New insights into stable magnetism of phase-change semiconductors could enable development of ultra-high-speed data stor

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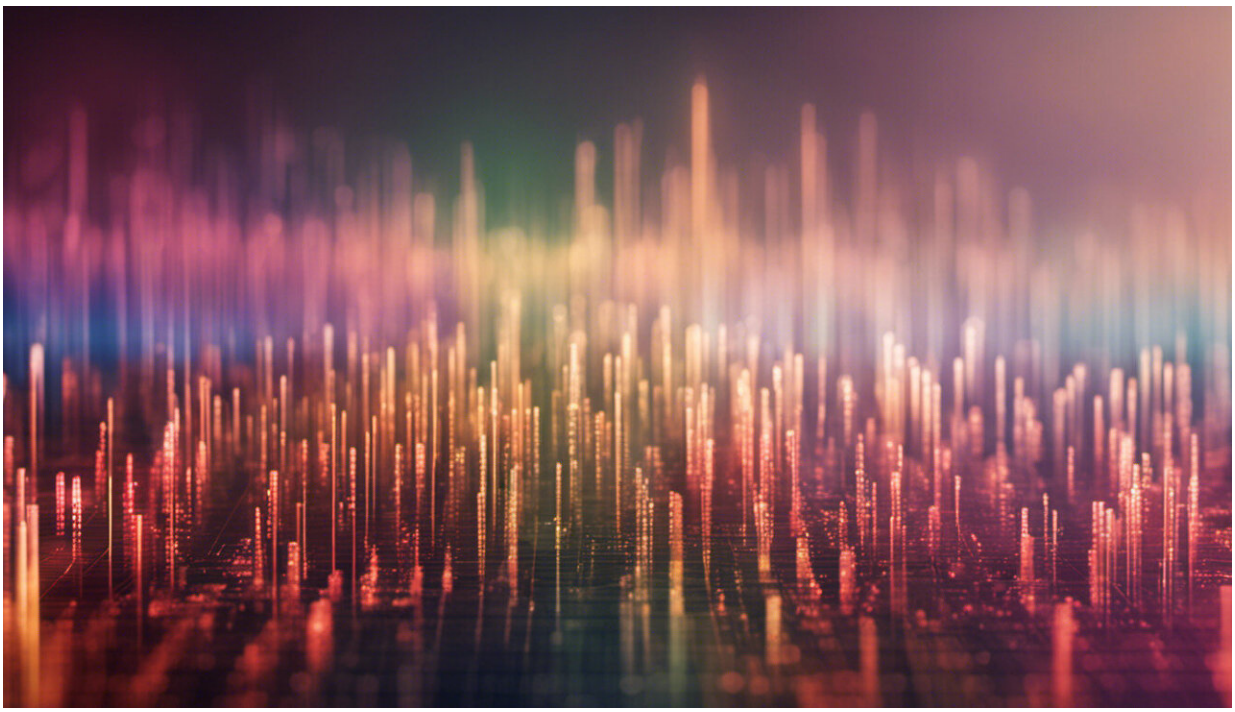

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Phase-change semiconductors have the ability to switch back and forth between amorphous (non-crystalline solid) and crystalline phases upon heating. As such, they are used widely in data storage and computer memory applications, for the reason that information can be written in

binary form using the two distinct states.

One particular phase-change alloy currently used in rewritable disc technology is that of germanium, antimony and tellunium, or $Ge_2Sb_2Te_5$ (GST). Researchers believe that this material may prove useful for the field of spintronics, generating a way of storing data which takes advantage of the inherent angular momentum, or spin, of electrons present in the material.

Recent research indicates that the atoms in GST could naturally create a stable bond with certain metals, thereby generating a permanent and stable ferromagnetic state potentially useful for high-speed read/write storage. However, to date, researchers have been unsure exactly how GST is able to form a stable ferromagnetic state.

Now, Kewu Bai at the A*STAR Institute for High Performance Computing, together with co-workers from A*STAR's Data Storage Institute and the Singapore University of Technology and Design, have completed an in-depth analysis of GST and its ability to maintain stable ferromagnetism when doped with iron.

"Alloying magnetic elements such as iron with semiconductors provides the materials necessary for future spintronics applications," explains Bai. "We know very little about the processes behind ferromagnetism from doping phase-change materials with metals, because the commonly used experimental techniques, such as X-ray diffraction, transmission microscopy and X-ray absorption, are not sufficient to characterize material microstructures."

The research team instead used first-principle calculations to determine the validity of the experiments they carried out. First-principle calculations use the inherent laws of nature — for example, bonding laws between atoms and laws for electron movements — to build up an

exact picture of the chemical structures at work, rather than relying on best-fit parameters in computer models.

“We used first-principle calculations to locate the site in GST at which iron molecules preferred to bond,” explains Bai. “The mechanism that led to the observed ferromagnetism was then uncovered.”

The researchers discovered that the iron molecules preferred to bond with the antimony molecules in GST. Along certain orientations within the crystalline phase, the iron–antimony bonding becomes dominant, leading to a stable ferromagnetism in the material.

“We are still in close collaboration with the Data Storage Institute team to explore multifunctional phase-change materials further,” explains Bai. “We hope to test our criteria for other transition metals that could also cause ferromagnetism in GST.”

More information: Ding, D. et al. Origin of ferromagnetism and the design principle in phase-change magnetic materials. Physical Review B 84, 214416 (2011).

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