Bringing signals into phase

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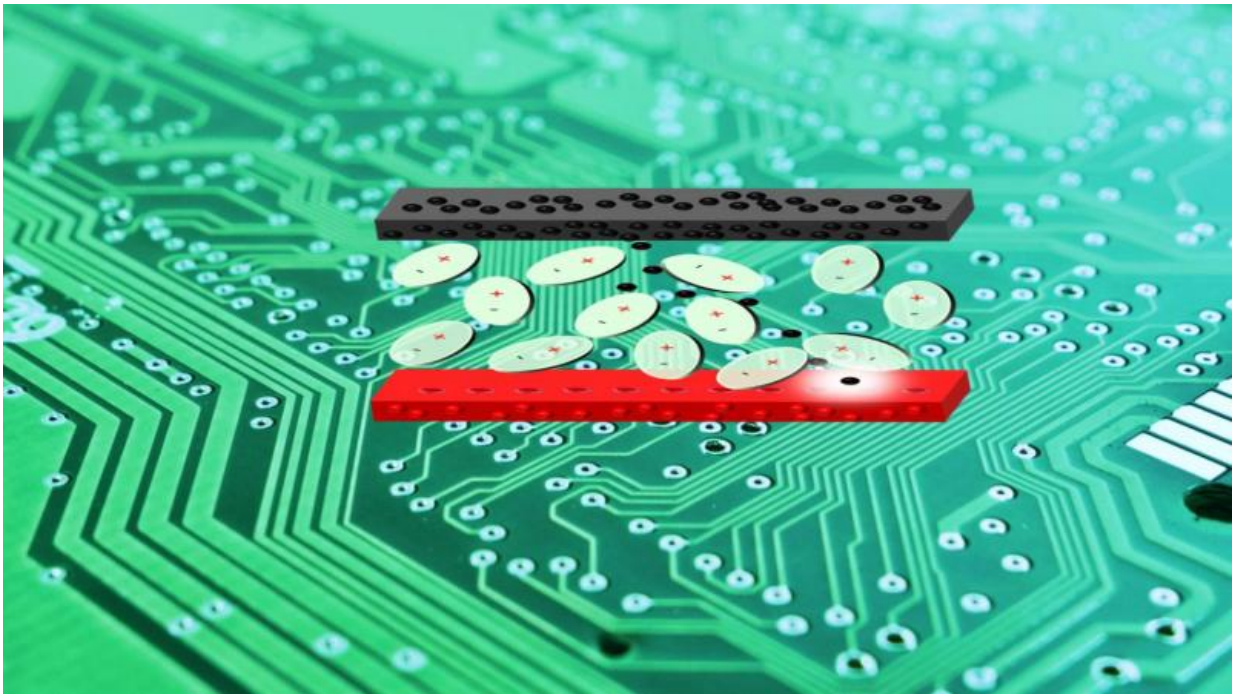

Blending polymer materials in the right combination can create fractional-order capacitors that are compatible with printed circuit boards. Credit: KAUST

How we use and generate electricity has changed dramatically over the past century yet the basic components that control its flow remain remarkably similar. Researchers at KAUST have now developed a novel type of component that could improve the performance of electrical circuits.

Electronic circuitry is traditionally constructed from three primary elements; a resistor, a capacitor and an inductor. A sinusoidal electrical signal passing through these devices will change in signal strength, or amplitude, and the relative timing of the crest of the wave, known as its phase. A resistor will change amplitude only while a capacitor and an inductor can also change phase, but only by exactly one quarter of the length of the wave, or 90°.

Components that could alter the phase of the electrical signal by a different amount would enable electrical circuits with more varied functionality. One such device, known as a fractional-order capacitor, was realized by electrical engineering doctoral student Agamyrat Agambayev, under the supervision of Hakan Bagci and Khaled Salama, and colleagues. "We use a solution-casting method to fabricate fractional-order capacitors," explains Salama. "This method allows us to easily blend different polymers and provide a mechanism to tune the device's properties."

Numerous approaches to creating a fractional-order capacitor have been demonstrated in the past but all have drawbacks. Using a liquid medium, for example, results in large devices that cannot be integrated with microelectronic circuits. Ideally, a fractional-order capacitor should be made from a dielectric material that is compatible with printed-circuit-board technology. It should also operate over a wide range of signal frequencies and have a controllable phase change, known as the constant phase angle or CPA.

The KAUST team have created a fractional-order capacitor using a polymer based on poly (vinylidene fluoride). They deposited a thin film on a layer of gold on a silicon substrate. The film was patterned as required and bonded to the printed circuit board to create the final device. The electrical properties of the polymer were controlled using a simple solution-mixing approach to add different amounts of

trifluoroethylene and/or cholorfluroethylene. They could tune the CPA of their devices from between 66 and 88 degrees depending on the blend composition. What's more, the devices acted over a wide range of frequencies from 0.1 to 10 megahertz.

The team has previously created graphene fractional-order capacitors, but they believe the tunablility offered by polymers represents a huge advance. "Next, we will look into modeling these structures to better understand their behavior," says Bagci. "This will help design fractional capacitors with better performance."

More information: Agamyrat Agambayev et al. Ferroelectric Fractional-Order Capacitors, *ChemElectroChem* (2017). DOI: 10.1002/celc.201700663

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