“Lithography in a Quantum World”

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Abstract:
For decades, the lithographic process used to fabricate microelectronics was well-described using classical physics. However, after many years of scaling, feature sizes have become sufficiently small that the quantum nature of light and matter has become significant. Quantum effects are manifested in dimensional variation, pattern collapse, line-edge roughness (LER) and defects (Fig. 1) caused by photon shot noise and molecular-scale statistical variations in materials.

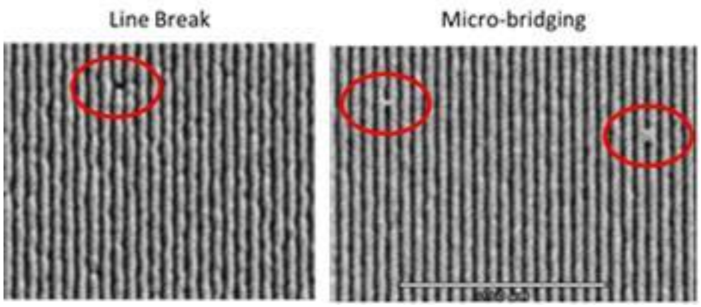

Fig. 1. Defects in line-space patterns induced by statistical effects in the lithographic process.

Quantum-level phenomena also have recently become more significant because of the transition to extreme ultraviolet (EUV) lithography, for which there have been technical challenges in creating powerful sources of light, resulting in photon shot-noise. Source power requirements will continue to increase as feature sizes scale smaller. In the future, accurate modeling of the lithographic process will require taking quantum statistical variations into account.

Multicomponent resists, such as chemically amplified resists, which have been used for nearly all advanced lithography since the 1990’s, are intrinsically prone to statistical fluctuations. Resist platforms such as metal-oxide and scissioning resists are platforms that may provide viable alternatives to chemically amplified resists.

Bio:
Harry J. Levinson is currently an independent lithography consultant. Dr. Levinson spent most of his career working in the field of lithography, starting at AMD. He also held positions at Sierra Semiconductor and IBM before returning to AMD in 1994. When wafer operations were spun off from AMD he moved to GLOBALFOUNDRIES and worked there until mid-2018. During the course of his career, Dr. Levinson has applied lithography to many different technologies, including bipolar memories, 64Mb and 256Mb DRAM development, the manufacturing of applications-specific integrated circuits, thin film heads for magnetic recording, flash memories and advanced logic. He was one of the first users of 5× steppers in Silicon Valley and was an early participant in 248 nm, 193 nm and EUV lithography. Dr. Levinson also served for several years as the chairman of the USA Lithography Technology Working Group that participated in

the generation of the lithography chapter of the International Technology Roadmap for Semiconductors. Harry has published numerous articles on lithographic science, on topics ranging from thin film optical effects and metrics for imaging, to overlay and process control, and he is the author of two books, *Lithography Process Control* and *Principles of Lithography*. He holds over 70 US patents. Dr. Levinson is an SPIE Fellow, previously chaired the SPIE Publications Committee, and served on SPIE's Board of Directors. In recognition of his contributions to SPIE, Dr. Levinson received the Society's 2014 Directors' Award. He has a BS in engineering from Cornell University and a PhD in physics from the University of Pennsylvania. His PhD thesis, titled *Resonances and Collective Effects in Photoemission*, addressed certain phenomenon involving the interactions of light and matter. For this work he received the Wayne B. Nottingham Prize in surface science.