Internship offers

General information

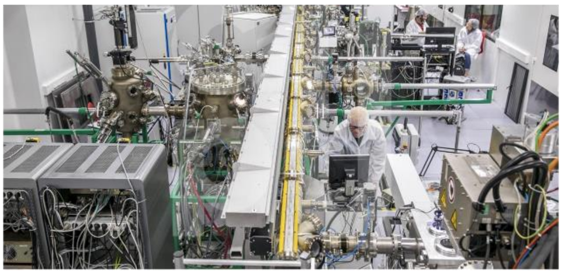
Work location : Jean Lamour Institute laboratory, Campus Artem, 2 Allée André Guinier 54000 Nancy, France
Duration : 5-6 month
Expected starting date : february-march 2022
Payment : 550 euros/month

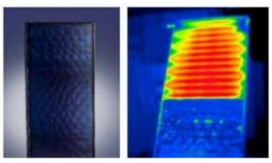
About the Jean Lamour Institute

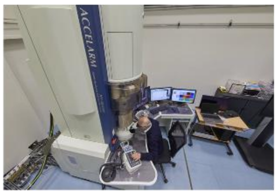
The Jean Lamour Institute (IJL) is a joint research unit of the CNRS and the University of Lorraine. Specialized in materials Science and Engineering, its research topics covers materials, metallurgy, plasmas, surfaces, nanomaterials, electronics. IJL employs 170 researchers and academics, 90 research support staff, 150 doctoral students and 25 post-docs.IJL collaborates with more than 150 industrial partners and academic collaborations with around thirty countries.

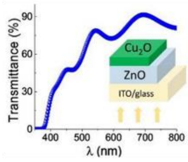
About Functional Thin Films for Energy applications group

The group studies the optical and electrical properties of thin films, nanostructures and devices obtained by the dry method (physical vapor deposition processes), mainly by IR / Visible spectroscopy and electrical measurements. These physical characterizations are completed by morphological and structural information obtained by electron microscopy (TEM, SEM) and X-ray diffraction (XRD).









Its research activity takes advantage of the possibility of creating thin coatings of complex compounds (such as oxides, nitrides, stable or metastable perovskites) or nanostructured films (transition metal nanoparticles in, or interfaced with, oxides) allowing to obtain original functional properties for three types of applications: thermochromism, optoelectronics and energy conversion.
With a long experience in vacuum deposition techniques, the group elaborates ceramic thin films and nano-structured layers by physical vapor deposition (PVD) methods.
The group has seven processing racks, three of which are connected to the D.A.U.M. Tube including a semi-industrial machine.

Application procedure

The position requires a security clearance attributed after the candidate selection and before the start of the internship. Applicants must send their CV and cover letter by **1st Decembre 2021** to the contact person mention in the job offer

Characterization of nano-objects by transmission electron microscopy tomography

Mission

The purpose of this internship is the use and development of tomography during the characterization of nano-objects by transmission electron microscopy. The nanomaterials observed will have various compositions and shapes and will have to be characterized at nanometric and atomic scales to understand the properties related to their use in different fields.

For the characterization of nano-objects, transmission electron microscopy is one of the most widely used methods because it can determine the shape, composition, and crystallographic structure at the nanometric scale. However, this technique generally only allows you to obtain a 2D image of a 3D object. By performing tomography in the microscope, it is possible to reconstruct the volumes and for example to locate variations in composition, pores, facets, etc. After acquisition of the data (images, diffraction images or elementary maps) at different angles, it will be a question of reconstructing in 3D the characterized particles to determine their shape and their crystallographic structure (by reconstructing the reciprocal network) and to locate with precision the elements present in the nano-object.

