CHEMICAL SHORT-RANGE ORDER AND LOCAL LATTICE DISTORTIONS IN HIGH-ENTROPY ALLOYS: STATE OF THE ART

A. Fantin [1]

[1] Federal institute of Materials Research and Testing (BAM), Germany
E-mail: *andrea.fantin@bam.de*

Understanding the complex atomic-scale structures within High-Entropy Alloys (HEAs) is crucial for tailoring their properties to diverse applications. The present contribution aims to provide an overview of the state-of-the-art experimental techniques employed in probing local lattice distortions and chemical short-range order in HEAs: from synchrotron/neutron-based techniques such as X-ray absorption spectroscopy and X-ray / neutron total scattering to less known techniques such as single-crystal diffuse scattering and atomic-resolution holography. The primary challenges in analyzing multi-component alloys lie in the inherent reduced scattering contrast between the five or more alloying elements, often neighbors in the periodic table, and their simple crystal structures with few or even one single Wyckoff site. These characteristics constrain the amount of information that can be obtained from the data, statement that applies to transmission electron microscopy, as well.

At the laboratory level, the more accessible thermo-physical methods such as differential scanning calorimetry and electrical resistivity showed to be valuable in the corroboration and quantitative estimation of ordering within HEAs.

It becomes evident that rather than relying solely on individual techniques, it is the combination of several experimental approaches, ideally complemented by simulations, that can effectively assign the contribution of each element to the alloy structure and, ideally, to the overall alloy performance. It is, therefore, important to recognize that each experimental method has its own strengths and weaknesses, which will also be shortly addressed.

References

Coury et al. : On the nature of chemical short-range order evolution, Pre-print (https://doi.org/10.21203/rs.3.rs-7339299/v1), 2025.
Bacurau et al. : Comprehensive analysis of ordering in CoCrNi and $CrNi_2$ alloys, Nature Communications, 15(1), 7815, 2024.
Fantin et al. : Local lattice distortions and chemical short-range order in MoNbTaW, Materials Research Letters, 12(5), 346–354, 2024.
Andreoli et al. : The impact of chemical short-range order on the thermophysical properties of medium and high-entropy alloys, Materials & Design, 238, 112724, 2024.
Fantin et al. : How atomic bonding plays the hardness behavior in the Al-Co-Cr-Cu-Fe-Ni high-entropy family, Small Science, 4(2), 230225, 2024.
Joubert et al. : Site occupancies in a chemically complex σ-phase from the high-entropy Cr-Mn-Fe-Co-Ni system, Acta Materialia, 259, 119277, 2023.
Kasatikov et al. : Chemical interaction and electronic structure in a compositionally complex alloy: a case study by means of X-ray absorption and X-ray photoelectron spectroscopy, Journal of Alloys and Compounds, 857, 157597, 2021.
Fantin et al. : Short-range chemical order and local lattice distortion in a compositionally complex alloy, Acta Materialia, 193, 329–337, 2020.