5 December 2023

Master research internship offer

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

General information

Work location : Jean Lamour Institute laboratory, Campus Artem, 2 Allée André Guinier 54000 Nancy, France
Duration : 5-6 month
Expected starting date : february-march 2024
Payment : ~ 600 euros/month

Missions / Activities

Scientific 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.
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.

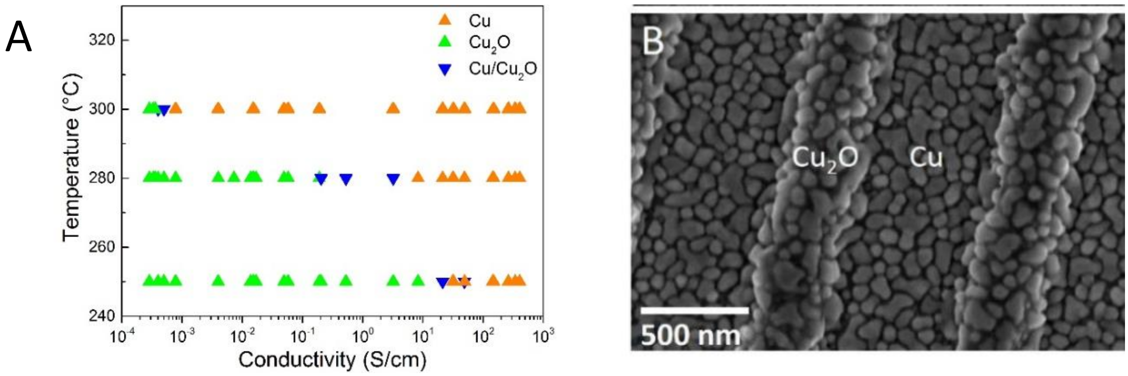

Figure 1: a) diagram showing the deposited material as a function of substrate conductivity. b) SEM image of a Cu and Cu_2O simultaneous deposition surface with alternating areas of low and high electronic conductivity.

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.

Skills

- Knowledge of solid state physics and materials characterization desirable.
- Autonomy, creativity and organizational skills.

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 to:
Dr. Alexandre Desforges, alexandre.desforges@univ-lorraine.fr