Dual-phase alloy extremely resistant to fractures

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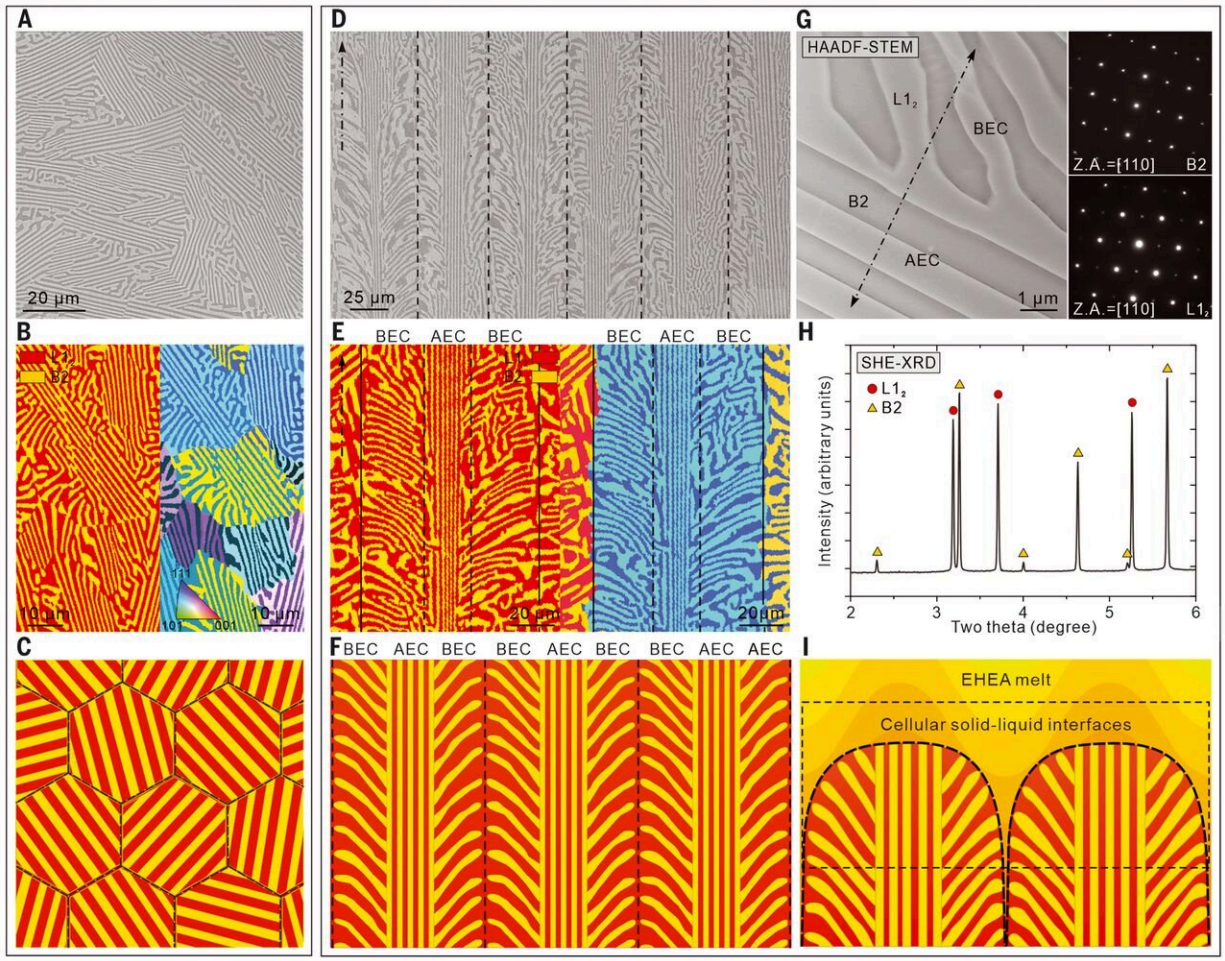

Fig. 1 Hierarchically arranged herringbone microstructure. (A to C) Conventionally cast EHEA serving here as reference material. (A) SEM backscattered electron image. (B) Electron backscattering diffraction (EBSD) phase map (left) and inverse pole figure (IPF) map (right). (C) Schematic diagram. (D to I) The directionally solidified EHEA with a hierarchical

herringbone microstructure. The black arrows in (D) and (E) indicate the DS direction, and also the tensile loading direction in Fig. 2A. (D) SEM backscatter electron image showing that the microstructure is composed of columnar grains. Grain boundaries are marked by black dashed lines. (E) Enlarged EBSD phase and IPF maps showing the columnar grain consisting of AEC and BEC. Black solid and dashed lines mark grain and colony boundaries, respectively. [(F) and (I)] Schematic diagram of herringbone structure and its formation principle, respectively. (G) HAADF-STEM image and related SAED patterns of B2 and L12 phases. The HAADF-STEM image shows clean dual-phase lamellae without evidence of nanoprecipitates or other phases, as is also indicated in (F). (H) SHE-XRD of B2 and L12 phases. Credit: DOI: 10.1126/science.abf6986

A team of researchers affiliated with multiple institutions in China, the U.S. and Germany has created a dual-phase alloy that has proven to be extremely resistant to fracturing. In their paper published in the journal *Science*, the group describes their alloy, why it is so resistant to fracture and possible uses for it. Xianghai An, with the University of Sydney, has published a Perspective piece in the same journal issue outlining new strategies in developing new-purpose alloys and the work done by the team in this new effort.

As An notes, the demand for new kinds of materials for new applications has been accelerating in recent years, driving new work in the development of alloy metals. Customers are looking for materials that are durable, ductile, strong and tolerant of damage. Unfortunately, there are no metals that have all these characteristics. Generally, customers must make a tradeoff, such as between a material's ability to stretch and its strength. To meet such needs, metallurgists are increasingly taking a new approach; instead of starting with a basic metal and adding small amounts of others (such as using iron to make steel), they are starting with varying amounts of different metals. When three or more are used, they are called multi-principal element alloys (MPEAs).

In this new effort, the researchers have developed a new type of MPEA called DS: EHEA, which features "multiscale spatial heterogeneities." More specifically, they used eutectic high-entropy alloys (those that melt and solidify at a temperature that is lower than their individual melting points) to create a dual-phase structured alloy. They found that a particular aluminum-iron-cobalt-nickel alloy solidified in a herringbone micropattern that was very highly resistant to fracturing. Its secret, they discovered, was in its hard and soft phases and the way cracks formed. Those that formed during the hard phase were stopped when they reached a border with a soft phase—the herringbone micropattern served to transfer stress. This gave the finished alloy not only very high resistance to fracture but a tripling of maximum elongation. The researchers suggest their approach could be used in a wide variety of applications that require eutectic high-entropy alloys.

More information: Peijian Shi et al, Hierarchical crack buffering triples ductility in eutectic herringbone high-entropy alloys, *Science* (2021). DOI: 10.1126/science.abf6986