14 November 2023

PhD contract offer

Subject: Understanding selective growth mechanisms based on electrical conductivity in ALD (eAS-ALD)

General information

Workplace: Nancy, France
Type of contract: PhD contract
Contract period: 36 months
Expected date of employment: October 2024
Proportion of work: Full time
Remuneration: 2044 euros/month
Desired level of education: Master's degree in physics or equivalent.
Experience required: -

Missions / Activities

Context
In physics as well as in chemistry, the increasing miniaturization of objects is leading to new properties. However, whether in the fields of microelectronics, energy or magnetism, current miniaturization techniques based on top-down etching are reaching their limits. A bottom-up approach has emerged, enabling the direct generation of micro- or nano-patterns through localized material growth. This synthesis method is known as area-selective atomic layer deposition (AS-ALD). It combines the use of atomic layer deposition (ALD), which is sensitive to the chemical state of the surface, and growth-inhibiting self-assembled organic molecules (SAMs), to produce small-scale patterns by localized growth of materials on substrates. SAMs have a number of drawbacks, however, and alternative methods are being sought. The aim of this thesis will be to clarify the mechanisms associated with an innovative selective ALD deposition solution proposed at the IJL, making it possible to dispense with the use of SAMs and overcome their limitations.

Thesis objectives and program
In our approach, the selection of growth zones is based on the local electrical properties of the surface. It does not require the use of SAMs. We also gain the ability to spatially control both the growth, or lack of growth, of materials and their oxidation state. In our case, control of the activation or inactivation of the growth and oxidation state of the deposited material depends on the electrical conductivity of the substrate. This method can be described as eAS-ALD (electrical area-selective ALD). Our team is the only one to propose this original approach.
Figure 1 below illustrates the possibility, using a copper-containing precursor, of spatially controlling the oxidation state of the deposited material (Cu or Cu_2O) by means of substrate temperature and electrical conductivity. In addition, higher values of substrate electrical resistivity can inhibit growth. While this method is highly promising from an application point of view, notably for the production of semi-transparent p-n photojunctions, it calls for further studies to understand and better control the elementary mechanisms involved in the spatial control of the oxidation state. Furthermore, external electrical control of film growth would open up new possibilities for the realization, for example, of materials with gradient or oxidation state junctions. The proposed thesis focuses on these objectives.

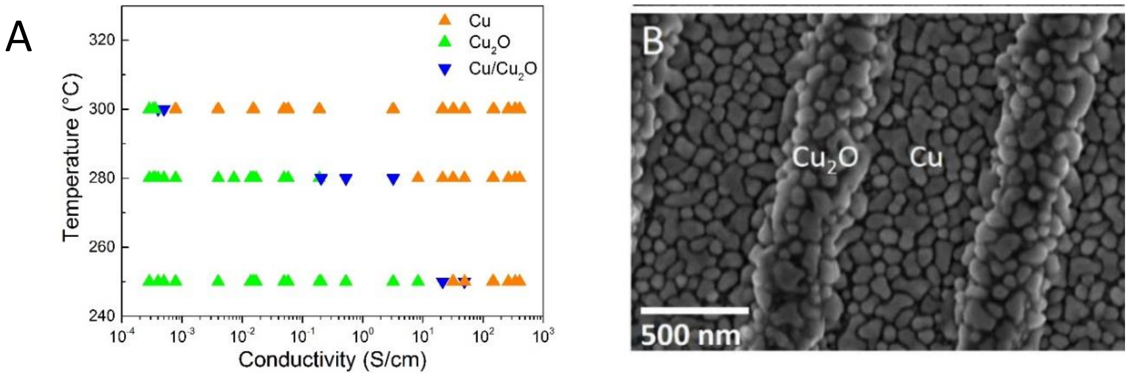

Figure 1: a) diagram showing the deposited material as a function of substrate conductivity. b) SEM image of a Cu and Cu_2O simultaneous deposition surface with alternating areas of low and high electronic conductivity.

Methodology

Key concepts will include the links between surface chemistry and electrical conductivity, bulk chemistry or crystalline structure, which will be explored using experimental methods. This will involve ALD synthesis and surface characterization using XPS and nano-MEB, Nano-Auger (SCAN equipment) available on the Competence Centre's ultra-high vacuum equipment Davm to access chemical and morphological information related to the early stages of growth (https://ijl.univ-lorraine.fr/depot-et-caracterisation-de-couches-minces-sous-ultravide-tube-daum). These analyses will be completed by transmission electron microscopy and associated spectroscopy. This approach will enable us to propose a growth model, identify the physico-chemical parameters essential for growth control, and envisage the generalization of the process.

Work context

The PhD student will work under the supervision of Pr. David Horwat et Dr. Alexandre Desforges in the ”Thin Films for Energy and Applications” team in IJL, in the ARTEM campus in Nancy.
Visits to external laboratories with which we collaborate are possible, depending on funding opportunities.
By the end of the thesis, the student will have mastered cutting-edge thin-film deposition and characterization technologies. They will have learned to work in the tube environment Davm, an ultra-high vacuum tube to which deposition machines and characterization tools are connected. He will have also mastered nanopatterning of thin films surface, which is widely used in industrial application such as semi-conductors or photovoltaic devices.

Skills

- Engineering degree or Master 2 in materials engineering.
- Knowledge of solid state physics and materials characterization desirable.
- Autonomy, creativity and organizational skills.
- Fluent in English.

Constraints and risks

The position you are applying for is located in a sector relating to the protection of scientific and technical potential. It therefore requires, in accordance with the regulations, that your arrival be authorized by the competent authority of the Ministry of Higher Education, Research and Innovation.

About Institut Jean Lamour

The Institute Jean Lamour (IJL) is a joint research unit of CNRS and Université de Lorraine.
Focused on materials and processes science and engineering, it covers: materials, metallurgy, plasmas, surfaces, nanomaterials and electronics.
It regroups 183 researchers/lecturers, 91 engineers/technicians/administrative staff, 150 doctoral students and 25 post-doctoral fellows.
Partnerships exist with 150 companies and our research groups collaborate with more than 30 countries throughout the world.
Its exceptional instrumental platforms are spread over 4 sites; the main one is located on Artem campus in Nancy.

Application

Applicants are invited to send a CV and cover letter together with diploma copies to:

Pr. David Horwat david.horwat@univ-lorraine.fr
Dr. Alexandre Desforges, alexandre.desforges@univ-lorraine.Fr