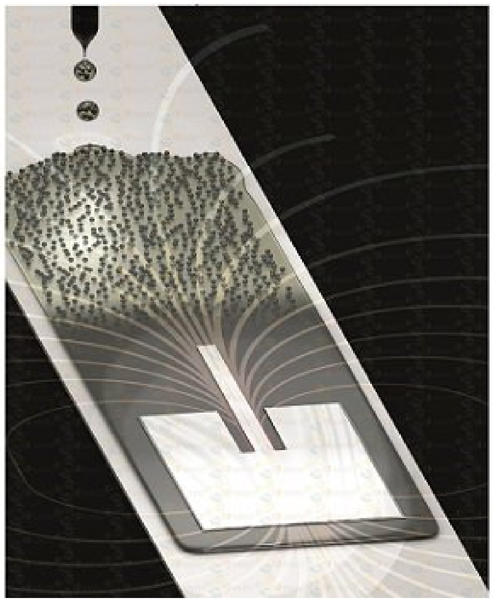
Tuning in to magnetic ink

April 4 2018



Magnetic substrates formed through inkjet printing may help manufacturers in their efforts to build micro-antennas that respond to all cellular frequency bands. Credit: KAUST

A new ink containing iron-oxide nanoparticles can be turned into fully printed and versatile components for cellular networks.

Inkjet printing technology can be used to produce radio frequency devices, such as antennas, that can be magnetically reconfigured on demand. This discovery by a team from KAUST boosts prospects for inexpensive electronics that work worldwide by tuning in to multiple cellular bands and standards.

A typical cellphone antenna is made by depositing metallic patterns onto insulating silicon or glass wafers. These miniature aerials have excellent reliability, but only operate at fixed frequency bands. To fabricate devices that can adapt to different wireless settings, researchers are increasingly turning to magnets. Replacing an insulating wafer with a magnetic one, for instance, can achieve frequency tuning that can cover mega- to gigahertz ranges.

Instead of the complex, multilayered ceramics currently used as magnetic substrates, Mohammad Vaseem, Atif Shamim and colleagues investigated an approach based on printable electronics-a technology that replaces the dye-filled fluids found in consumer printers with special inks containing substances, such as metallic nanoparticles, and then custom-prints device patterns with relative ease and high speeds.

"If magnetic substrates can be printed, we can achieve huge cost savings and add new functionalities," says Shamim. "There are a number of other metrics that can be optimized, such as thickness, that are impossible with fixed substrates."

By injecting iron-based reagents into a hot acetic acid solution, the researchers synthesized magnetic iron-oxide nanoparticles that dispersed into deionized water to form an ink. Subsequent printing tests showed immediate promise: when deposited as a thin film on a glass substrate, the new magnetic substrate could act as an energy-storing inductor device with an adjustable capacity of over 20 percent.

Printing the magnetic ink thicker than a few nanometers, however, proved impossible due to its natural brittleness. To strengthen the ink, the team modified the nanoparticles' surfaces with hydrocarbon chains to help the tiny magnets mix evenly into an epoxy resin known as SU-8.

The resulting paste was screen-printed and UV-cured into free-standing magnetic sheets of a few millimeters in thickness.

The innovative, fully printed magnetic wafer displayed promising antenna tuning of over 10 percent-a figure the team aims to improve by perfecting their printing recipes.

"The surprise was that we got antennas with a good tuning range, even though we mixed in 50 percent SU-8," notes Shamim. "This means we could extend this tuning range further by adjusting this ratio and also move to more sophisticated roll to roll processes that print at meters per minute."

More information: Mohammad Vaseem et al. Iron Oxide Nanoparticle-Based Magnetic Ink Development for Fully Printed Tunable Radio-Frequency Devices, *Advanced Materials Technologies* (2018). DOI: 10.1002/admt.201700242

Provided by King Abdullah University of Science and Technology