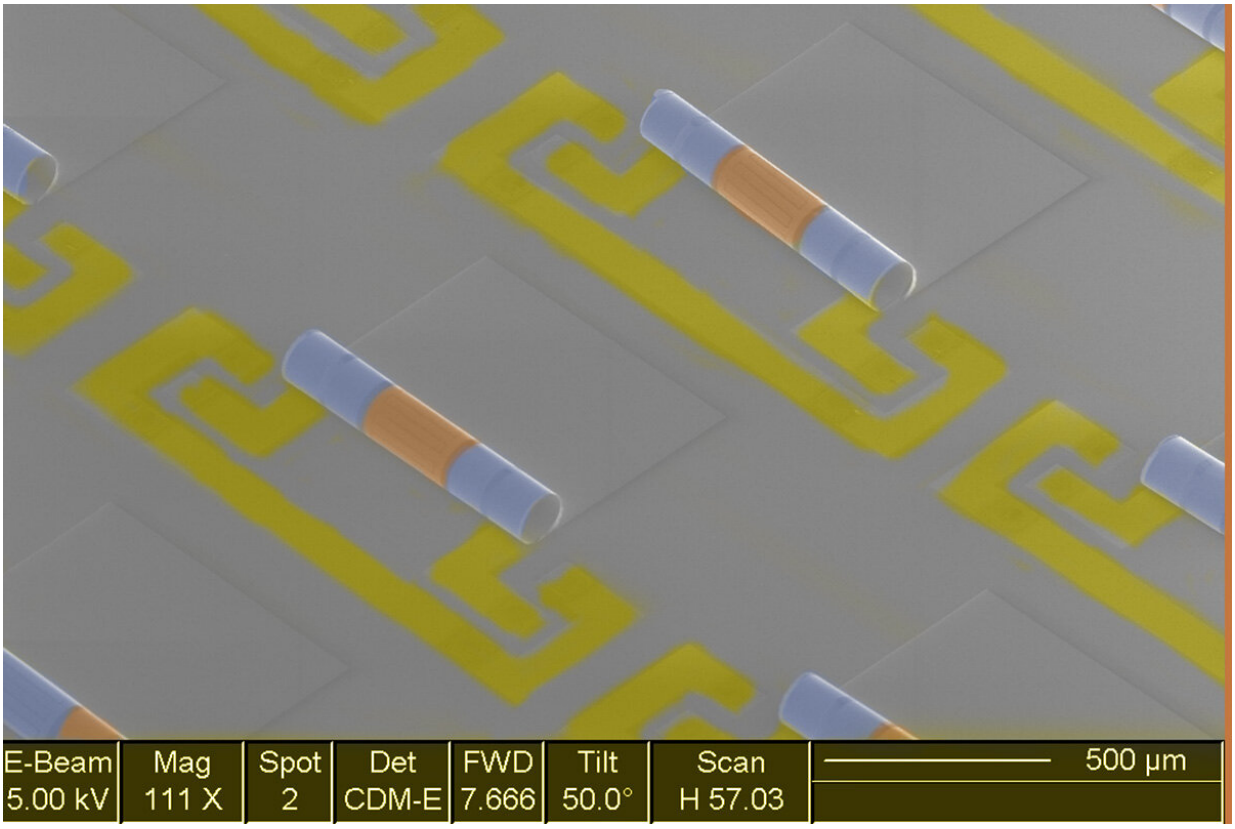
Electronic components join forces to take up 10 times less space on computer chips

August 11 2020, by Lois Yoksoulian



Electron microscope image of an array of new chip components that integrate the inductors, blue, and capacitors, yellow, needed to make the electronic signal filters in phones and other wireless devices. Credit: Xiuling Li

