

NEWS RELEASE

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Molecular Memories, Once Doubted, Prove Durable and Practical

FOR IMMEDIATE RELEASE

In the ongoing quest to create computing devices that are both incredibly small and incredibly powerful, scientists – envisioning a future beyond the limits of traditional semiconductors – have been working to use molecules for information storage and processing.

Until now, researchers were skeptical that such molecular devices could survive the rigors of real-world manufacturing and use, which involve high temperatures and up to one trillion operational cycles. But scientists at the University of California, Riverside and North Carolina State University have demonstrated that molecular memories are indeed both durable and practical – a finding that could spur development of the technology.

The scientists' results, in a paper titled "Molecular Memories that Survive Silicon Device Processing and Real-World Operation," are described in the Nov. 28 issue of the journal *Science*.

Dr. Jonathan S. Lindsey, Glaxo Distinguished University Professor of Chemistry at NC State and one of the paper's authors, said the team was faced with a very basic problem. "If molecular materials can't compete against semiconductor materials under the rigorous conditions of the real world," he said, "then trying to implement them in electronic devices would be pointless. Because our goal is to develop molecule-based memory devices, we first had to test their durability and stability."

Led by Dr. David F. Bocian, professor of chemistry at the University of California, Riverside, the team attached porphyrins – disk-shaped organic molecules similar to chlorophyll – with specific electronic properties to an electroactive surface, storing information in the form of the molecules' positive charges.

After a series of tests, the scientists found that the resulting molecular memories were "extremely robust" and offered clear advantages over traditional semiconductor-based technology.

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“The porphyrin-based information-storage elements exhibit charge-retention times that are long (minutes) compared with those of the semiconductor elements in dynamic random access devices (tens of milliseconds),” the university chemists report in their paper.

In addition, their testing showed that such molecule-based information-storage devices “meet the processing and operating challenges required for use in electronic devices.” In particular, they proved that “these molecules are stable under extremes of temperature (400°C) and large numbers of read-write cycles (1 trillion).”

That demonstrated stability, they conclude, “indicates that these molecular architectures can be readily adapted to current semiconductor fabrication technology and operated under the conditions required for a practical device.”

By establishing the practicality of molecular memories, says Lindsey, the findings should help eliminate doubts about the role of organic materials in electronic devices.

“There is a perception that organic molecules are fragile,” Lindsey said. “The critical question has been whether, given the high temperatures and other stresses of production and use, any molecule-based devices could meet functionality standards. I believe our research has laid this question to rest, and demonstrated that appropriately chosen molecules can readily function in practical devices.”

That knowledge, he said, should speed development of molecule-based electronics, which promise smaller, faster and far more powerful computers and other applications.

The research was funded by ZettaCore Inc. and the Defense Advanced Research Projects Agency (DARPA) Moletronics Program. Bocian and Lindsey are co-founders of ZettaCore and serve as consultants for the company.

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Note to editors: An abstract of the paper follows.

“Molecular Memories that Survive Silicon Device Processing and Real-World Operation”

Authors: David F. Bocian, Zhiming Liu, Amir A. Yasseri, University of California, Riverside; Jonathan S. Lindsey, North Carolina State University.

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Abstract: If molecular components are to be used as functional elements in place of the semiconductor-based devices present in conventional micro-circuitry, they must compete with semiconductors under the extreme conditions required for processing and operating practical devices. Herein, we demonstrate that porphyrin-based molecules bound to Si (100), which exhibit redox behavior useful for information storage, can meet this challenge. These molecular media in an inert atmosphere are stable under extremes of temperature (400° C) for extended periods (approaching 1 hour) and do not degrade under large numbers of read-write cycles (10^{12}).