Scientists see chemical short-range order in medium-entropy alloy

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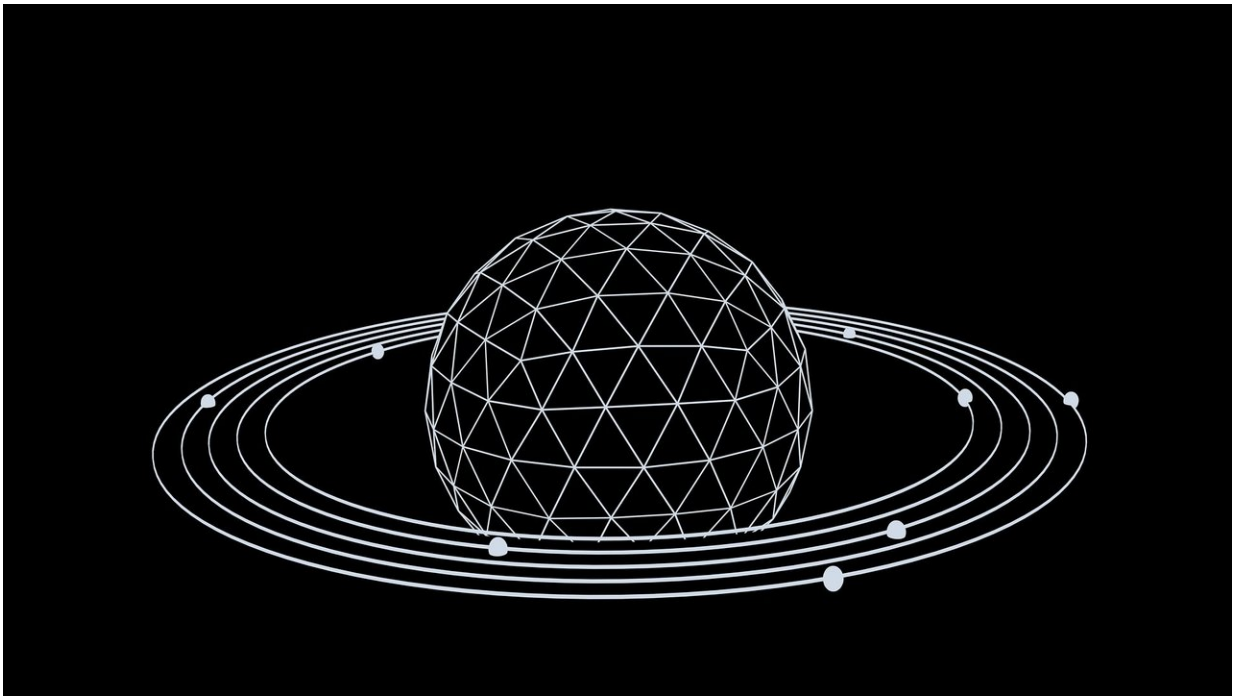

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Chinese scientists have made direct observations of face-centered cubic VCoNi (medium)-entropy alloys (MEA) and for the first time proposed a convincing identification of subnanoscale chemical short-range order (CSRO). This achievement undisputedly resolves the pressing question of if, what and why CSRO exists, and how to explicitly identify CSRO.

This work, published in *Nature* on April 29, was conducted by Prof. Wu Xiaolei from the Institute of Mechanics of the Chinese Academy of Sciences (CAS) in collaboration with Prof. Ma En's team from Xi'an Jiaotong University and Prof. Zhu Jing's team from Tsinghua University.

Multi-principal element alloys—also known as high (medium)-entropy alloys (HEAs/MEAs)—are a hot and frontier topic in multidisciplinary fields. In these HEAs/MEAs, enthalpic interactions among constituent elements may induce various degrees of local chemical order (LCO), of which CSRO is arguably the most difficult to decipher.

"CSRO is the crucial cut-in point for understanding the unique mechanical and physical behaviors of these HEAs/MEAs. However, a monumental challenge lies in how to see CSROs. Seeing is believing," said Prof. Wu Xiaolei, leader of the research team.

"The identification of CSROs demands not only irrefutable diffraction evidence, but more importantly, also intricate chemical information on subnanometer-length scale regarding the different preferences of constituent species for occupying certain lattice planes/sites in the first and second nearest-neighbor atomic shell(s). Such concrete evidence of CSRO has been sorely missing thus far," said Prof. Ma.

In this study, the researchers used a complete suite of tools and methods to analyze correlations and justify their origin, in order to avoid missing links or interference from artifacts.

These tools unequivocally nailed down the CSRO, including its spatial extent, atomic packing configuration and preferential lattice occupancy by chemical species.

Modeling of CSRO order parameters and correlations reveals that the CSROs originate from the nearest-neighbor preference for unlike (V-Co

and V-Ni) pairs and avoidance of V-V pairs.

The researchers also used atomic strain mapping to demonstrate the dislocation interactions enhanced by the CSROs. This sheds light on their effects on plasticity mechanisms and mechanical properties upon deformation.

"This work is a significant jump on the CSRO, providing for the community systematic and clear-cut experiments with direct evidence that resolves the debate/uncertainty (or even controversy) left from previous work," said Ma.

"Local chemical order develops as an intrinsic feature in HEAs and MEAs. This offers a new knob to turn, i.e., we have an opportunity to tune the degree of CSRO to tailor the mechanical and physical properties of these new materials," said Wu.

More information: Direct observation of chemical short-range order in a medium-entropy alloy, *Nature* (2021). DOI: 10.1038/s41586-021-03428-z

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