As part of the internship, the intern will perform the following missions:

- Bibliography
- Data collection by transmission electron microscopy
- Data processing to obtain 3D images or 3D maps

Skills

- Physics and / or materials sciences
- Basics in the characterization of materials
- Mastery of digital tools and their uses
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science
- Ability to work in a team
- Excellent interpersonal skills
- Rigor and sense of organization

Contact

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Non-equilibrium synthesis of Gold-Copper Nanoparticles: Applications to plasmonics

Mission

Downscaling objects to nanoscale have revealed unexpected physical phenomena and has opened up new fields of application. Nowadays, there are technologically mature processes for large-scale synthesis of nano-objects of simple composition (pure substances, stable binary alloys, etc.). One research direction consists in synthesizing nano-objects of more complex shape or architecture to generate local phenomena and properties exacerbation.

The study of Nano-objects, complex by their composition or by their microstructure, is much more recent. For instance, the first Nanoparticles composed of a phase with more than three elements were not synthesized until 2018 [1]. Likewise, if the metastable phases constitute an important breeding ground for new materials, the possibility of synthesis at the nanometric scale remains very limited by conventional chemical routes. Non-equilibrium processes (plasmas, lasers, ultrasound, etc.) carried out in liquids are promising both for the synthesis of high entropy materials (at least 5 elements in solid solution in a single phase), metastable (PbO and Cu-Ag in solid solution) [2], [3] and nanoparticles of complex microstructure [4]. All these Nanoparticles have shown very promising functional properties

During this internship we will focus on the study of the Au-Cu system which has the advantage of being composed of two plasmonic materials and therefore appropriate for a study of optical properties. In addition, the combined presence of relatively large domains of solid solutions and intermetallic compounds (Au_3Cu, AuCu, $AuCu_3$) will allow a better understanding of the solidification mechanisms of nanoparticles under extreme conditions of strong thermal gradients. As part of the internship, the intern will perform the following missions:

This internship will have several stages:

- Development of thin layers of Au-Cu alloys of different compositions
- Synthesis of Nanoparticles by plasma processes in liquids
- Characterization of structural (X-ray and electron diffraction) and morphological (scanning electron microscopy and transmission electron microscopy) properties.
- Studies of optical properties (in collaboration with a foreign university)
- Correlation between structural and optical properties, investigation of possible synergistic effects

[1] Y. Yao et al., « Carbothermal shock synthesis of high-entropy-alloy nanoparticles », Science, vol. 359, no 6383, p. 1489-1494, mars 2018, doi: 10.1126/science.aan5412.
[2] H. Kabbara, J. Ghanbaja, A. Redjaïmia, et T. Belmonte, « Crystal structure, morphology and formation mechanism of a novel polymorph of lead dioxide, γ-PbO2 », J. Appl. Crystallogr., vol. 52, no 2, 2019,
[3] N. Tarasenka et al., « Synergistic Effect of Plasma and Laser Processes in Liquid for Alloyed-Nanoparticle Synthesis », Phys. Rev. Appl., vol. 13, no 1, p. 014021, jan. 2020,
[4] A. O. Larin et al., « Plasmonic nanosponges filled with silicon for enhanced white light emission », Nanoscale, vol. 12, no 2, p. 1013-1021, jan. 2020,

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science, rigor and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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Creation of an interactive interface for the visualization of complex atomic structures: Applications to the discovery of materials by machine learning

Mission

Discovering new materials is a cornerstone of the environmental, energy and digital transition. While it is now easier to manufacture new materials, the question of relevance in terms of expected performance still arises with the same acuteness. This is why LORIA and its partners from the Jean Lamour Institute, Uppsala University and ITMO (Russia), propose to study the contribution of artificial intelligence to guide the discovery of new metal alloys.

When pure, metals organize themselves into relatively simple geometric shapes like cubes or hexagons (Figure 1a). These structures have a high number of symmetries, which influences their final properties. The introduction of other atoms - to make alloys - will distort the structure (figure 1b and c) with effects on properties which are not yet quantified.

The intern will perform the following tasks in particular:

- Establish an algorithm to establish all the possible atomic combinations for a given alloy
- Design a 3D visualization tool for these structures
- Design experiment to assess the accuracy of the models.

