New Targets May Hit Bull’s-Eye for Chip Makers

December 7 2006

The bull’s-eye solution to the semiconductor industry’s hunt for more exact means to measure the relative positions of ever-tinier devices squeezed by the millions onto silicon chips might be new types of targets, and not expensive new equipment, according to modeling studies by the National Institute of Standards and Technology.

If the counterintuitive findings hold up, the industry could continue to rely on the high-throughput optical equipment it now uses to align level after level of intricate circuitry patterns—even as the size of individual devices drops well below 50 nanometers (nm). This would spare chip makers of the challenge and extra cost of switching to more complex technology for so-called overlay measurements.

During chip production, instruments measure distances between selected lines on one target on one chip layer, and corresponding lines on another target on the layer immediately above. These measurements are used to determine the size of the offset between levels. A state-of-the-art microprocessor chip could have 28 levels, and the relative position of any two targets must be determined with a precision of only a nanometer or two. Because the dimensions of chip features are already dwarfed by the wavelength of visible light, many suspect that the industry’s bag of technological tricks for extending conventional optical measurement methods will be exhausted within the next few rounds of miniaturization.

“Alternative tools—such as atomic-force microscopes—would provide the required resolution, but they are slower and are not likely to be as

cost effective as the rapid, non-destructive optical techniques already used for overlay measurements," explains NIST physicist Richard Silver. Silver and colleagues explored improved designs for the targets, or benchmark reference patterns, used to check the precision and accuracy of overlay measurement equipment.

The target patterns investigated in the NIST modeling studies are the nanotechnology equivalent of slightly overlapping picket fences. Together, the two sets of densely arranged nanoscale lines and grooves create a hybrid target that strongly reflects light, creating an image measurable with a conventional optical microscope.

The individual sets of lines are so dense that no individual optical image of the lines occurs, yet the combined superstructure results in the new unique optical pattern. The intensity patterns of the reflected light are unique to the combination, and the patterns are easily analyzed to determine the relative position of the lines that make up the pattern. In the modeling studies, feature sizes ranging from 10 nm to 50 nm were positioned as close as 100 nm apart, beyond the theorized limits of resolution.

As important, says Silver, the combined pattern greatly magnifies—by better than 40 times—the size of the overlay offset between layers. An article describing the pattern design and modeling results has been submitted to Optics Letters. Responding to immediate interest from the semiconductor industry, NIST is working with the partners to fabricate prototype targets with the new geometry.

Source: NIST

Citation: New Targets May Hit Bull's-Eye for Chip Makers (2006, December 7) retrieved 26

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April 2024 from https://phys.org/news/2006-12-bulls-eye-chip-makers.html

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