New 2D materials: preparation, characterization and application (KDIT118)
syllabus

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The so called reduced dimesional (rD) materials, where the extension of the material at least for one direction is close to atomic size (less than 1 nm), have received an increasing attention in the last 2-3 decades. On the basis of their morphology we can distinguish 2D, 1D and 0D materials where the quantum confinement (quantum size effect) restrictied for 1, 2 or 3 directions, respectively. Although, the physical phenomena denoted as quantum size effects are theoritically well established in the first half of the twentieth century, because of the hard realization of these materials, the experimental material science could handle them only from the last decade of the last century. Nevertheless, the development of rD materials has been experiencing a renaissance since the adventure of new carbon forms, like bucky ball (0D), single wall carbon nanotubes (1D) or graphene (2D). Immersing in the huge field of the science and technology of rD materials, over this course we concentrate only on the 2D materials, like graphene, silicene, phosphorene, germanene, boron nitride, transition metal dichalcogenides and ultrathin titania / alumina films.
First the preparation of the true 2D materials will be presented followed by showing the methods for their characterization (surface science techniques). The flexible tuning of the properties of 2D materials will be presented in details for applications in the electronics, catalysis and electro/photo-catalysis. Extended discussions will be devoted to several special 2D materilas, like graphene, transition metal dichalcogenids or hexagonal boron nitrides. The very recents reports of the science of 2D materials will also be exposed and the new challenges in the field will be enlightened.

(1) A short overview of the self-supporting 2D materials and their preparation;
(2) Graphene story and the related adventures; quantum confinement and band structure;
(3) General physical and chemical properties of 2D materials, characterisation methods;
(4) Conducting, semi-conducting and insulating 2D materials;
(5) Transition metal dichalcogenids (TMDs), an important class of 2D materials;
(6) Physical and chemical tuning of the properties of 2D materials by defect tailoring;
(7) Application fields like nanoelectronics, optoelectronics and energy producion/storage;
(8) Special cases of 2D materials, very new challenges (oxide and superconducting films);
(9) 2D materials in nanocomposits;
(10) Free discussion on the topics of the course;

Suggested literature (examples only):

A. V. Kolobov, J. Tominaga: Two-Dimensional Transition-Metal Dichalcogenides Springer 2016.
M. Dragoman, D. Dragoman: 2D Nanoelectronics, Springer 2017.
A. Dey, A. Chroneos, N. St. J. Braithwaite, Ram P. Gandhiraman, and S. Krishnamurthy: *Plasma engineering of graphene;* Applied Physics Reviews 3 (2016) 21301.
F. Perreault, A Fonseca de Faria and M. Elimelech: *Environmental applications of graphene-based nanomaterials*; Chem. Soc. Rev. 44 (2015) 5861.
H. Wang, H Yuan, S. S. Hong, Y. Li, and Y. Cui : *Physical and chemical tuning of two-dimensionaltransition metal dichalcogenides*; Chem. Soc. Rev., 44 (2015) 2664.
L. C. Lew Y. Voon, J. Zhu, and U. Schwingenschlögl: *Silicene: Recent theoretical advances;* Appl. Phys. Rev. 3 (2016) 40802.