Einblicke in die Forschungsarbeit

MASTERARBEIT

„Evaluating old techniques in new technology“

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Evaluating old techniques in new technology

Frances Lenahan is an alumna of the Elite Graduate Program “Advanced Optical Technologies” at the Friedrich-Alexander Universität Erlangen-Nürnberg. There, and at the Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie (IISB), the scientist simulated lithography systems in the extreme ultraviolet regime to evaluate imaged patterns formed through the diffraction of light for integrated circuit technology.

The drive for smaller chips is never-ending

Development of modern society and the global economy is largely driven by the development of digital electronics. From washing machines to transportation, integrated circuit technology has found its way into nearly every aspect of our lives.

Gorden Moore, the co-founder of Fairchild Semiconductor and Intel, developed a prediction method for the number of transistors in a dense integrated circuit. Based on observation and the projection of a historical trend, this so-called Moore’s Law states that for a chip of a certain size, the number of transistors will double about every two years. This trend has been largely maintained since 1975 and is used in the semiconductor industry to guide long-term planning and research targets.

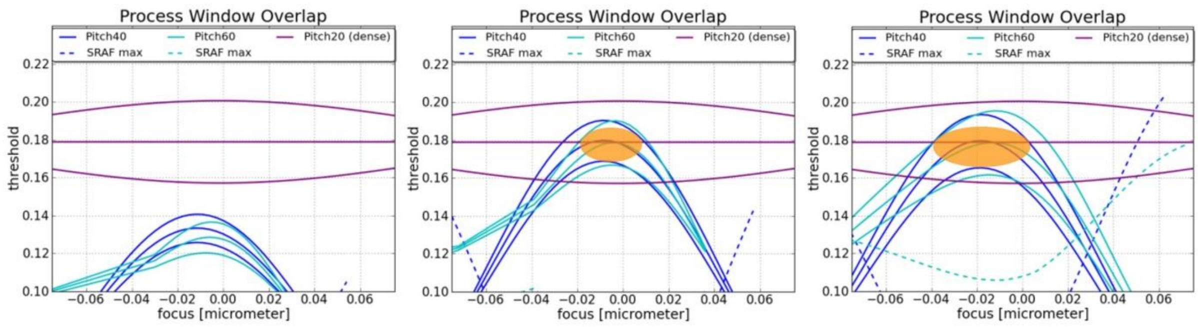
As these chips grow denser, they also become cheaper to fabricate and more powerful. They are fabricated with a technique called photolithography, which uses light to transfer a pattern from a mask onto a photoresist. The transferred pattern is four times smaller than the mask, which allows for multiple chips to be printed as a unit for improved throughput. Various techniques have been developed to move beyond the theoretical resolution limit of the pattern features as well as aid in imaging. Frances Lenahan worked with one such technique, utilizing sub-resolution assist features, which distort the image to assist in forming the desired pattern.

Until recently, the leading commercial technology for photolithography used light in the deep ultraviolet regime, with a wavelength of 193 nm. The newest development in this field uses instead 13.5 nm wavelength light in the extreme ultraviolet regime. As a result, the minimum resolvable feature size of the printed pattern is significantly reduced, improving the ability to fit more transistors onto the chip.

A smaller wavelength introduces new problems

With the development of a 13.5 nm laser strong enough for use in photolithography, research began the switch from deep-UV systems to extreme-UV systems. Due to the high absorption at this wavelength, the new systems are reflective, rather than transmissive, and therefore require an oblique incidence angle for the light hitting the mask. This gives rise to a new class of problems related to asymmetry and so far unseen or negligible in the previous systems.

Frances Lenahan used simulations to explore the influence of sub-resolution assist features in the new, reflective photolithography systems. Much of their influence is shown to match what is known in the transmissive systems, particularly in regards to how the diffracted spectrum of light responds to the dense environment introduced by these added features. However, many of the more-subtle phase effects arising from the mask topography is stronger in the reflective systems. This is due not only to the inherent asymmetry of the system but to the size-scale of the mask features with respect to the wavelength, as well.



Der The picture shows the influence of some resolution enhancement techniques on the processing requirements for three mask pitches. An overlap of the three curves is necessary to efficiently fabricate all three patterns and a larger overlap allows greater processing variability. With sub-resolution assist features introduced, there is a significant improvement in the overlap area, particularly for the depth of focus.