Chain Scissionable Resists Based on Poly(acetal) Motif for Extreme Ultraviolet Lithography

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By

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ABSTRACT

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Scissionable polymers are polymers that will depolymerize under different stimuli including acid, base, and free radicals. These polymers have been investigated in the development of photoresists and other degradable materials. This work focuses on the poly(phthalaldehyde), PPA, family of scissionable polymers. The PPA backbone consists of acetal linkages that are very sensitive to acids. Upon exposure to acids, the polymer chain depolymerizes to its corresponding monomers. This depolymerization behavior makes PPAs excellent candidates as photoresist materials. Several new architectures are being explored. For example, PPAs with tethered photoacid generators (PAG)s, which release acid upon irradiation, depolymerize upon exposure followed by a post exposure bake step. The depolymerized monomers in exposed areas could be easily removed using appropriate organic solvents while the unexposed areas remain unchanged. Therefore, both unsubstituted and substituted PPAs may equally serve as a positive tone photoresist.

This study focuses on the development of low exposure dose, sensitive PPA photoresists, which do not suffer from materials stochastic issues related to non-uniformities at nanoscale present in multi-component systems for extreme ultraviolet lithography (EUVL). In order to improve the lithographic performance of the PPA photoresists, the structure of the polymer backbone as well as PAGs are being investigated and tailored

for EUVL. Aryl sulfonates, imidosulfonates, and iminosulfonates were prepared as non-ionic PAGs for PPA photoresists. The steric and electronic nature of these sulfonate PAGs can be easily tuned to optimize acid generation efficiency and their compatibility with a polymer photoresist matrix. All synthesis, characterization, and lithographic evaluation will be presented.

BIOGRAPHICAL SKETCH

Jingyuan Deng was born in Zhengzhou, Henan, China in October 1993. He believes "justice without force is powerless; force without justice is tyrannical" and started practicing Kyokushi Karate at the age of 16. He attended Nagoya University in 2012 and graduated with a B.E. in chemistry. After graduating from Nagoya University, he moved to the University of Tokyo to study organometallic and polymer chemistry under the supervision of Kyoko Nozaki. Upon completing his M.E. from the University of Tokyo, Jingyuan moved to Cornell University to pursue a doctorate degree in 2018. At Cornell University, he developed photoresist materials for EUV lithography in collaboration with Intel Corporation. He finished his Ph.D. degree in 2022 and decided to further pursue his career in semiconductor industry.

This dissertation is dedicated to my mother and father, who taught me the meaning of love, persistence, and life.

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My favorite philosopher, Arthur Schopenhauer wrote “Our happiness lies entirely outside us; for it exists only in the heads of others” in his essays, The Wisdom of Life. I do not believe in imaginary happiness. I will be patient and courageous throughout my life and hopefully I can make my life with less suffering.

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