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UMD advance lights possible new path to creating next gen computer chips

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(PhysOrg.com) -- University of Maryland researchers have made a breakthrough in the use of visible light for making tiny integrated circuits. Though their advance is probably at least a decade from commercial use, they say it could one day make it possible for companies like Intel to continue their decades long tread of making ever smaller, faster, and cheaper computer chips.

For some 50 years, the integrated circuits, or chips, that are at the heart of computers, smart phones, and other high-tech devices have been created through a technique known as photolithography, in which each computer chip is built up in layers.

In photolithography, each layer of a conductive material (metal, treated silicon, etc,) is deposited on a chip and coated with a chemical that hardens when exposed to light. Light shining through a kind of stencil know as a mask projects a detailed pattern onto the photoresist, which hardens where it's exposed. Then, the unhardened areas of photoresist and underlying metal are etched away with a chemical. Finally, the remaining photoresist is etched away using a different chemical treatment, leaving an underlying layer of metal with the same shape as the mask.

However, fitting more and more circuits on each chip has meant making smaller and smaller circuits. In fact, features of circuits in today's computer chips are significantly smaller than the wavelength of visible light. As a result, manufacturers have gone to using shorter and shorter wavelengths of light (radiation), or even charged particles, to enable them to make these circuits.

University of Maryland chemistry Professor John Fourkas and his research group recently introduced a technique called RAPID lithography that makes it possible to use visible light to attain lithographic resolution comparable to (and potentially even better than) that obtained with shorter wave length radiation.

"Our RAPID technique could offer substantial savings in cost and ease of production," Fourkas said. "Visible light is far less expensive to generate, propagate and manipulate than shorter wavelength forms of electromagnetic radiation, such as vacuum ultraviolet or X-rays. And using visible light would not require the use of the high vacuum conditions needed for current short wavelength technologies."

The key to RAPID is the use of a special "photoinitiator" that can be excited, or turned on, by one laser beam and deactivated by another. In new work just published online by *Nature Chemistry*, Fourkas and his group report three broad classes of common dye molecules that can be used for RAPID lithography.

In earlier work, Fourkas and his team used a beam of ultrafast pulses for the excitation step and a continuous laser for deactivation. However, they say that in some of their newly reported materials deactivation is so efficient that the ultrafast pulses of the excitation beam also deactivate molecules. This phenomenon leads to the surprising result that higher exposures can lead to smaller features, leading to what the researchers call a proportional velocity (PROVE) dependence.

"PROVE behavior is a simple way to identify photoinitiators that can be deactivated efficiently," says Fourkas, "which is an important step towards being able to use RAPID in an industrial setting."

By combining a PROVE photoinitiator with a photoinitiator that has a conventional exposure dependence, Fourkas and co-workers were also able to demonstrate a photoresist for which the resolution was independent of the exposure over a broad range of exposure times.

"Imagine a photographic film that always gives the right exposure no matter what shutter speed is used," says Fourkas. "You could take perfect pictures every time. By the same token, these new photoresists are extremely fault-tolerant, allowing us to create the exact lithographic pattern we want time after time."

According to Fourkas, he and his team have more research to do before thinking about trying to commercialize their new RAPID technology. "Right now we're using the technique for point-by-point lithography. We need to get it to the stage where we can operate on an entire silicon wafer, which will require more advances in chemistry, materials and optics. If we can make these advances -- and we're working hard on it -- then we will think about commercialization."

Another factor in time to application, he explained, is that his team's approach is not a R&D direction that chip manufacturers had been looking at before now. As a result, commercial use of the RAPID approach is probably at least ten years down the road, he said.

More information: Multiphoton photoresists giving nanoscale resolution that is inversely dependent on exposure time was authored by Michael P. Stocker, Linjie Li, Ravael R. Gattass and John T. Fourkas. To learn more about research in the Fourkas laboratories, visit www2.chem.umd.edu/groups/fourkas

Provided by University of Maryland