

High entropy MXenes with eight and nine transition metals and methods of making thereof

High-entropy (8–9 metal) MXenes with tunable surfaces expand 2D material options for energy storage and catalysis.

Metal alloys have been popular since the Industrial Revolution to enhance mechanical properties of metals while diminishing unwanted properties like thermal conductivity. However, this process requires the balancing of two chemical properties: entropy and enthalpy. Early studies have shown that increasing the number of metals present in metal alloys may circumvent issues with enthalpically-unstable materials by increasing the entropy of the system, thus leading to the term of "high-entropy" materials. "High-entropy" currently is used to describe many multi-compositional metal materials without clear characterization of the stability of materials as related to their inherent entropy and enthalpy thresholds, which obscures whether or not entropy is enough to stabilize all atomic configurations of a multi-compositional metal material. To address this limitation, researchers at Purdue University have designed a computation-based system in which they can directly measure the relationship between entropy and enthalpy within such a material and then applied their results to modulate the surface topology and electronic behaviors of newly synthesized 2D high-entropy materials known as MXenes. This has expanded the available compositions and tunability of high-entropy 2D materials, which can be used in applications such as energy storage, catalysis, or mechanical reinforcements.

Technology Validation:

- X-Ray Diffraction (XRD) characterization of selected alloys based on aluminum carbide (AlC₃) with different transition metals was performed
- Secondary-ion Mass Spectrometry (SIMS) dynamic measurements for each layer showing metal ion occupancies
- Transmission Electron Microscopy (TEM) images showing morphology of MXene films

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Category

Energy & Power Systems/Energy Storage
Materials Science & Nanotechnology/Nanomaterials & Nanostructures
Digital Health & Medtech/Medical Image Processing

Further information

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Advantages

- More complex compositions (containing 2-9 transition metals) than previously made
- Pipeline established from computational studies to experimental results
- Modulation of surface topology and electronic properties

Applications

- Energy storage
- Catalysis
- Mechanical properties for electronics, mechanical reinforcements, composites

TRL: 3

Intellectual Property:

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