Printable silicon for ultra-high performance flexible electronic systems

SCIENTISTS AT the University of Illinois at Urbana-Champaign have demonstrated a route to ultrahigh performance, mechanically flexible thin-film transistors by carving specks of single crystal silicon from a bulk wafer and casting them onto sheets of plastic. The process could enable new applications in consumer electronics such as inexpensive wall-to-wall displays and intelligent but disposable radio frequency identification tags and could even be used in applications that require significant computing power. "Conventional silicon devices are limited by the size of the silicon wafer, which is typically less than 12 inches in diameter," said John Rogers, a professor of materials science and engineering and co-author of a paper in the journal *Applied Physics Letters*. "Instead of making the wafer bigger and costlier, we want to slice up the wafer and disperse it in such a way that we can then place pieces where we need them on large, low-cost substrates such as flexible plastics."

Compared with paths for similar devices that use organic molecules for the semiconductor this approach has important advantages. Single-crystal silicon's reliability and materials properties are well known from decades of research in silicon microelectronics and it has good electrical properties (roughly 1,000 times better than known organics).

Using conventional lithographic patterning and etching processes, researchers fabricated single-crystal, microstructured silicon objects from wafers. The processing sequence generated objects as small as 50 nanometres on a side. They then used two approaches for transferring objects to substrates to create high performance, thin-film transistors. "In one approach, we used procedures that exploit high-resolution rubber stamps for transfer printing," said co-author Ralph
Nuzzo, of the Frederick Seitz Materials Research Lab.

"In the other approach, the objects were dispersed in a solvent and then cast using solution-based printing techniques." Both approaches can be implemented in a manufacturing environment, and would scale nicely to large-area formats, Nuzzo said.

The devices can be integrated with a wide range of material types, including low-cost plastics by separating the processing of the silicon from the fabrication of other transistor components. Fabricating circuits by continuous, high-speed printing techniques could offer different capabilities than can be achieved with existing silicon technologies, Rogers said. "We can think in terms of unconventional electronics putting devices in places where standard silicon chips can't go due to expense or geometry."

Components could be printed on the insides of windshields and other non-flat surfaces besides huge, wall-sized displays being built at far less cost. Printing-based methods remove that constraint of current fabrication techniques which favour flat chips. "Another aspect of low-cost electronic printing is embedding information technology into places where it didn't exist before," Nuzzo said. "By inserting electronic intelligence into everyday items, we could exchange information and communicate in exciting new ways." An example, he said, would be low-cost radio frequency identification tags that could take the place of ordinary product bar codes. Such tags could ease congestion in supermarket checkout lines and help busy homemakers maintain shopping lists. — Our Bureau

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