This internship requires programming skills and 3D visualization tools, basic knowledge of probability and an open mind. The partnership and international nature of the project will put the trainee in contact with both researchers and teachers from the different partner countries.

The internship will take place both at Institut Jean Lamour and LORIA (https://www.loria.fr/en/)

[1] Y. Yao et al., « Carbothermal shock synthesis of high-entropy-alloy nanoparticles », Science, vol. 359, no 6383, p. 1489-1494, mars 2018, doi: 10.1126/science.aan5412.

Skills

- Knowledge in Artificial Intelligence and applied Mathematics
- Basic knowledge in Physics and / or materials sciences
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science, rigor, and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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Transition metal nitride nanoparticles for new photothermal therapies

Mission

Transition Metal Nitrides (TMN) have been seen in previous years as strong candidates to replace gold as a plasmonic material. While in a recent theoretical study, Lalisse et al. [1] tempered the interest of NMTs for detection or data storage applications, but validated the superiority of thermoplasmonic responses of NMTs compared to gold. The high performance in optical heating, combined with high melting points and for certain NMTs (eg TiN, ZrN) and biocompatibility make them serious candidates for photothermal therapies.

Nanoparticles can be heated by exposure to a luminous flux by plasmonic effects in the case of metals (resonance with the electrical modes of the particles) [2], or by the resonance between the incident photons and the magnetic modes in the case of dielectric and semiconductor materials [3]. However, the efficiency of heating this type of material by coupling between an electromagnetic wave (light) and the nanoparticle is very dependent on the ratio between the incident wavelength and the diameter of the nanoparticles. Thus, even a relatively small dispersion in size of the nanoparticles can lead to very dispersed results in terms of optical heating.

NMTs have the advantage of having an optical behavior that lies between metals and dielectrics. Therefore, two heating modes can be activated using electrical (plasmon) and magnetic modes. In addition, their relatively high loss coefficient makes the dependence of heating efficiency on size less discrete and rather monotonous. This means that a dispersion in size of the Nanoparticles will only slightly affect the efficiency of the optical heating. In addition, a number of NMTs such as TiN and ZrN are recognized as biocompatible in bulk.

The purpose of the internship will therefore be to synthesize Nanoparticles of different sizes and different compositions. Numerical modeling should be planned upstream to determine the size interval with the most efficient optical heating (allowing exposure to be limited) in the infrared range. The chosen size interval will also take into account biocompatibility through cytotoxicity studies conducted by another trainee.

This internship will have several stages:

- Elaboration of thin films of transition metal nitrides
- Synthesis of Nanoparticles by plasma processes in liquids
- Characterization of structural (X-ray and electron diffraction) and morphological (scanning electron microscopy and transmission electron microscopy) properties.
- Studies of optical properties (in collaboration with a foreign university)
- Studies of the absorption of Nanoparticles by human cells (in collaboration with the teams from the Hospital and L2CM laboratory)

[1] Lalisse, A. et al. Plasmonic efficiencies of nanoparticles made of metal nitrides (TiN, ZrN) compared with gold. Sci. Rep. 6, (2016) 38647 doi: 10.1038/srep38647
[2] Baffou, G. and Quidant, R. (2013), Thermo-plasmonics: using metallic nanostructures as nano-sources of heat. Laser & Photonics Reviews, 7: 171-187. doi:10.1002/lpor.201200003
[3] George P. Zograf et al. Resonant Nonplasmonic Nanoparticles for Efficient TemperatureFeedback Optical Heating Nano Letters 2017 17 (5), 2945-2952

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science, rigor and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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Growth of metastable alloy nanoparticles on the graphene surface

Mission

Researchers are working to develop complex nanomaterials to bring out new properties. Among these complex materials, hybrid nanomaterials that result from a coupling between two compounds can exhibit synergistic effects between their constituent parts and induce exacerbated or novel properties. These materials have strong application potential in a wide variety of fields: optics, microelectronics, smart coatings, energy conversion and storage, health and diagnostics, photovoltaics, fuel cells, pollution control, catalysis, sensors, etc.

