The Photopolymer Science and Technology Award

The Photopolymer Science and Technology Award No.151100, the Outstanding Achievement Award 2015, was presented to Christopher Kemper Ober (Cornell University) for his outstanding achievements in photopolymer science and technology, “Development of new advanced photoresist for microelectronics”.

Christopher K. Ober

Christopher K. Ober is the Francis Bard Professor of Materials Engineering, Materials Science and Engineering, Cornell University. He received B. Sc. (1978) degree in chemistry from the University of Waterloo, Canada, M. S. (1980) and Ph. D (1982) degrees in chemistry from the Department of Polymer Science & Engineering, University of Massachusetts, Amherst, joined the Department of Materials Science & Engineering, Cornell University in 1986, and was promoted a full professor in 2001. He has developed new F2 and ArF resists, block copolymers resists, and nanoparticle resists with excellent resolution and extremely high sensitivity. He was the President, IUPAC polymer division (2008-2011), and was named a Fellow of the American Chemical Society in 2009 and a Fellow of the American Association for the Advancement of Science in 2014.

Prof. Ober has engaged in development of many photoresists including F2, ArF, and EUV resists, and contributed to the progress of photopolymer science and technology as described below.

1. He has investigated photoresists that are processed in non-polar “orthogonal” solvents such as supercritical CO₂ and hydrofluoroethers. Such resists undergo little pattern collapse because of the low surface energies of the developer [1].

2. Ober has pioneered the use of block copolymers (bcp) in photoresists, first investigating bcps for surface modifiers and etch-resistant additives for conventional photoresists as early as 1994. Subsequent studies have focused on the directed self-assembly (DSA) of new photoresist bcps in which one of the blocks is a highly sensitive crosslinkable unit and the other is easily removed. Ober’s goals include creating more lithographically sensitive bcps with a more easily removed sacrificial block, better long-range control, and creation of multiple ordered phases in a single block copolymer. Ober has developed unique block copolymer based on hydroxy styrene and α -methyl styrene. In this work he has shown that solvent vapor annealing provides the ability to create long-range order. Using graphoepitaxy he has further established that microphase alignment can be introduced over long range. By combining with

negative tone patterning and selected annealing solvents Ober and his group have shown that more than one pattern (lines and dots) can be created in a single layer bcp resist. Solvent annealing has also been used in a new system, the PMMA-block-poly(hydroxyethyl methacrylate) bcp. Using mixed solvents, Ober has shown that many microstructures are possible (sphere, cylinder, lamella and gyroid) from a single block copolymer and these structures can be easily trapped in the solid state. More recently his focus has been on block copolymers containing trifluoroethyl methacrylate blocks because of their great sensitivity [2].

3. Ober and his group have studied molecular glasses (MG) as possible replacements for polymer based photoresists. Their small size, amorphous (glassy) character, high T_g and good etch resistance make them very interesting for high-resolution patterning. Ober and his group have created a number of chemically amplified MG materials based on calixarenes and novolac-like MGs. In addition, through collaborations with Japanese researchers he has explored MGs made from hexaphenyl benzene and noria. Using EUV patterning he has shown that high resolution (sub-30 nm) patterns with good LER values can be produced. Ober working with NIST researchers

has also shown that the intrinsic LER of molecular glasses is better than a polymer photoresist, but that the development speed is extremely high. More recently he has explored molecular glass photoresists for patterning organic semiconductors using the concept of orthogonal processing [3].

4. In recent work, Ober and his group have shown that metal oxide nanoparticles, 2 to 3 nm in size, can act as superb EUV photoresists and have excellent resolution and extremely high sensitivity ($\sim 3\text{--}5\text{ mJ/cm}^2$). These materials originally developed as additives to increase RI and etch resistance of conventional photoresists, these nanoparticles, made from zirconium or hafnium oxide, can be patterned as both negative and positive tone materials and do not involve chemical amplification. These nanoparticle resists are among the most sensitive materials tested to date under EUV conditions. Currently Ober is working on understanding the fundamental photo-patterning mechanism of these photoresists. Interestingly, the more transparent material is more sensitive and capable of the highest resolution ($\sim 20\text{ nm}$) in contrast to current thinking on EUV resist design [4].

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