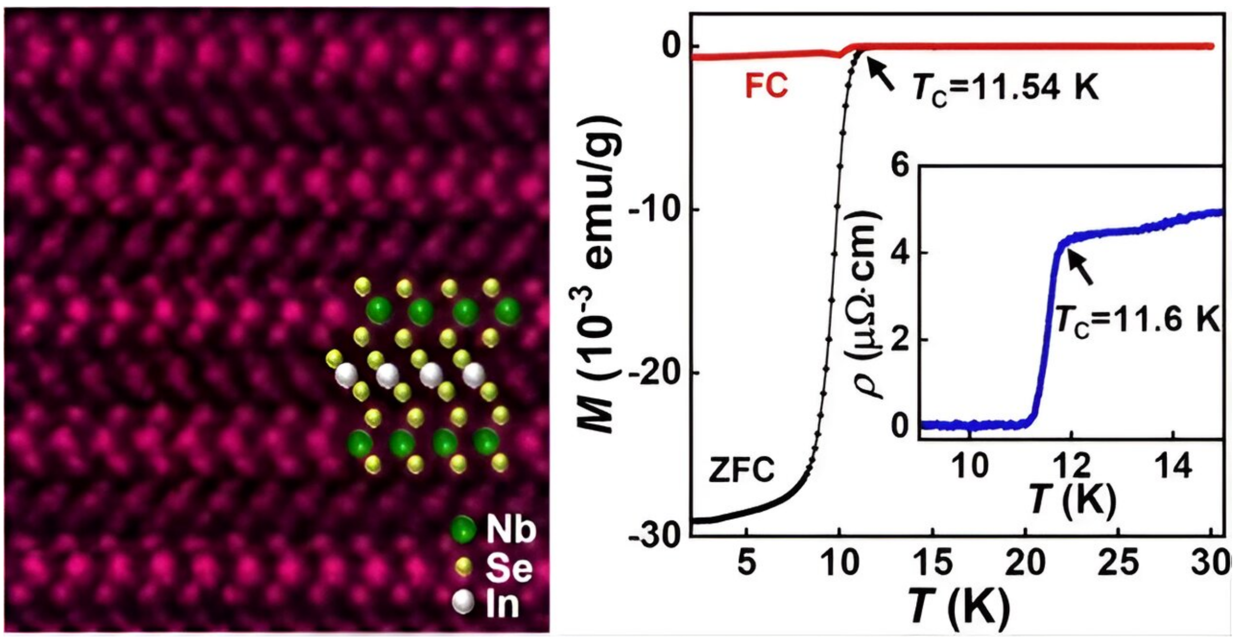
New superconducting material discovered in transition-metal dichalcogenides materials

January 19 2024, by Zhao Weiwei and Zhang Changjin



The crystal structure and superconducting properties of $(InSe_2)_{0.12}NbSe_2$. Credit: Niu Rui

With the support of electrical transport and magnetic measurement systems of Steady High Magnetic Field Facility (SHMFF), a research team from Hefei Institutes of Physical Science (HFIPS), Chinese Academy of Sciences (CAS), discovered a new superconducting material called $(InSe_2)_xNbSe_2$, which possesses a unique lattice structure. The superconducting transition temperature of this material reaches 11.6

K, making it the transition metal sulfide superconductor with the highest transition temperature under ambient pressure.

The results were published in *Journal of the American Chemical Society.*

TMD materials have received lots of attention due to their numerous applications in the fields of catalysis, energy storage, and integrated circuits. However, the relatively low superconducting transition temperatures of TMD superconductors have limited their potential use.

In this study, scientists successfully fabricated a new superconducting material with the chemical formula $(InSe_2)_xNbSe_2$. Unlike the conventional conditions where isolated atoms are inserted into the van de Waals gaps of low dimensional materials, in $(InSe_2)_xNbSe_2$ the intercalated indium atoms were found to form $InSe_2$-bonded chains.

"This material has a very high transition temperature among all transition metal dichalcogenide (TMD) superconductors," said Prof. Zhang Changjin, who led the team, "and it exhibits an impressive critical current density."

The superconducting transition temperature of the $(InSe_2)_{0.12}NbSe_2$ sample could be as high as 11.6 K at ambient pressure, which is 60% higher than that of pristine $NbSe_2$.

Furthermore, the $(InSe_2)_xNbSe_2$ superconductor exhibits large critical current density of $8x10^5$ A/cm_2, which is also the highest among all TMD superconductors. The critical current density is comparable with high-temperature superconductors such as cuprate and iron-based compounds, demonstrating its good application prospects.

This discovery opens up new possibilities for advancing superconductivity research and developing high-temperature superconductors with improved performance, according to the team.

More information: Rui Niu et al, Enhanced Superconductivity and Critical Current Density Due to the Interaction of InSe2 Bonded Layer in $(InSe_2)_{0.12}NbSe_2$, *Journal of the American Chemical Society* (2024). DOI: 10.1021/jacs.3c09756

Provided by Hefei Institutes of Physical Science, Chinese Academy of Sciences

Citation: New superconducting material discovered in transition-metal dichalcogenides materials (2024, January 19) retrieved 27 April 2024 from https://phys.org/news/2024-01-superconducting-material-transition-metal-dichalcogenides.html

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