Graphene is considered to be a substrate of choice. Indeed, its chemical stability, its remarkable elastic modulus associated with an exceptional electronic and thermal conductivity and its high accessible and functionalizable surface, places it at the heart of much research on the development of innovative hybrid materials. The internship work proposes to develop graphene films by self-assembly for use as a substrate. Then the growth of nanoparticles of alloys (for example Cu / Ag) will be carried out by cathodic sputtering. Part of the work will involve the use of the institute's ultra-vacuum TUBE: one of the most sophisticated technological tools in the world where a groin of state-of-the-art equipment is connected to it. The in-depth characterization of the nanoparticles formed (under experimental conditions to be optimized) will be carried out in particular by transmission electron microscopy and optical methods. Their use for surface-enhanced Raman scattering (SERS for “Surface-Enhanced Raman Spectroscopy”) or photocatalysis will be studied in particular.

This internship will have several stages:

- Development of hybrid nanomaterials: graphene film by self-assembly and inorganic deposition by PVD. Modification of the surface chemistry of graphene films.
- Characterization of structural (X-ray diffraction and Raman spectrometry) and morphological (scanning electron microscopy and transmission electron microscopy) properties.
- Studies of optical properties
- Correlation between structural and optical properties, investigation of possible synergistic effects

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B1 (common European framework of reference for languages)
- Curiosity and taste for science, rigor and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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Cobalt oxides thin films for the catalytic decomposition of water

Mission

Amongst the different solutions for increasing the share of renewable energies in the European energy mix, the use of fuel cells is a particularly promising avenue. This type of device makes it possible to generate electricity without producing greenhouse gases. The operation of fuel cells is based on the reaction between hydrogen and oxygen. However, the production of hydrogen in large quantities by environmentally friendly processes is a technological barrier that must be opened in the coming years. This internship is part of this theme with the aim of offering new surfaces based on thin films of cobalt oxides. These films will be produced by magnetron sputtering under reactive conditions. The advantage of this technique relies in the fine control of the chemical composition of films and its possibility to produce composite films, that is to say films containing several phases of cobalt oxides. This approach brings a significant advance in this crucial technological field in which the characteristics of the material produced have a strong impact on the reaction mechanisms involved and the performances obtained.

The intern will work within the Thin Films for Energy and Applications team (team 202) of the Jean Lamour Institute which is the largest research laboratory at the University of Lorraine and the largest French laboratory in Science of materials.

This internship will have several stages:

- Production of thin films of cobalt oxides by reactive magnetron sputtering. The deposition reactor is connected to the TUBE of the IJL.
- Characterization of structural properties (X-ray diffraction and Raman spectrometry), morphological (scanning electron microscopy and transmission electron microscopy). Measurement of electrical properties by 4-point resistivimetry and Hall effect and optical properties (UV-visible spectrophotometry).
- Determination of the performance of thin films for the photocatalytic decomposition of water
- Correlation between the basic properties of films and their catalytic performance. Particular attention will be paid to the composite nature of the films and their nanostructure.

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science, rigor, and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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Functional properties of high entropy nitride thin films: from experimental measurement to modelling

Mission

High entropy alloys (HEA) are made up of at least 5 metallic elements in a significant concentration (> 5 at%). They crystallize in these simple structures like CFC, CC or HC and do not give rise to the formation of intermetallic compounds. HEAs have improved mechanical properties compared to conventional metal alloys, thus opening the way to new applications. Recently, a new class of materials, based on the concept of HEA, has emerged by the addition of non-metallic elements such as oxygen or nitrogen resulting in the formation of high entropy oxides or high nitrides. entropy (HEN). Thin-film deposition techniques allow HEN coatings to be developed and their chemical composition to be easily varied. The work published to date focuses on mechanical, tribological and oxidation resistance properties. To open new applications for HEN coatings, it is essential to study properties other than those mentioned above. This is the objective of this internship proposal: to study the electrical and optical properties of thin films of HEN.

