PhD Position at IJL

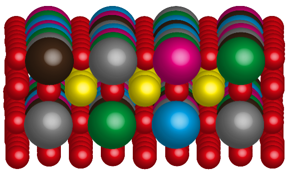
High Entropy Oxide Thin Films Grown by Molecular Beam Epitaxy

General information

Workplace: Institut Jean Lamour, Nancy, France
Type of contract: PhD contract with University of Lorraine
Contract period: 36 months
Expected date of employment: October 2026
Remuneration: ~2300 € / month (gross salary) from ANR
Desired level of education: Master's degree in materials science, physics or chemistry.

Context

High entropy Oxides (HEOs), discovered by Röst *et al*. [1], refer to entropy stabilized oxides containing five or more principal cations in near to equiatomic concentration and with unique cationic sublattices and unusual cation coordination values. Surrounded by oxygen atoms (anions), the enthalpy of mixing is equal to zero, the HEO being stabilized by the entropic term. The first HEO reported [1] was a rocksalt structured (CoCuMgNiZn)O. Based on an enhanced configurational entropy, the incorporation of multiple elements in a phase pure system has led to the identification of eight major classes of HEO, namely those adopting structures such as rocksalt, fluorite, bixbyite, perovskite, spinel, pyrochlore, layered and magnetoplumbite. The exploration of such a field of research is blooming as the concept of high entropy materials offers new perspectives in the design of materials and oxides with multiple possible combinations and compositions. While the growth of HEO as epitaxial thin films is very limited with only a handful of reported studies [2-4], their functional properties appear to surpass those of their constituents [5]. Their immense compositional space should facilitate tailoring their functional properties. Consequently, HEO represent an ideal playground to continue discovering new bulk and surface properties. To disentangle decisive factors linked to the growth, stability, and properties of such complex materials, investigations of model systems under controlled conditions are of paramount importance.



To this end, the thesis will aim at obtaining high structural quality epitaxial thin films which would overcome the current lack of sample availability. The HEO single crystals will be synthesized by molecular beam epitaxy. The bulk and surface structures will be investigated down to the atomic level using state-of-the-art equipments including transmission electron microscopy and surface science equipments under ultra-high vacuum conditions. This approach will lead to an atomistic description of bulk and surfaces of HEO systems, knowledge necessary to adapt this material for applications. This project is based on the expertise of 2 research teams, 3 technical centers and on facilities unique in IJL.

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 the 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.
By 2026, IJL has 258 permanent staff (33 researchers, 133 teacher-researchers, 92 IT-BIATSS) and 389 non-permanent staff (146 doctoral students, 43 post-doctoral students / contractual researchers and more than 200 trainees), from some seventy different nationalities.
Partnerships exist with 150 companies and our research groups collaborate with more than thirties 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 CV, cover letter, names of references and M1/M2 marks together to the advisor and co-advisor:

Dr. Karine Dumesnil (CR-CNRS), Email : karine.dumesnil@univ-lorraine.fr
Dr. Julian Ledieu (DR-CNRS), Email : julian.ledieu@univ-lorraine.fr

The PhD student will be affiliated to the C2MP doctoral school (Chemistry - Mechanics - Materials – Physics, https://doctorat.univ-lorraine.fr/en/doctoral-schools/c2mp/presentation).

The PhD student will be hosted by two Research groups: « SPIN » (101) and « Surface and Metallurgy » (203) of the Institut Jean Lamour, CNRS-Université de Lorraine, Campus Artem, Nancy.

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References:

[1] C. Rost, E. Sachet, T. Borman, A. Moballegh, E.C. Dickey, D. Hou, J.L. Jones, S. Curtarolo and J.-P. Maria, Entropy-stabilized oxides, Nat Commun 6, (2015) 8485. https://doi.org/10.1038/ncomms9485 .

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[3] Y. Sharma, B.L. Musico, X. Gao, C. Hua, A.F. May, A. Herklotz, A. Rastogi, D. Mandrus, J. Yan, H.N. Lee, M.F. Chisholm, V. Keppens, and T.Z Ward, Single-crystal high entropy perovskite oxide epitaxial films, Phys. Rev. Mat. 2, (2018) 060404(R). https://doi.org/10.1103/PhysRevMaterials.2.060404

[4] R. Kumar Patel, S. Kumar Ojha, S. Kumar, A. Saha, P. Mandal, J.W. Freeland, and S. Middey, Epitaxial stabilization of ultra thin films of high entropy perovskite, Appl. Phys. Lett. 116, (2020) 071601. https://doi.org/10.1063/1.5133710

[5] J.L. Braun, C.M. Rost, M. Lim, A. Giri, D.H. Olson, G.N. Kotsonis, G. Stan, D.W. Brenner, J.-P. Maria and P.E. Hopkins, Charge-Induced Disorder Controls the Thermal Conductivity of Entropy-Stabilized Oxides, Adv. Mater. 30, (2018) 1805004. https://doi.org/10.1002/adma.201805004