2021-2022 Internship proposal at LMGP Lab.

Deposition of metal oxide and metal-organic frameworks thin films via spatial atomic layer deposition and liquid-phase atomic layer deposition for the fabrication of gas sensors and nitric oxide-releasing platforms

Abstract

Summary

The preparation of thin films to improve the physical and chemical properties of materials is a widespread practice that has revolutionized the world since ancient times. Thin films can be found in solar cells as transparent conductive oxide and absorber layers, aircraft components as corrosion-resistant layers, smart windows as thermochromic layers, arthroscopic microsurgery devices as optical layers, and data storage media (e.g. hard drives) as multilayer structures. Interestingly, the development and improvement of thin film deposition technologies has coincided with advances in the booming electronics industry. Over the years, the scaling down of electronic components and, particularly, the broadening of industrial applications of artificial materials, has demanded techniques that allow the fabrication of thin films with specific mechanical, chemical, optical, and electrical properties while precisely controlling their thickness and homogeneity. For this reason, numerous methods have been developed to deposit thin films from both liquid and gas phases.

Generally speaking, thin films can be produced from the gas phase by physical or chemical means. Physical vapor deposition (PVD) encompasses techniques such as sputtering, arc vapor deposition, and thermal evaporation, while chemical techniques can be divided into chemical vapor deposition (CVD) and atomic layer deposition (ALD). It is worth noting that, although physical and chemical processes rely on the efficient transport of materials in the gas phase to a solid substrate, in the chemical ones the film is formed from the product of a chemical reaction that involves one or more species. Bearing this in mind, ALD can be distinguished from PVD and CVD, both considered steady state techniques, because it is based on self-limiting chemical reactions that take place between species and the surface of the substrate to be coated. Correspondingly, by exposing the substrate to alternate pulses of two or more different precursors, with a purging step in between, it is possible to precisely control the thickness of the film to be deposited down to a monolayer. In addition, the conformality and uniformity of the films over three dimensional (3D) and high aspect ratio structures, coupled with the high scalability of the process (e.g., spatial ALD [SALD]) and the diverse list of materials that can be prepared (e.g., oxides, nitrides, sulfides, and metals) has made ALD an attractive technique for nanoscience and semiconductors technology.

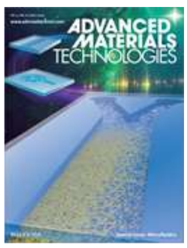
In the LMGP we developed a SALD system that can be used to produce metal oxide and metal-organic frameworks thin films in an open atmosphere and much faster than conventional ALD. In addition, we are developing a microfluidic system to perform ALD in the liquid phase (LALD) that will allow us to deposit materials that are not available in traditional gas-phase ALD systems. Moreover, the less expensive equipment required to handle liquids rather than gases, and the possibility to deposit thin films at room temperature and pressure, are some of the attractive characteristics that LALD has to offer.

Project description

The goal of this internship is to work within a team that aims to deposit metal-oxide (e.g., Cu_2O, ZnO, TiO_2) and MOFs (e.g., HKUST-1, ZIF-8) thin films with an SALD system and a microfluidic LALD system. After the optimization of the deposition parameters by characterizing the thin films with techniques such as ellipsometry, scanning electron microscopy (SEM), transmission electron microscopy (TEM), Raman spectroscopy, and X-ray diffraction (XRD), the prospective intern will apply these materials to gas sensors and gas-releasing platforms through collaborations with other French and international laboratories.

Related Publications

- https://pubs.rsc.org/en/content/articlelanding/2021/dt/d1dt00232e#!divAbstract
- C. Crivello, S. Sevim, O. Graniel, C. Franco, S. Pané, J. Puigmartí-Luis, D. Muñoz-Rojas, *Advanced technologies for the fabrication of MOF thin films*, **2020**, Materials Horizons, doi: 10.1039/d0mh00898b
- S. Sevim, C. Franco, H. Liu, H. Roussel, L. Rapenne, J. Rubio-Zuazo, X. Z. Chen, S. Pané, D. Muñoz-Rojas, A. J. DeMello and J. Puigmartí-Luis, Adv. Mater. Technol., **2019**, 4, 1800666.



See https://sites.google.com/site/workdmr/dmr/spatial-ald for a more comprehensive list

Scientific environment:

The candidate will work within the LMGP, Materials and Physical Engineering Laboratory, in the Funsurf group.

Located in the heart of an exceptional scientific environment, the LMGP offers the applicant a rewarding place to work. LMGP Web Site: http://www.lmgp.grenoble-inp.fr/

Possibility to travel to Barcelona (Spain) in the framework of on-going collaborations

Profile & requested skills:

The candidate must have a good ranking (top 25%) in master or engineering school. Ideally, (s)he should have some experience in surface chemistry and materials sciences. We are looking for a highly motivated student who is interested to work in an inter-disciplinary group and on an interdisciplinary project. Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates should be fluent in English and have good writing and presentation skills.

Subject could be continued with a PhD thesis: **YES, provided funding is achieved**

Allowance: Internship allowance will be provided (~550 euros/mois)

Duration : 6 months

CONTACT

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