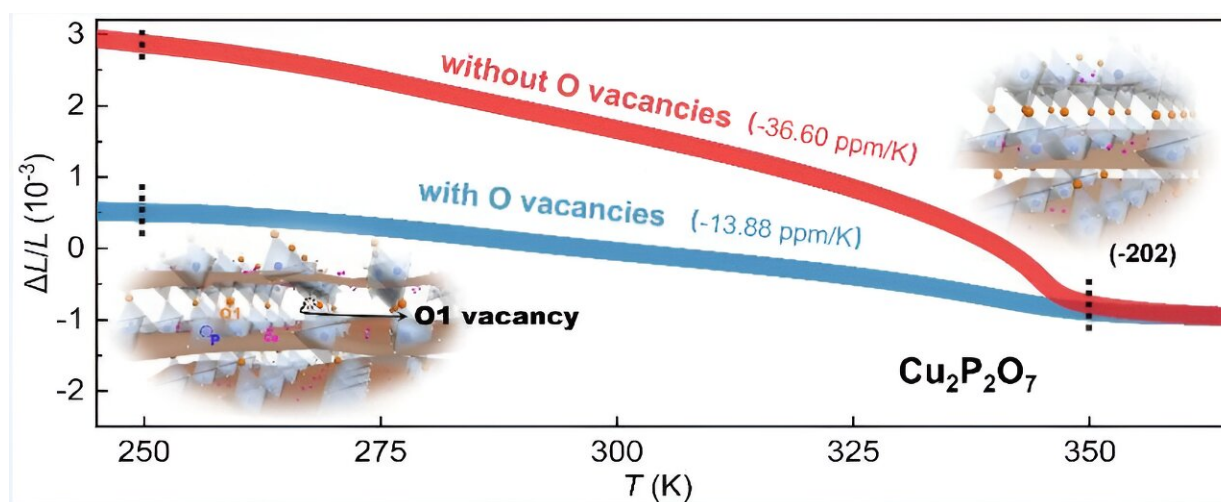


Researchers develop high-performance zero thermal expansion composite for precision devices

September 14 2023, by Zhao Weiwei



Credit: Xie Lulu

Recently, a research group led by Prof. Peng Tong from Hefei Institutes of Physical Science (HFIPS), Chinese Academy of Sciences (CAS), significantly improved the negative thermal expansion (NTE) effect of $\text{Cu}_2\text{P}_2\text{O}_7$, a new but excellent NTE material, and prepared a zero thermal expansion (ZTE) $\text{Cu}_2\text{P}_2\text{O}_7/2024\text{Al}$ composite with high specific thermal conductivity and good machinability.

The research results were published in *Journal of Materials Science &*

Technology and Ceramics International.

With the advancement of high-tech fields, it is not possible to adjust the dimensions of precision equipment. However, thermal expansion with temperature is a [fundamental property](#) of many regularly used materials that is difficult to control. Combining NTE materials with ordinary positive [thermal expansion](#) materials is an efficient way to produce ZTE materials.

In this study, researchers discovered that increasing the sintering temperature improves the NTE impact of $\text{Cu}_2\text{P}_2\text{O}_7$ (from -13.88 ppm/K to -36.6 ppm/K at 250-350 K). The vibration of the bridge oxygen atom causes the NTE effect in $\text{Cu}_2\text{P}_2\text{O}_7$.

The results of temperature dependent X-ray powder diffraction, temperature dependent neutron powder diffraction, and X-ray absorption near edge structure demonstrated that $\text{Cu}_2\text{P}_2\text{O}_7$ produced at [lower temperatures](#) had more oxygen vacancies, resulting in a weaker phase transition and NTE impact.

A series of $\text{Cu}_2\text{P}_2\text{O}_7/2024\text{Al}$ composites were made using the powder metallurgy method in a fast-hot-pressing sintering apparatus using enhanced $\text{Cu}_2\text{P}_2\text{O}_7$ as reinforcement. The composite exhibited ZTE (-0.014 ppm/K at 273-333 K) with up to 50% $\text{Cu}_2\text{P}_2\text{O}_7$ volume addition.

When compared to other reported isotropic ZTE materials, this ZTE composite had a low density of 3.41g/cm^{-3} and a [high thermal conductivity](#) of $49.7\text{WK}^{-1}\text{m}^{-1}$, resulting in a high specific thermal conductivity.

Furthermore, its bending strength could reach 205 MPa, and this type of composite had good machinability due to the matching moduli of $\text{Cu}_2\text{P}_2\text{O}_7$ and 2024Al, as well as a well-bonded interface.

"Our research provided a good candidate NTE material for compositing and a kind of ZTE composite with excellent comprehensive properties which is expected to be used in high-tech fields with high demand of dimension stability," said Xie Lulu, first author of the papers.

More information: L. Lu Xie et al, The enhanced negative thermal expansion in less-oxygen-vacancies copper pyrophosphate, *Journal of Materials Science & Technology* (2022). [DOI: 10.1016/j.jmst.2022.10.054](https://doi.org/10.1016/j.jmst.2022.10.054)

Lulu Xie et al, Zero thermal expansion, high specific thermal conductivity, and good machinability of $\text{Cu}_2\text{P}_2\text{O}_7/2024\text{Al}$ composite, *Ceramics International* (2023). [DOI: 10.1016/j.ceramint.2023.08.240](https://doi.org/10.1016/j.ceramint.2023.08.240)

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