The Photopolymer Science and Technology Award

The Photopolymer Science and Technology Award No.02100 was presented to Masamitsu Shirai, Toyofumi Shinozuka, Haruyuki Okamura, Masahiro Tsunooka (Graduate School of Engineering, Osaka Prefecture University), Shinji Kishimura, Masayuki Endo and Masaru Sasago (Semiconductor Company, Matsushita Electric Industry Co. Ltd.) for their outstanding contribution published in Journal of Photopolymer Science and Technology, **14**, 621-629 (2001), entitled "157nm Single-Layer and Bilayer Resists Based on α -Methylstyrene Polymers".

Masamitsu Shirai

Masamitsu Shirai received his B.S. and M.S. degrees in applied chemistry from Osaka Prefecture University (OPU) and he became a research associate at the same university in 1973. He continued his doctoral studies at OPU in the field of polymer chemistry. In 1978 he received his Ph.D. degree from OPU on interaction between dyes and polyelectrolytes. After working as an assistant professor and then an associate professor at OPU, he was promoted to a professor of applied chemistry at OPU in 1997. He spent his early career as a postdoctoral fellow (1978-1979) at the State University of New York at Syracuse, USA. His research interests include synthesis and applications of photosensitive polymeric materials, especially photoresists, photoinitiators, UV curing materials, photoinduced modification of polymer solid surface, and photodegradation and stabilization mechanisms of polymeric materials.

Toyofumi Shinozuka

Toyofumi Shinozuka received his B.S. degree in 1998 and his M.S. degree in 2000 in applied chemistry from Osaka Prefecture University. Now he is working for his Ph.D. degree at Graduate School of Engineering, Osaka Prefecture University. His current interest is synthesis and photochemistry of resist materials for 157nm lithography. He is a member of the Society of Polymer Science, Japan.

Haruyuki Okamura

Haruyuki Okamura received his B.S. degree in 1994 and his Ph.D. degree in 1998 from Kyoto University on synthesis and properties of fullerene-containing polymers with well-defined structures. He joined Osaka Prefecture University as a research associate in 1999. His research interests include synthesis of resist materials, photoacid and photobase generators, UV curing materials, fullerene-containing polymers, and the development of controlled polymerization. He is a member of the Society of Polymer Science, Japan.

Masahiro Tsunooka

Masahiro Tsunooka received his M.E. degree from Osaka Prefecture University (OPU) in 1965. He was appointed as a research associate at OPU in the same year. He received his Ph.D. degree from OPU in 1970 on photo-polymerization and photo-graft polymerization. After being a postdoctoral fellow (1971-1972) at the University of Toronto (Canada), he was promoted to an associate professor in 1973 and a professor in 1990 at OPU. Throughout his carrier, he has been engaged in polymer photochemistry, especially photodegradation and stability of polymers and photosensitive polymers including photoresists and UV curing materials.

Shinji Kishimura

Shinji Kishimura received his B. S. and M. S. degrees from Osaka Prefecture University in 1984 and 1986, respectively. In 1986, he joined Mitsubishi Electric Corporation, and has been working on the development of photolithography (g-, i-line and KrF) and the integration of DRAM and EEPROM. From 1996 to 1998, he was assigned for a researcher of ArF lithography in ASET. In 1999, he moved to Matsushita Electric Industrial Co., Ltd. Since then, he has been working on the development of next generation lithography, especially 157nm lithography. In 2001, he received his doctor degree in engineering from Osaka Prefecture University.

Masayuki Endo

Masayuki Endo received B.S. and M.S. degree from Kyoto University, Faculty of Engineering in 1981 and 1983, respectively. In 1983, he joined Matsushita Electric Ind. Co., Ltd. Since then, he has been working for optical lithography, especially for resist and resist processes. In 1992, he received Ph.D. degree from Osaka University, Faculty of Engineering. He is now in charge of the development of next generation lithography in Matsushita Electric Ind. Co., Ltd. He is a member of The Japan Society of Applied Physics.

Masaru Sasago

Masaru Sasago manages the advanced lithography project at the Process Group of ULSI Process Technology Development Center, Semiconductor Company, Matsushita Electric Industrial Co., Ltd. in Kyoto, Japan. Along with 24 years experience at Matsushita, he has positions in research and management, including participation in ASET in Japanese government national R&D program. He has also served as a research manager and strategist assigned to manage the ArF lithography laboratory at ASET in 1996-1998. Dr. Sasago is a very prominent researcher for the excimer laser lithography such as KrF, ArF, VUV and EUV. As author and co-author of more than 300 technical papers and presentations, Dr. Sasago served as a chairman of Japanese lithography working-group of the International Technology Roadmap for Semiconductor (ITRS). His pro-fessional affiliations include IEE Japan, the JSAP, and tech-nical committee member of ASET, Selete and steering committee of Microprocesses and Nanotechnologies (MNC). Dr. Sasago obtained a Ph. D. in natural science from Kobe University, Japan in 1995.

Vacuum ultraviolet (VUV) lithography using F₂ laser at 157nm is a good candidate as post ArF lithography. It is urgently required to develop new resist materials for the new wavelength lithography. A number of commercially available KrF and ArF resists and conventional polymeric materials generally show very low transmittance at 157nm, except for hydrofluorocarbons, poly-siloxanes and polysilsesquioxanes. Although recent research on single-layer resist materials with high transparency at 157nm is focused on the fluorocarbon polymers, it needs the expense of manufacturing cost and development effort. Resist materials which are relatively transparent at 157 nm are important because they can be used as a ultra thin resist in combination with a hard mask. Furthermore, they can be used as a tool-testing resist.

Prof. Shirai and his co-workers have been working in the field of photopolymer science including syntheses of photoacid generators, photobase generators, and photoresists.[1,2] They have devised many types of resist materials and resist processes including surface modification resist process for ArF lithography.[5-9] Their current work is focused on F₂ resist materials. They have designed and synthesized novel photopolymers based on methacrylonitrile and α -methylstyrene derivatives.[10-12] The polymers were relatively transparent at 157nm (transmittance: ~35% for 0.1 μ m thick film) and applied to 157nm resists. Polymers without tertiary hydrogen atoms in the main chain were prepared to eliminate the negative character of the resists, which was often observed for many polymeric materials on VUV irradiation at high exposure dose. Methacrylonitrile, which is relatively transparent at 157nm and photochemically stable, was selected as a base component of the resists. It was shown that good hole and L/S images could be obtained using those polymers as single-layer and bilayer resists for F₂ laser lithography.

Irradiation of polymers with VUV light sometimes induces undesirable photochemical reactions such as crosslinking and/or main-chain scissions which are not observed by UV or deep UV irradiation. The photoinduced crosslinking is a serious problem for positive resists. The photoinduced degradation of resists is also a

significant problem in relation to outgassing. Fundamental studies on photochemical reactions of conventional polymers and well-known resists for ArF or KrF lithography were done using VUV light.[13-19] Main-chain scission was observed for poly(methacrylate) based resists but crosslinking was observed for polystyrene based resists and poly(norbornene carboxylate) based resists. These findings were applied to design the resist materials for F₂ lithography.

Their important research results have been presented at the annual Conference of Photopolymer Science and Technology and 13 issues of the papers have been published in *Journal of Photopolymer Science and Technology*. These contributions give the fundamental aspects of development of new resist materials.

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