Carving out circuits that click into place

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A strategy for assembly of electronic systems-especially the flexible structures needed for high-performance devices of the future-uses integrated circuits as Lego-like building blocks. "This plug-and-play approach is absolutely disruptive," says Ph.D. candidate Sohail Shaikh from KAUST: this unique method of assembly creates completely new options for manufacturing processes of these systems.

Existing technologies for building electronic devices, such as computers, smartphones and robots, rely on complex automated manufacturing processes. These involve high-precision equipment to align and package thousands of components that range from a few millimeters upward in size. Once aligned, these components are connected to printed circuit boards using numerous tiny pins.

These manufacturing processes work well for today's electronic components and supports, which are rigid and hard. However, they do not suit the emerging electronic systems-increasingly multifunctional, high-performance devices that demand greater miniaturization in addition to better accuracy and precision. In particular, bonding and alignment are exceptionally difficult to achieve for flexible integrated circuits and soft substrates needed for devices that are wearable and implantable.

To tackle this problem, Muhammad Hussain and his team from KAUST developed a modular approach in which building blocks presenting complementary geometries produce electronic systems via lock-and-key-type assembly to eliminate any steps that require bonding or soldering.

They carved various shapes displaying different sizes, heights and angles out of the back of fragile, ultra-thin flexible silicon integrated circuits to form so-called male modules. Next, they etched grooves, corresponding to inverse replicas of these shapes, into the flexible substrate to generate hosts for the male modules.

"This approach makes the entire assembly simple, easy and highly reliable for conventional and fully flexible electronic systems," says Shaikh.

The researchers converted commercially available integrated circuits into unique geometrical shapes that differ according to their function, allowing these modules to be physically singled out by touch or with the naked eye. They showed that a person wearing a blindfold could manually assemble these modules into an electronic system, demonstrating the yield and accuracy of their strategy.

This feature could provide for job opportunities for the visually impaired in the semiconductor manufacturing and electronics assembly industries, notes Hussain. "Differentiating objects by touch is a unique ability implemented by the visually impaired in their daily life," he says.

Hussain's team is currently investigating the self-assembly of modular components into electronic systems. "Guiding the modules to their binding sites using fluidic agitation or surface tension may eliminate the need for manual handling, which would increase the throughput," he adds.

More information: Sohail F. Shaikh et al. Modular Lego-Electronics, *Advanced Materials Technologies* (2017). DOI: 10.1002/admt.201700147