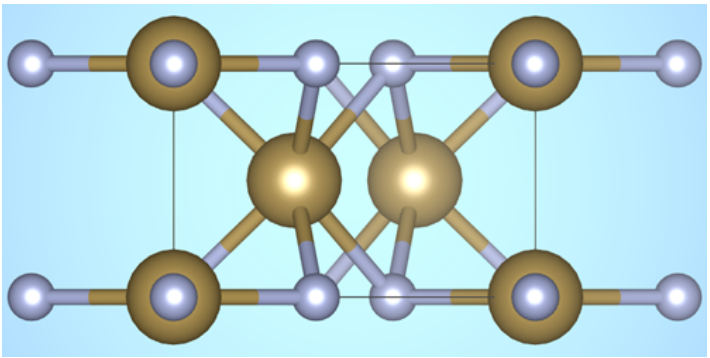
A Metal with Two Heat Carriers

Metals typically rely on electrons to transport heat, but one has been identified that conducts heat efficiently through both electrons and phonons.

By **Ryan Wilkinson**

Materials that have high thermal conductivity usually fall into one of two categories: metals, which transmit heat mainly via electrons; and insulators or semimetals, which transmit heat mainly via lattice vibrations called phonons. Materials in which both electrons and phonons contribute strongly to thermal conductivity are rare, because the physical mechanisms that favor electron transport typically suppress phonon transport, and vice versa. Now Feliciano Giustino and his colleagues at the University of Texas at Austin have theoretically predicted and experimentally realized such a material [**1**]. The team's strategy could be used to design next-generation thermal conductors for nanoelectronic components and other applications.

The researchers began by establishing the conditions under which electrons and phonons contribute significantly to a material's thermal conductivity. They found that a large electron contribution requires a high Fermi velocity—the speed of electrons at their highest occupied energy level, the Fermi level. Meanwhile, a large phonon contribution requires a high speed of sound in the material and a low density of electron states at the Fermi level.



Credit: S. Jung *et al.* [**1**]

By screening several metals and semimetals against these criteria, Giustino and his colleagues determined that a specific crystal form of tantalum nitride known as ϵ-TaN is a promising metal candidate. The researchers performed first-principles calculations, which predicted that single crystals of ϵ-TaN should have a high room-temperature thermal conductivity of about 273 W m^{-1} K^{-1}, between that of aluminum and gold. The thermal conductivity should have an electron contribution of around 20% and a phonon contribution of around 80%. The researchers then synthesized the material and confirmed their predictions through heat-transport experiments, verifying the large electron and phonon contributions to the material's thermal conductivity.

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REFERENCES

1. S. Jung *et al.*, "Balanced electron and phonon heat transport in metallic ϵ-TaN," **Phys. Rev. B 114, 274301 (2026).**