Electronic filters are essential to the inner workings of our phones and

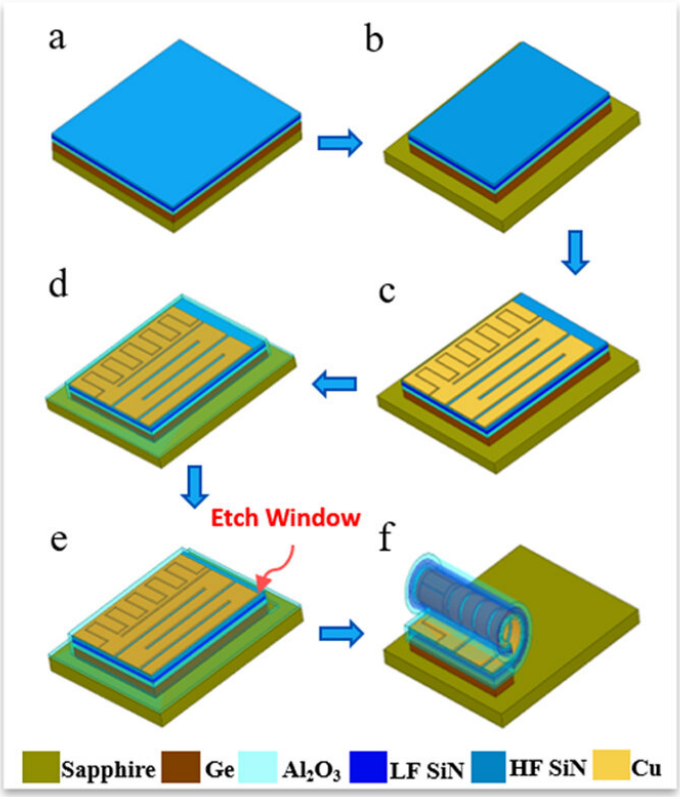
other wireless devices. They eliminate or enhance specific input signals to achieve the desired output signals. They are essential, but take up space on the chips that researchers are on a constant quest to make smaller. A new study demonstrates the successful integration of the individual elements that make up electronic filters onto a single component, significantly reducing the amount of space taken up by the device.

Researchers at the University of Illinois, Urbana-Champaign have ditched the conventional 2-D on-chip lumped or distributed filter network design—composed of separate inductors and capacitors—for a single, space-saving 3-D rolled membrane that contains both independently designed elements.

The results of the study, led by electrical and computer engineering professor Xiuling Li, are published in the journal *Advanced Functional Materials*.

"With the success that our team has had on rolled inductors and capacitors, it makes sense to take advantage of the 2-D to 3-D self-assembly nature of this fabrication process to integrate these different components onto a single self-rolling and space-saving device," Li said.

In the lab, the team uses a specialized etching and lithography process to pattern 2-D circuitry onto very thin membranes. In the circuit, they join the capacitors and inductors together and with ground or signal lines, all in a single plane. The multilayer membrane can then be rolled into a thin tube and placed onto a chip, the researchers said.



The device-fabrication process includes the deposition of metals by electron-beam evaporation and lithography to define the metal pattern and etching process. The final etching step then triggers the self-rolling process of the stacked membrane. Credit: Xiuling Li.

"The patterns, or masks, we use to form the circuitry on the 2-D membrane layers can be tuned to achieve whatever kind of electrical interactions we need for a particular device," said graduate student and co-author Mark Kraman. "Experimenting with different filter designs is relatively simple using this technique because we only need to modify that mask structure when we want to make changes."

The team tested the performance of the rolled components and found that under the current design, the filters were suitable for applications in

the 1-10 gigahertz frequency range, the researchers said. While the designs are targeted for use in radio frequency communications systems, the team posits that other frequencies, including in the megahertz range, are also possible based on their ability to achieve high power inductors in past research.

"We worked with several simple filter designs, but theoretically we can make any filter network combination using the same process steps," said graduate student and lead author Mike Yang. "We took what was already out there to provide a new, easier platform to lump these components together closer than ever."

"Our way of integrating inductors and capacitors monolithically could bring passive electronic circuit integration to a whole new level," Li said. "There is practically no limit to the complexity or configuration of circuits that can be made in this manner, all with one mask set."

More information: Zhendong Yang et al, Monolithic Heterogeneous Integration of 3D Radio Frequency L–C Elements by Self-Rolled-Up Membrane Nanotechnology, *Advanced Functional Materials* (2020). DOI: 10.1002/adfm.202004034

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