This internship aims to develop thin films of high entropy metal nitrides (or phased array metal nitrides) and to characterize their functional properties. It can be described according to 4 main phases:

- Production of thin films of high entropy metal nitrides by reactive magnetron sputtering. The deposition reactor is connected to the TUBE of the IJL. It is a unique device consisting of a 70 m long ultra-vacuum transfer tunnel connecting around 25 thin-film deposition and characterization equipment.
- Characterization of structural (X-ray diffraction and Raman spectrometry), morphological (scanning electron microscopy and transmission electron microscopy) properties and determination of the chemical composition of films by Castaing microprobe.
- Measurement of mechanical properties by nanoindentation, of electrical properties by 4-point resistivity and Hall effect and of optical properties (UV-visible spectrophotometry).
- Correlation between the functional properties of films and their chemical composition / microstructure in order to propose a model to determine the main factors governing the properties of use of this new class of materials.

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science, rigor and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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Finite element simulation of heat flows in an RTA annealing furnace

Mission

As part of the thermochromic perovskite activity developed in the FMEA team, the production of ternary oxides of the RMeO3 type (R: rare earths, Me: transition metal) by magnetron sputtering leads to the synthesis of amorphous coatings that needs to be crystallized under conditions such that the loss of oxygen is minimized in order to obtain thermochromic perovskites having a metal / insulator transition temperature. The annealing step can be carried out in an RTA furnace which heats by radiation. As thermochromic perovskites have an emissivity which varies as a function of temperature, it is necessary to control the heat fluxes passing through the sample as a function of its emissivity and according to its positioning in the furnace, taking into account the interface resistances and the substrate on which the film is located.

The trainee will have to develop a finite element code making it possible to predict the temperature at the surface of a composite sample (substrate + films) of variable emissivity subjected to an IR ray in an RCA type treatment oven.

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B2 (common European framework of reference for languages)
- Writing and analytical skills
- Mastery of digital tools and their uses, in particular finite element calculations
- Ability to interact and work in a team
- Scientific rigor and sense of organization

Contact

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Advanced characterization of Siberian remains (Yakutia, XVI - XIXth century)

Mission

The ancient Yakuts, breeders of cows and horses, spread from the Lake Baikal region (Russia) in the Middle Ages to the Arctic Circle in the 17th century and to the Arctic Ocean in the 19th century. Their traditional way of life and their social organization evolved as a result of contact with the Europeans, who founded their first settlements in the first half of the 17th century. The recent history of the Yakuts is an exceptional opportunity to generate new interdisciplinary processes in order to study the mechanisms of cultural evolution linked in particular to technological development in the fields of mining, forging, and the representation of power by the indigenous elites, all in the context of contact with Europeans and the mobility of subjects. For this, we will compare objects and jewelry, including the signet rings of chieftains, worn by more than a hundred subjects from frozen tombs.
The characterization techniques available at the IJL (scanning electron microscopy, transmission, secondary ion mass spectroscopy, etc.) and in synchrotrons will be used to have a detailed knowledge of the materials composing these jewels. This study will make it possible to formulate hypotheses regarding manufacturing techniques. These hypotheses can then be verified in the field by archaeologists.
This internship will have several stages:

- Comparative bibliographic study on ancestral metallurgical techniques in Siberia and Europe
- Interpretation of experimental results obtained at the Synchrotron and by electron microscopy (scanning and transmission)
- Modeling of diffusion mechanisms

Skills

- Physics and / or materials sciences / Basics in the characterization of materials
- English language: level B2 (common European framework of reference for languages)
- Curiosity and taste for science, rigor, and sense of organization
- Ability to work in a team, Excellent interpersonal skills

Contact

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