

Within an ANR project, **Laboratoire des Matériaux et du Génie Physique**  
 (Materials Science and Process Engineering) is seeking to recruit a:

### **Post-Doctoral Fellow (f/m):**

#### ***Atomic-level control over ultrathin 2D layers of Transition Metal Dichalcogenides by a Molecular Layer Deposition route and in situ characterization tools***

2D-materials, especially transition metal dichalcogenides (TMD) [1], have recently received considerable attention recently since they are emerging as a class of exceptional semiconductor materials with many potential applications (supercapacitors, batteries, electronics and opto-electronics, flexible electronics, ...). However, a sizeable bottleneck for their full deployment stems from the lack of scalable fabrication methods with atomic scale precision. In the recent years, a 2-step Atomic Layer Deposition/Molecular Layer Deposition process and annealing has been used for the synthesis of 2D MoS<sub>2</sub> and WS<sub>2</sub> [2,3]. It has the advantage of being compatible with the manufacturing environment and avoid the use of toxic sulfur molecules as for instance H<sub>2</sub>S ("green" chemistry). However, as far as MoS<sub>2</sub> and WS<sub>2</sub> are concerned, the 2D crystallization is obtained by an annealing at a rather high temperature (> 800°C), which severely hinder the integration capabilities of those materials. Alternatively, Tin disulfide (SnS<sub>2</sub>), which is a semiconductor with a band gap in the range [2.2-2.35eV] (depending on the layer thickness), appears as a good candidate since it has a low melting point (865°C) in comparison to those of MoS<sub>2</sub> and WS<sub>2</sub>. Moreover, Tin is an earth-abundant metal with almost all of its oxide and sulfide derivatives (SnS, Sn<sub>2</sub>S<sub>3</sub>, SnS<sub>2</sub>, SnO et SnO<sub>2</sub>) being semiconductors and non-toxic.

The successful candidate will take part of the ULTiMeD project, funded by the French ANR, which aims at the atomic-level control over ultrathin 2D layers of Transition Metal Dichalcogenides by a Molecular Layer Deposition route. The work consists in investigating the early stage of deposition and crystallization of 2D SnS<sub>2</sub> (later on TiS<sub>2</sub>) films processed with organosulfides (as Sulfur source alternative to H<sub>2</sub>S) in a custom-built portable ALD reactor. The latter is specifically designed to perform *in situ* characterization studies during growth by using *in situ* ellipsometry, residual gas analysis (RGA) and a complementary suite of synchrotron X-ray structural and spectroscopic techniques (fluorescence, diffraction, absorption) [4-6]. For the purpose of synchrotron X-ray measurements the reactor is moved to SOLEIL (St Aubin, France) and installed at beamline SIRIUS. The project then hardly focuses on atomic and molecular layer depositions as well as on *in situ* chemical and structural characterization during deposition and annealing with state of the art instruments. Collaborations with partners of the ULTiMeD project (C2P2, Lyon ; IPVF, Paliseau, SOLEIL) and scientists at CEA Leti, will allow to select the most efficient "green" chemistry to be implemented in ALD like deposition techniques in which the LMGP is involved in, including Spatial ALD (SALD) for fast deposition on flexible substrates, as well as to perform *ex situ* X-ray Fluorescence, *in situ* Raman Scattering and X-Ray Photoelectron Spectroscopy.

**References:** [1] Y.P. Venkata Subbaiah et al (2016), Adv. Funct. Mater **26**, 2046 ; [2] S. Cadot et al. (2017), Nanoscale **9**, 538 ; [3] S. Cadot et al. (2017), J. Vac. Sci. Technol. A **35**, 061502. [4] R. Boichot et al. (2016), J. Chem. Mater. **28**, 592. [5] M. H. Chu et al. (2016), Cryst. Growth Des. **16**, 5339. [6] E. V. Skopin et al. (2018), Nanoscale, **10**, 11585.

**Keywords:** Transition Metal Dichalcogenides, Atomic Layer Deposition, surfaces and interfaces, advanced structural and chemical characterization, Synchrotron radiation techniques



#### **Laboratoire des matériaux et du génie physique**

Grenoble-INP – MINATEC – 3, parvis Louis Néel – CS 50257 - 38016 Grenoble Cedex 1 - France

Tél. + 33 (0)4 56 52 93 00 ■ Fax + 33 (0)4 56 52 93 01

Internet : [www.lmgp.grenoble-inp.fr](http://www.lmgp.grenoble-inp.fr) ■ E-mail : [Prenom.Nom@grenoble-inp.fr](mailto:Prenom.Nom@grenoble-inp.fr)

**Unité mixte de recherche 5628 CNRS ■ Institut Polytechnique de Grenoble**

The candidate should hold a PhD in physics, chemistry or material science or closely related science.

Previous experience in ALD/MLD growth and surface X-ray diffraction will be an advantage. She/he should also have:

- Experience or knowledge of relevant research topics in solid state physics, and/or chemistry;
- Ability and initiative to get to the heart of the problem and take it effectively through to completion;
- Good interpersonal, communication and scientific presentational skills;
- Good organizational and planning skills;
- Self motivation

**This is a full 18 months fixed term contract.**

**Work Location :** LMGP, Grenoble INP - MINATEC, Grenoble, France

Interested applicants should submit:

- (1) 1 page cover letter stating the motivation, research experience and goals, and anticipated available date;
- (2) curriculum vitae, and
- (3) contact information for 2 to 3 references

**Contact person:** Pr. Hubert Renevier ([Hubert.Renrevier@grenoble-inp.fr](mailto:Hubert.Renrevier@grenoble-inp.fr))

Grenoble Institute of Technology (Grenoble INP)

Laboratoire des Matériaux et du Génie Physique, UMR 5628

Grenoble INP - MINATEC, 3 parvis L. Néel - CS 50257, 38016 Grenoble 1, France

Phone : 33 456 529 248

**Application deadline: November 1, 2018**



**Laboratoire des matériaux et du génie physique**

Grenoble-INP – MINATEC – 3, parvis Louis Néel – CS 50257 - 38016 Grenoble Cedex 1 - France

Tél. + 33 (0)4 56 52 93 00 ■ Fax + 33 (0)4 56 52 93 01

Internet : [www.lmgp.grenoble-inp.fr/](http://www.lmgp.grenoble-inp.fr/) E-mail : [Prenom.Nom@grenoble-inp.fr](mailto:Prenom.Nom@grenoble-inp.fr)

**Unité mixte de recherche 5628 CNRS ■ Institut Polytechnique de Grenoble**