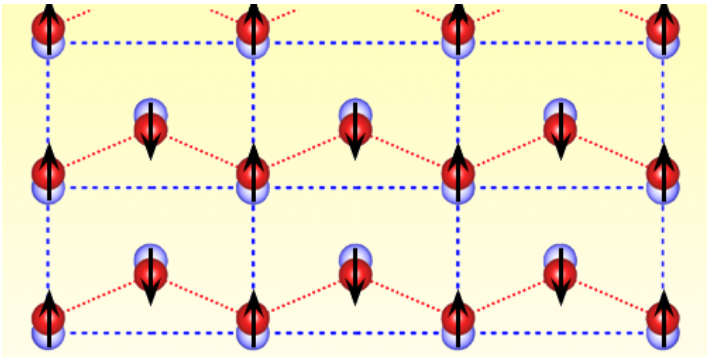
Designer Disorder in a Crystalline Conflict Zone

Inducing correlated disorder into a crystalline material could offer a way to tune the material's phonon properties and thermal conductivity.

By **Marric Stephens**

Crystals are some of the simplest solids to describe theoretically. Comprising a pattern that repeats in space, their large-scale structures can be predicted from just a few parameters. Now, Daniel Chaney at the University of Bristol, UK, and colleagues have created a crystal whose structural order is locally modified by a second, smaller-scale pattern [**1**]. They show that this "correlated disorder" alters how phonons propagate in a material, suggesting a method for controlling its thermal properties.

Two crystals with similar structures can be grown atop one another, such that they lock together like jigsaw puzzle pieces. If one layer subsequently tries to change its crystal structure, the jigsaw interlocking can frustrate the change. The team used this effect to generate a crystallographic "conflict" in a 300-nm-thick film of a uranium-molybdenum (UMo) alloy. They grew a UMo layer onto a niobium underlayer at $800\,^{\circ}$C, a temperature at which both materials have cubic lattices. On cooling, UMo usually decomposes to form orthorhombic uranium and cubic molybdenum. Instead, the niobium-UMo interlocking preserved the alloy's mixed state, forcing it to retain its initial cubic structure.



Credit: D. Chaney *et al.* [**1**]

X-ray scattering experiments revealed that this conflict distorted UMo's cubic lattice, with atoms in alternating planes displaced in opposite directions. This pattern remained coherent over regions 5–30 Å across, with the precise correlation length depending on factors including the alloy's molybdenum content.

The team found that phonons had significantly shorter lifetimes in the perturbed lattice than in a simulated, unperturbed lattice. In UMo, heat transport is dominated by electrons, not phonons. But, the researchers say, correlated disorder could be used to tune the thermal conductivity of materials in which phonons play a larger role.

Marric Stephens is a Corresponding Editor for *Physics* based in Bristol, UK.

REFERENCES

1. D. Chaney *et al.*, "Tuneable correlated disorder in alloys," **Phys. Rev. Mater. 5, 035004 (2021).**