the Luminescence team, at the interface between colloidal synthesis (Benoît Mahler), structural characterizations and optical properties measurements (Julien Houel).

Intern profile:

Student with a taste for interdisciplinarity, with a background in chemistry and/or materials science.

OUTLOOKS :

BIBLIOGRAPHY :

[1]D. B. Sulas-Kern, E. M. Miller, J. L. Blackburn, Energy Environ. Sci. 2020, 13, 2684–2740.

[2]B. Mahler, V. Hoepfner, K. Liao, G. a Ozin, J. Am. Chem. Soc. 2014, 136, 14121–14127.

[3]M. Nasilowski, B. Mahler, E. Lhuillier, S. Ithurria, B. Dubertret, Chem. Rev. 2016, 116, 10934–10982.