Researchers create world's first transparent integrated circuit

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Researchers at Oregon State University have created the world's first completely transparent integrated circuit from inorganic compounds, another major step forward for the rapidly evolving field of transparent electronics.

The circuit is a five-stage "ring oscillator," commonly used in electronics for testing and new technology demonstration. It marks a significant milestone on the path toward functioning transparent electronics applications, which many believe could be a large future industry.

A report on the findings has been accepted for publication in a professional journal, *Solid State Electronics*. The research has been supported by the National Science Foundation, Army Research Office, and HP. Recently, OSU also licensed to HP the rights to market new products based on this work, which provides the university a partner to help scale-up and commercialize the technology.

"This is a quantum leap in moving transparent electronics from the laboratory toward working commercial applications," said John Wager, a professor of electrical engineering at OSU. "It's proof that transparent transistors can be used to create an integrated circuit, tells us quite a bit about the speeds we may be able to achieve, and shows we can make transparent circuits with conventional photolithography techniques, the basic patterning methods used to create electronics all over the world."

Collaborators on the work at OSU include Wager; Doug Keszler, professor and head of the OSU Department of Chemistry; Janet Tate, a professor of physics; and Rick Presley, who as a master's candidate in electrical engineering at OSU has been at the cutting edge of a new electronics industry.

Transparent electronics, scientists say, may hold the key to new industries, employment opportunities, and new, more effective or less costly consumer products. Uses could range from transparent displays in the windshield of an automobile to cell phones, televisions, copiers, "smart" glass or game and toy applications. More efficient solar cells or better liquid crystal displays are possible.

Recently, OSU announced the creation of a transparent transistor based on zinc-tin-oxide. The new transparent integrated circuit is made from indium gallium oxide. Both of these compounds, which are amorphous heavy-metal cation multi-component oxides, share some virtues – they have high electron mobility, chemical stability, physical durability and ease of manufacture at low temperatures.

They also will be cost-effective and safe - alternative heavy metals such as gold and silver have been ruled out because of their expense, and others such as mercury, lead or arsenic avoided due to environmental concerns.

There are still challenges that need to be met, Wager said. The technology needs to be scaled up to larger sizes, all process steps must be functional for manufacturing, physical protection is needed for the new circuits, new markets and products identified. And work will continue toward a "P-channel" device would provide a number of advantages, such as lower power consumption, simple electronic architecture, and ability to do both analog and digital processing.

"What's exciting is that all of the remaining work seems very feasible," Wager said. "It will take some time, but we just don't see any major obstacles that are going to preclude the commercial use of transparent electronics with these compounds.

"In a way," Wager added, "it's shocking how fast this field has progressed. We might be able to bring transparent integrated circuits to widespread use in five years or so, a process that took a couple of decades in the early evolution of conventional electronics."

When perfected, researchers say, some transparent electronics applications may be so cheap and effective that they could be used in "throw away" devices, or used to replace conventional circuits that don't even require transparency. The electronic capabilities of the materials are sufficiently impressive that have already outperformed organic and polymer materials that are the basis of millions of dollars of research every year.

OSU officials believe the evolution of these products and the collaboration with HP may be one of the most valuable the university has ever developed with private industry.

The project is affiliated with the Oregon Nanoscience and Microtechnologies Institute, a research collaboration involving Oregon's three public research universities - OSU, Portland State University, and the University of Oregon – as well as the Pacific Northwest National Laboratory, the state of Oregon, and the regional business community.

Source: Oregon State University