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Lithographic breakthrough with laser spike anneal to create higher fidelity circuit patterns

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Researchers sponsored by Semiconductor Research Corporation (SRC) today announced that they have developed a new laser-based method for ultra-fast anneal of thin photoresist films used to transfer semiconductor patterns onto silicon wafers.

Pioneers in the use of lasers to expedite baking of photoresist and understanding photoresist activation chemistry, Professors. Michael Thompson and Christopher Ober from Materials Science and Engineering at Cornell University are perfecting the unique advantages of laser heating versus current state-of-art hotplate bake used in chip patterning processes.

The new laser-based approach provides significant improvement in the critical lithographic steps required for creation of integrated circuits (ICs). Historically, a lengthy bake of the wafer at low temperatures has been required to avoid degradation of the photoresist properties. Driven by industry demand for continued scalability of ICs, Cornell researchers have determined that heating at much higher temperatures for millisecond times using continuous wave lasers not only activates the necessary photoresist chemical reactions at higher throughput, but also improves the pattern fidelity and line-edge roughness over conventional methods by limiting the chemical diffusion.

"Faster, higher fidelity pattern transfer in the fab means better chip

performance at reduced cost. This new laser method can deliver a breakthrough in thermal processing for the industry," said Ober regarding the SRC-funded effort. "Until now, lithography progress has been held back by the traditional methods for heating the resist that were regarded by many as already optimized. The laser proves otherwise."

Among the many challenges that the industry will face in the move to 450 millimeters (mm) is how to limit cost while continuing to improve the materials, equipment and processes needed to fabricate the rapidly shrinking features. As one of the key benefits of the laser-based bake process, Cornell Ph.D. candidate Byungki Jung has shown significant improvements in line-edge roughness for both current 193 nanometer (nm) immersion lithography as well as for next-generation 13nm extreme ultraviolet (EUV) lithography.

Photoresists are applied to the wafer surface to form extremely thin, patternable layers. Currently, they are exposed and then baked on a hot plate at low temperatures of 80-150°C (175-300°F) for approximately one minute to activate the resist chemistry and create a solubility differential between exposed and unexposed parts of the resist, which delineates the post-develop pattern. The photoresist typically consists of a proprietary mixture of polymers formulated for specific lithography treatments. Prolonged heating, especially at higher temperatures, causes excessive chemical diffusion to take place which degrades the image quality.

The novel application of laser spike heating—for a duration of milliseconds only—preserves the polymer integrity at much higher temperatures (up to 800°C or 1450°F) and provides a means to maximize resist sensitivity while minimizing pattern roughness, thereby facilitating enhanced scalability.

Semiconductor companies are currently experimenting with the laser

technology for their own next-generation lithography applications. The laser spike anneal method is projected to be applicable to current 300mm processes as well as to 450mm manufacturing technologies, although further resist optimization with this novel process is likely needed.

"We're at the point where companies can begin to transfer the laser spike anneal to their internal R&D lines and optimize their resist formulation and/or lithography processes, enabling an alternate path for improving pattern resolution beyond the traditional baking technique that has remained essentially unchanged for the past 50 years," said Bob Havemann, Director of Nanomanufacturing Sciences at SRC. "As a next step, we anticipate creation of improved photoresists that can further leverage the benefits of this novel, more efficient annealing method."

More information: For more information about the research, please visit: people.ccmr.cornell.edu/ ~mthompson or people.ccmr.cornell.edu/~cober .

Provided by Semiconductor Research Corporation

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