Vietnamese professor holds the 'key' to promising breakthrough new generation SSD and RAM technology

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A team of scientists from the Tokyo Institute of Science, led by Vietnamese-born Professor Pham Nam Hai, has successfully developed a ferromagnetic semiconductor (FMS) that operates at temperatures higher than any similar material previously reported. According to research published in the journal *Applied Physics Letters* (Volume 126, Issue 16, April 24, 2025), this material reaches a Curie temperature (TC) of up to 530K – significantly higher than room temperature.

If you don't know, the Curie temperature is a special temperature threshold at which a ferromagnetic material (like iron or some semiconductors) loses its permanent magnetism and becomes paramagnetic.

FMS materials are known for their combination of both electric and magnetic properties, which are particularly suitable for spintronic devices that utilize both the charge and spin of electrons. Among these, Group III-V iron-doped semiconductors such as (In,Fe)Sb and (Ga,Fe)Sb stand out due to their potential to achieve high TC. However, the introduction of large amounts of magnetic elements such as Iron without destroying the crystal structure remains a major challenge.

In previous studies, materials such as (Ga,Mn)As had low TC and could not be used effectively at room temperature. Although previous studies achieved TC of 420K, this number was still not enough for stable operation in practice.

In a new study, Professor Pham Nam Hai and his colleagues have found a way to solve the problem. They created thin films of (Ga,Fe)Sb using a technique called "step-flow growth" on GaAs (100) substrates tilted slightly at an angle of about 10° to the axis. This method allowed them to add up to 24% Fe without damaging the material structure.

Using this technique, the scientists created (Ga?.??Fe?.??)Sb films with Curie temperatures ranging from 470K to 530K – the highest ever reported in the field of FMS research to date.

"In conventional (Ga,Fe)Sb samples, maintaining the crystal structure at high Fe doping levels is always a difficult problem. By applying the step-flow growth technique on inclined substrates (vicinal substrates), we

have successfully overcome this challenge and achieved the world's highest TC in the field of FMS materials ," said Professor Hai.

To confirm the magnetic behavior, the team used magnetic circular dichroism spectroscopy, a technique that examines how light interacts with spin-polarized electronic states. They also analyzed the magnetization data using Arrott plots, a method used to determine the exact temperature at which a material becomes magnetic.

The magnetic moment of each Fe atom in the sample was measured to be about 4.5 ?B, close to the ideal value of 5 ?B expected for the Fe^{3}? ion in the zinc blende structure. This is about twice the magnetic moment of common metallic iron (?-Fe).

They also tested the long-term durability. A 9.8 nm thick film stored in open air for 1.5 years still exhibited strong magnetism, although the TC dropped slightly to 470K.

'Our results demonstrate the feasibility of fabricating FMS with high TC compatible with room temperature operation, an important step towards the realization of spintronic devices ,' added Professor Hai. This work shows that careful control of growth methods and material design can lead to more robust and practical semiconductors for future spintronics.

Spintronics promises to bring the following advantages:

1. Virtually no standby leakage
2. Low power consumption
3. Extremely durable
4. Excellent read-write performance
5. All in one *'nonvolatile'* package (no data loss during power failure)
6. And is said to be easily integrated with existing CMOS electronic circuits.

Spin-based Magnetoresistive RAM (MRAM) is also a candidate for the "universal memory" of the future.