



## Post-doc on the investigation by in-situ transmission electron microscopy of mechanical properties of HEA nanoparticles

**Project description:** Metallic nanoparticles (NPs) exhibit unique physico-chemical properties departing from those of bulk materials, primarily due to their high surface-to-volume ratio. These distinctive features make them highly attractive for applications in catalysis, biomedicine, and optics. In this context, high-entropy alloys (HEAs) NP represent an emerging and promising class of materials, as the combination of multiple metals within a single nanostructure enables precise tuning and enhancement of their properties. However, mechanical stresses can induce structural transformations that may strongly influence their performance. Therefore, understanding the response of alloy NPs to mechanical loading is essential for improving their stability and optimizing their functional behavior.

The goal of this postdoctoral project is to carry out state-of-the-art experimental research on mechanical properties of HEA NPs with the intent of elucidating the link between structure and properties. More precisely, the project will stem from the recognized expertise of the CEMES laboratory in in-situ TEM nanoindentation [1] to identify key deformation mechanisms at play. Experimentally, this will involve preparing suitable supports and indenter surfaces prior to performing TEM measurements, in order to determine yield stress values and assess possible plastic deformation behaviors. This will be supported by numerical simulations developed by the LEM where nanoindentation simulations at the atomic scale will be performed by Molecular Dynamic (MD) as well as finite elements (FE), both areas in which LEM has established expertise [2].

In addition, the researcher will take advantage of a unique consortium funded by the French National Research Agency (ANR YOSEMITE) including five partners: CEMES, LEM, MPQ (physical synthesis of HEA NPs) [3], ICMMO (chemical synthesis of HEA NPs) [4] and CINAM (modelling the structural stability of HEA NP). The postdoctoral researcher will therefore have access to nanoparticles whose synthesis is expertly handled by the MPQ and ICMMO teams [3,4]. Furthermore, the joint position between CEMES (responsible for the experimental work) and LEM (developing the “digital twin” of the experiments) will ensure efficient knowledge transfer among all partners, an essential factor for the project's success.

**Job description:** 12 months from January 2026 at LEM (Châtillon) and CEMES (Toulouse) in France. May be extendable.

**Academic Level:** Ph. D in Physics, Materials Science, Nanomaterials

**Activities:** surface preparation and NP manipulation, in-situ TEM nanoindentations of HEA NPs, setting up an analysis procedure of experimental data, MD and FE calculations.

**Expertise:** skills in TEM (different modes), ability to set up original instrumental developments, experience in investigating mechanical properties of materials. Previous experience in the synthesis/fabrication of materials would be a real plus

**Location:** LEM (Châtillon) and CEMES (Toulouse), France

**Salary:** 3000€-3300€ / month

**Application:** send your CV with publication list, a motivation letter and list of referees to [marc.legros@cemes.fr](mailto:marc.legros@cemes.fr), [hakim.amara@onera.fr](mailto:hakim.amara@onera.fr) and [Riccardo.gatti@onera.fr](mailto:Riccardo.gatti@onera.fr)

[1] Legros, M. et al., Observing deformation in situ. *Nat. Mater.* 23, 20–22 (2024) [2] Erbi, M. et al., Tuning elastic properties of metallic nanoparticles by shape controlling: From atomistic to continuous models, *Small*, 2302116 (2023) [3] Krouna S. et al., Atomic-scale insight into the thermal stability of high-entropy nanoalloys, *Adv. Mat.* 37, 2414510 (2025) [4] Moreira Da Silva C. et al., Colloidal synthesis of nanoparticles: from bimetallic to high entropy alloys, *Nanoscale* 14, 9832 (2022)