Researchers devise simple, inexpensive approach to making soft magnetic films for microwave applications

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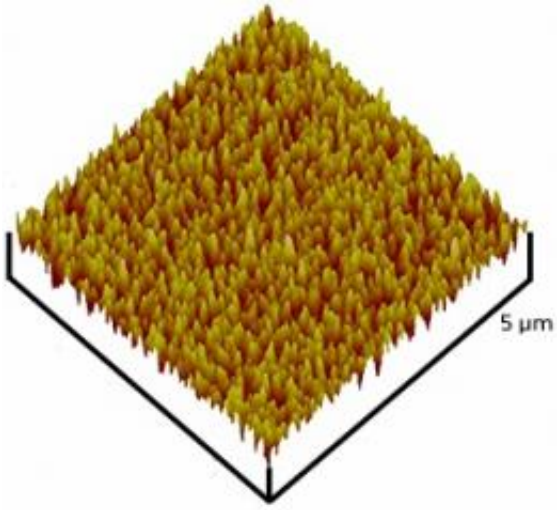

Magnetic columnar iron-cobalt-nickel nanofilm with high permeability from suitable additives. Credit: Bao-Yu Zong

Soft magnetic materials can be easily magnetized and demagnetized. They are widely used in microwave devices, such as absorption of electromagnetic radiations.

Developers tend to use thin films of soft magnetic materials, as opposed to their bulk form, in mobile applications, such as cell phones and laptops, as well as military applications, such as stealth aircrafts. However, the conventional approach to making soft magnetic films

requires a high vacuum environment, which is expensive and time-consuming. Moreover, the usual fabrication system is not suitable for the preparation of large sheet films, thereby limiting its application in manufacturing the soft magnetic materials for microwave absorption.

Bao-Yu Zong at the A*STAR Data Storage Institute and co-workers have now demonstrated the viability of fabricating soft magnetic thin films through electrodeposition, a plating technique that is scalable and can be performed at room temperature. The approach is not only simpler and cheaper to operate, but also versatile enough for making a wide range of soft magnetic materials for microwave applications.

The researchers chose to work with iron–cobalt–nickel alloy, a soft magnetic material with low permeability, high coercivity and other less-than-ideal properties. They added small amounts of organic compounds, including dimethylamine borane and sodium dodecyl sulfate, to the plating solution prior to deposition. The resulting thin films had much higher permeability and lower coercivity, which make them more desirable for microwave applications. The researchers suggest that the additives might have prevented iron from oxidizing during electrodeposition, thereby improving the quality of thin films obtained.

Zong and his team also explored the effect of adding inorganic compounds, such as aluminum potassium sulfate, to the plating solution. They detected an increased resistivity in the thin films — a result that is likely to be a consequence of the change in morphology of the material; that is, the shape of the nanoparticles changed from common granular to columnar (see image), as revealed by atomic force microscopy. The iron–cobalt–nickel thin films also exhibit strong microwave absorption in comparison to ordinary magnetic films. These unique properties are perfect for high-frequency microwave applications, including magnetic data storage, portable wireless and biotechnology devices.

The researchers have high hopes that their approach is applicable to the fabrication of a wide range of soft magnetic materials. "Our technique is cost-effective and scalable. We can create soft magnetic thin films on different size and type of substrates," says Zong. "In a subsequent step, we hope to transfer this methodology to related industrial companies."

More information: Research article in Journal of Materials Chemistry

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