Hybrid Inorganic/Organic Systems
for Opto-Electronics
Collaborative Research Centre 951

HIOS

Colloquium Announcement

of the Collaborative Research Centre 951
"Hybrid Inorganic/Organic Systems for Opto-Electronics"

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2D Nanosheets produced by liquid phase exfoliation of layered materials

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Hybrid colloidal materials based on plasmonic nanoparticles

Time: Thursday, 28.10.2021, 15:15

Place: The colloquium takes place online (ZOOM)

Meeting-ID: 615 2251 9123
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2D Nanosheets produced by liquid phase exfoliation of layered materials

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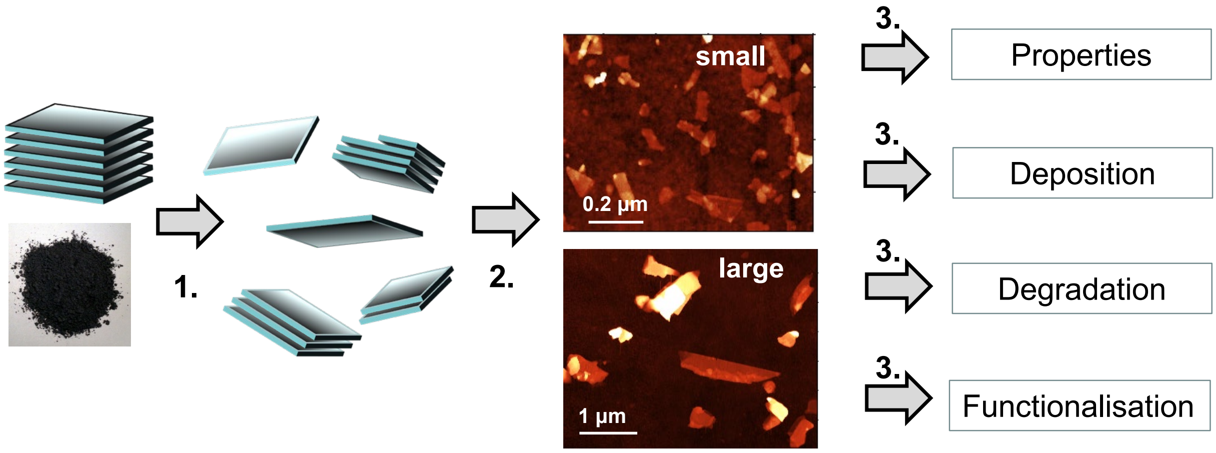
2D materials are exciting for two reasons: i) layer number dependent properties and ii) the broad palette of accessible layered crystals potentially giving access to any desired function. Over ten years ago, it was demonstrated that 2D nanosheets can be obtained from layered crystals via liquid phase exfoliation (LPE) resulting in colloidal dispersions. However, sample polydispersity was a problem until recently. Now, we have arrived at a point where size selection (e.g. liquid cascade centrifugation[1]) and size measurement protocols are in place, which can be readily applied to the whole nanosheet zoo.

In this talk, our recent progress in LPE, size selection, characterisation and functionalisation is summarised. By comparing various material classes, a model to understand the exfoliation was developed which reveals that the exfoliation quality is proportional to the ratio of in plane and out of plane bonding. [2] With our realisation that both size and thickness result in changes in optical extinction spectra due to edge and confinement effects, it became possible to quantitatively determine the nanosheet dimensions optically as we initially showed for transition metal dichalcogenides (TMDs).[1,3,4] Such metrics have now been developed for ~10 materials beyond TMDs. The understanding of the optical spectra is useful to monitor degradation kinetics in various liquids as function of time/temperature.[5,6] Activation energies can be determined and passivation of defects, e.g. by functionalisation,[6] subsequently studied. Functionalisation in general has the potential to ultimately enable the fabrication of hybrids, vertical and horizontal heterostacks etc. for new functional materials. To this end, we explore various functionalisation sequences for TMDs including covalent and noncovalent approaches.



[1] *ACS Nano* **2016,** *10* (1), 1589-1601.

[2] *ACS Nano* **2019,** *13* (6), 7050-7061.

[3] *Nature Commun.* **2014,** *5*, 4576.

[4] *Chem. Mater.* **2019,** *31* (24), 10049-10062.

[5] *Chem. Mater.* **2019,** *31* (21), 9127–9139.

[6] *Adv. Mater.* **2021,** *accepted*, doi:10.1002/adma.202102883.

Hybrid colloidal materials based on plasmonic nanoparticles

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Plasmonics has become one of the most active fields in nanophotonics. In the last several years, there has been a rapid increasing activity within this field as its wide application field ranging from sensing and biomedicine to imaging and information technology.

In our study, silver nanowires with controllable length (1 - 4 µm) and diameter (30-100 nm) have been successfully synthesized via a two-step injection polyol route. A homogeneous silica shell has been coated on the silver nanowires through a modified Stöber method, employing sodium hydroxide to replace ammonia solution. In addition, the silica shell can be further functionalized by fluorescent molecules based on perylenediimide (PDI). The optical properties of the silica-coated silver nanowires with incorporated dye molecules have been investigated by dark field spectroscopy, which is combined with atomic force microscopy and fluorescence studies with a confocal microscope on the same individual particles. [1] Such system is a perfect candidate for the chiral sensor application, in which the silver nanowire with PDI doped silica shell serves as the waveguide for surface plasmon polaritons. [2]

More recently, we have performed the kinetic study on the adsorption of 2,3,5,6-Tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F_4TCNQ) on the surface of Ag nanoparticles (Ag NPs) in water-free organic solvent by combining the merits of the phase-transfer modified Ag NPs and the organic molecule F_4TCNQ. [3] A two-step process has been discovered, which consists of the electron transfer from Ag NPs to F_4TCNQ and the ionization of F_4TCNQ, followed by the formation of Ag-F_4TCNQ complex with the synergy of Ag^+ ions.

[1] M. Rothe, Y. Zhao, G. Kewes, Z. Kochovski, W. Sigle, P. A. van Aken, C. Koch, M. Ballauff, Y. Lu, O. Benson, *Sci. Rep.* **2019,** 9(1), 3859.

[2] M. Rothe, Y. Zhao, J. Müller, G. Kewes, C. Koch, Y. Lu, O. Benson, *ACS Nano* **2021**, 15, 351–361.

[3] Y. Zhao, A. Opitz, A. Eljarrat, Z. Kochovski, C. Koch, N. Koch, Y. Lu, *ACS Appl. Nano. Mater.* **2021**, under review.