Université de Paris

2021-2022

Master thesis proposal

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Director: Cristiano Ciuti

Title:
Synthesis of innovative High Entropy NanoAlloys

Keywords:
Nanoalloys, Synthesis

Scientific description:
With their rapid development and broad fields of application, high entropy alloys (HEA) in bulk form have become an inspiring and intriguing field of research for their mechanical properties [1,2]. Due to the high mixing entropy effect, these materials, containing multiple elements (typically 4 to 6) in nearly equiatomic composition, tend to form simple solid solution microstructures and have attracted significant attention from the scientific community in Material Science [3]. On the other hand, at the nanoscale, research is still in its very beginning whereas at this scale remarkable properties have often been demonstrated [4]. To develop these novel nanoalloys with improved mechanical behavior, stability, formability, and other advanced properties, it requires innovative synthesis and processing strategies based on the understanding of the fundamental transformation and deformation mechanisms. In this project, we aim to develop a strategy for the design of innovative materials by engineering nanoparticles (NPs) in complex alloy systems to achieve original mechanical properties. The Grail of any metallurgist can therefore be achieved by developing advanced materials with a substantial improvement of both strength and ductility
This internship will focus on the synthesis by soft chemical method and pulsed laser deposition (PLD) of high-entropy nanoalloys that are promising new nanosystems for mechanical applications. Concerning wet chemistry, we will use original approach recently developed by the ICMMO laboratory at Orsay to synthesize multimetallic particles of controlled size and composition. The key point of this synthesis is to compensate the differences in the reactivities of the different metallic precursors used by increasing the temperature of the synthesis. Under these conditions, the decomposition of all the metallic precursors occurs at the same rates, resulting in uniform alloying. On the other hand, the PLD method is very powerful to growth multi-component thin films that can be easily structured by post-synthesis laser simulated annealing.
Then, we will perform advanced TEM experiments with intend to study central questions regarding the synthesis and the structural properties of nanoparticles made of three, four or five metals in order to determine if we can simultaneously control the size, shape and composition of nanoalloys.

[1] B. Cantor et al., Mater. Sci. Eng. A 375-377, 213 (2004).
[2] J.-W. Yeh et al., Adv. Eng. Mater. 6, 299 (2004).
[3] E.P. George et al., Nat. Rev. Mater. 4, 515 (2019).
[4] D. Guo et al., J. Phys. D:Appl. Phys. 47, 013001 (2014).

Techniques/methods in use: Fabrication of nanomaterials in ultra-high-vacuum, Aberration corrected electron microscopy

Applicant skills: Good knowledge of materials science and/or solid-state physics (knowledge in crystallography and nanomaterial synthesis will be major assets). Strong motivation to perform in a multidisciplinary environment at the frontier of physics and chemistry. Autonomy, collaborative spirit, oral and writing skills in French or in English.

Applications in English or in French should include:
- A short cover letter.
- Names and contact information of at least one reference.
- Up-to-date CV with education history and any research experience.
- Copy of university marks at the bachelor and Master levels.

Industrial partnership: N

Internship supervisor(s) damien.alloyeau@u-paris.fr and christian.ricolleau@u-paris.fr
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Internship location: Laboratoire MPQ, Université de Paris, Paris 13e

Possibility for a Doctoral thesis: YES. ANR project under review and Doctoral School competition