2024-2025 Internship proposal at LMGP Lab.

Deposition of high- quality oxide semiconductors for piezoelectric applications via Spatial Atomic Layer Deposition

Abstract

In ever more challenging environmental conditions an increasing amount of scientific work is devoted to the investigation of new materials for energy applications. But apart from finding better materials, new processing tools need to be developed allowing the scalable deposition of high quality materials at low temperatures. Atomic Layer Deposition (ALD) is an attractive candidate since it has unique unrivalled features including: i) a highly precise control of layer thickness; ii) the capability of depositing uniform and conformal coatings even on high aspect ratio features; and iii) the possibility to deposit high quality films at low temperatures. These qualities are a result of ALD mechanism: ALD is a particular case of Chemical Vapor Deposition (CVD) in which the reaction is restricted to the sample surface, thus being self-limited. This is achieved by exposing the sample to the reactants at different time, i.e. in a sequence of pulses. In this way, the metal precursors are supplied and react with the surface, ideally forming a monolayer. Excess precursor is then purged, usually by evacuation. The second precursor is then injected and reacts with the chemisorbed layer forming a monolayer of the desired material plus by-products that have to be purged along with the excess precursor. The cycle is then repeated the necessary number of times to obtain a very precise film thickness. But also as a result of the ALD particular mechanism, deposition rates are very low and vacuum processing makes it complicated and expensive to scale up.

Recently, a new approach to atomic layer deposition (ALD) has been developed that doesn't require vacuum and is much faster than conventional ALD. This is achieved by separating the precursors in space rather than in time. This approach is most commonly called Spatial ALD (SALD). In the LMGP we have developing a novel atmospheric SALD system to fabricate active components for new generation solar cells and other applications, showing the potential of this novel technique for the fabrication of high quality materials that can be integrated into devices. We are also exploring alternative ways to control particle sintering and crystallization during film growth.

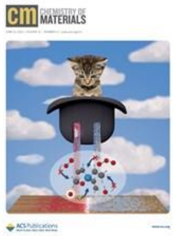
Project description

The goal of this internship is to use SALD for piezoelectric applications and to understand the material characteristics. Doping is an important step in piezoelectric ZnO materials as it allows for the control of electrical properties. Copper (Cu) and Nickel (Ni) appears to be a well-matched doping material to enhance the piezoelectric properties of ZnO [ref]. Consequently, this internship will focus on optimizing the deposition of Cu films for improved piezoelectric properties. The SALD team has already optimized ZnO itself for enhanced piezoelectric properties. The candidate will build on this ZnO study by substituting Cu in different ratios. Besides deposition with SALD, the thesis will also include characterizations of morphological, chemical composition, and crystallographic structure. Additional post-processing steps, such as thermal annealing in different environments, may be required to inspect characteristic changes.

This internship will be closely related to our ongoing project on ZnO films. In our team (Mr. H. Okcu´s thesis), structural control of the growing ZnO films has been achieved using SALD, resulting in enhanced piezoelectric properties. However, the fundamental mechanisms, such as how nucleation and growth mechanisms were being affected by these parameters, still require further understanding. Therefore, in situ characterization using Quartz Crystal Microbalance (QCM) and Gas-Phase Fourier Transform Infrared Spectroscopy (FTIR) can be conducted to further explore these growth phenomena. Depending on the progress of the internship, the setup can be adapted and optimized.

This internship at LMGP offers young researchers the opportunity to prepare for experimental research by gaining expertise with various characterization tools and understanding material science concepts in a hands-on manner. They will have numerous opportunities to improve their presentation skills in a highly communicative environment. Depending on their contribution and progress, interns may also have the chance to be co-authors on scientific publications. Overall, the internship offers an excellent opportunity for candidates to enhance their resumes and potentially continue as doctoral candidates at LMGP.

Related Publications
Some publications from the team are:
Nature Communications ***volume 13**, Article number: 5322 (2022)*
Commun Mater 2, 78 (2021)
ACS Applier Materials & Interfaces, **2021**, 13(18), 21971–21978
Chemical Engineering Journal, **2021**, 403,126234
Advanced Materials Technologies, **2020**, 5 (12), 2000657.



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Chemistry of Materials, **2020**, 32, 12, 5153–5161

See https://sites.google.com/site/workdmr/publications 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/

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, depending on available funding**

Allowance: Internship allowance will be provided (~600 euros/month)

Duration : 6 months

CONTACT

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