

Press Release

Locating the Elusive

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HZB scientists observe how a material at room temperature exhibits a unique property – a „multiferroic“ material with potential uses for cheap and quick data storage.

Researchers at Helmholtz-Zentrum Berlin (HZB) in close collaboration with colleagues in France and UK, have engineered a material that exhibits a rare and versatile trait in magnetism at room temperature. It's called a "multiferroic," and it means that the material has properties allowing it to be both electrically charged (ferroelectric) and also the ability to be magnetic (ferromagnetic), with its magnetisation controlled by electricity.

This research was based around a material known as barium titanate (BaTiO₃), a ferroelectric crystal that is promising to have potential uses in multi-state data storage while being cost effective. Their paper titled, "Interface-induced room-temperature multiferroicity in BaTiO₃" appears now in Nature Materials.

"We've shown a way where you can obtain a multiferroic at room temperature," said Sergio Valencia, post doc researcher at HZB, referring to the scarcity of room temperature examples. "Barium titanate is ferromagnetic, so it means you have a net-magnetic moment you can really control by an electric field. The idea is that you can apply a voltage to the ferroelectric reversing the ferroelectric polarization which in turn affects the magnetization of your film [BaTiO₃]."

You can use this for example to write bits of information in memories of computers by only applying voltages, which is much cheaper in terms of power than traditionally applying magnetic fields."

It is this ability to control the material's magnetism and to be able to do it at room temperatures which makes this multiferroic potentially more cost-effective compared to other current multiferroic materials, which require complex arrangements to work.

Finding these two traits of ferromagnetic and ferroelectric working together in a compound is tricky due to the strange love-hate relationship exhibited by the two phenomena. What a ferromagnetic requires to exist is not the same as what a ferroelectric requires. Yet strangely, the two compliment each other and share a strong relationship, where one affects the other. The scarcity of these multiferroics however, is a result of this unique phenomenon combined with the few naturally occurring examples. "They are scarce and the problem is that most of them are multiferroic only at very low temperatures," added Valencia. "Therefore they are not useful for applications. If you have to go to -270 °C for a multiferroic then it's really complicated and expensive to implement them in room temperature working devices."

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HZB staff scientist Florin Radu checks the BaTiO₃ sample alignment in the ALICE diffractometer.

Foto: HZB

The researchers witnessed this multiferroic behaviour by investigating magnetic moments of Titanium (Ti) and Oxygen (O) atoms in BaTiO₃ by using BESSY II synchrotron radiation source of Helmholtz-Zentrum Berlin.

They used a research method known as soft X-ray resonant magnetic scattering. The team was able to witness the dual traits of both ferroelectric and ferromagnetic in the thin films of BaTiO₃. And since BaTiO₃ is a non-magnetic ferroelectric material at room temperature, the ferromagnetism was induced by proximity to natural ferromagnets such as iron (Fe) and Cobalt (Co). In order to achieve these results the researchers deposited a ten atom thin film of iron and cobalt on top of a four atom thin BaTiO₃ film. “These small thicknesses are indeed required for the implementation of such materials in devices to keep their small size,” added Valencia.

The **Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)** operates and develops large scale facilities for research with photons (synchrotron beams) and neutrons. The experimental facilities, some of which are unique, are used annually by more than 2,500 guest researchers from universities and other research organisations worldwide. Above all, HZB is known for the unique sample environments that can be created (high magnetic fields, low temperatures). HZB conducts materials research on themes that especially benefit from and are suited to large scale facilities. Research topics include magnetic materials and functional materials. In the research focus area of solar energy, the development of thin film solar cells is a priority, whilst chemical fuels from sunlight are also a vital research theme. HZB has approx. 1,100 employees of whom some 800 work on the Lise-Meitner Campus in Wannsee and 300 on the Wilhelm-Conrad-Röntgen Campus in Adlershof.

HZB is a member of the Helmholtz Association of German Research Centres, the largest scientific organisation in Germany.