The Photopolymer Science and Technology Award

The Photopolymer Science and Technology Award No. 98100 was presented to Kaichiro Nakano, Katsumi Maeda, Shigeyuki Iwasa, and Etsuo Hasegawa (NEC Corporation) for their outstanding contribution published in Journal of Photopolymer Science and Technology 10(4), 561-570 (1997), entitled "Chemically Amplified Resist Based on High Etch-Resistant Polymers for 193-nm Lithography".

Kaichiro Nakano

Kaichiro Nakano received his B.S. and M.S. degrees in Chemical Engineering from Kobe University in 1988 and 1990, respectively. He joined NEC Corporation in 1990, and is now Assistant Manager of the Functional Organic Material Research Laboratory, Functional Devices Research Laboratories. He is engaged in the research and development of resist materials. He is a member of the Japan Society of Applied Physics.

Katsumi Maeda

Katsumi Maeda received his B.S. and M.S. degrees in Applied Chemistry from University of Osaka Prefecture in 1989 and 1991, respectively. He joined NEC Corporation in 1991, and is now Assistant Manager of the Functional Organic Material Research Laboratory, Functional Devices Research Laboratories. He is engaged in the research and development of resist materials. He is a member of the Japan Society of Applied Physics.

Shigeyuki Iwasa

Shigeyuki Iwasa received his B.S. and M.S. degrees in Industrial Engineering Chemistry from Science University of Tokyo in 1990 and 1992, respectively. He joined NEC Corporation in 1992, and is now Research Fellow of the Functional Organic Material Research Laboratory, Functional Devices Research Laboratories. He is engaged in the research and development of resist materials. He is a member of the Japan Society of Applied Physics.

Etsuo Hasegawa

Etsuo Hasegawa received his B.S., M.S., and Ph.D. degrees in Applied Chemistry from Waseda University in 1973, 1975, and 1978, respectively. He joined NEC Corporation in 1991, and is now Senior Manager of the Functional Organic Material Research Laboratory, Functional Devices Research Laboratories. He is engaged in the research and development of electronics devices related to functional organic materials, especially for ArF resist, liquid crystal materials, and organic conducting polymers. He has more than 90 publications in the research field of polymer science. He is a member of the Chemical Society of Japan and the Society of Polymer Science, Japan

K. Nakano, K. Maeda, S. Iwasa, and E. Hasegawa developed a novel ArF chemically amplified positive resist which satisfied practical etching durability requirements and produced good resolution.

In function-separated alicyclic polymers¹⁾ composed of functionally different monomers, the incorporation of the alicyclic groups which provide the dry-etching resistance is limited to below 50 mol% by their strong hydrophobic nature; this results in poor dry-etching resistance. To overcome this problem, Nakano et al. designed function-integrated polymers (which had conflicting hydrophobic and hydrophilic groups in their monomer unit) with a carboxyl substituent in the alicyclic group. As a result, the polymers were able to contain up to 100 mol% of the alicyclic group as well as remain soluble in alkaline developer²⁾. This design concept enabled alicyclic polymers to be used as practical ArF resist polymer.

In 1997, Nakano et al. reported in *J. Photopolym. Sci. Technol.*³⁾ that a function-integrated polymer having the carboxy-tetracyclododecyl group as an alicyclic moiety provided better etching durability than the KrF resist and satisfied the other requirements for an ArF resist polymer. In combination with their study on the influence of the protection groups on dissolution characteristics⁴⁾, they demonstrated that a positive resist with an ethoxyethyl-protected copolymer had a good resolution of 0.15- μm L/S³⁾. Meanwhile, for the adhesion problem specific to the alicyclic polymers, they made a quantitative analysis by determining

the surface free energy of alicyclic polymers, and they showed the relationship between the polymer structures and the adhesion.

In conclusion, their proposed function-integrated polymers are remarkable resist materials from the view point of polymer structure. Moreover, their work has greatly contributed to advances in 193-nm resist development.

References

1. Kaichiro Nakano, Katsumi Maeda, Shigeyuki Iwasa, Takeshi Ohfuji, and Etsuo Hasegawa, "Positive Chemically Amplified Resist for ArF Excimer Laser Lithography Composed of a Novel Transparent Photoacid Generator and an Alicyclic Terpolymer", *Proc. SPIE*, **2438**, 433-444 (1996).
2. Katsumi Maeda, Kaichiro Nakano, Takeshi Ohfuji, and Etsuo Hasegawa, "Novel Alkaline-Soluble Alicyclic Polymer Poly(TCDMACOOH) for ArF Chemically Amplified Positive Resists", *Proc. SPIE*, **2724**, 377-385 (1996).
3. Kaichiro Nakano, Katsumi Maeda, Shigeyuki Iwasa, and Etsuo Hasegawa, "Chemically Amplified Resist Based on High Etch-Resistant Polymers for 193-nm Lithography", *J. Photopolym. Sci. Technol.*, **10**, 561-570 (1997).
4. Shigeyuki Iwasa, Katsumi Maeda, Kaichiro Nakano, Takeshi Ohfuji, and Etsuo Hasegawa, "Design and Characterization of Alicyclic Polymers with Alkoxy-ethyl Protecting Groups for ArF Chemically Amplified Resists", *J. Photopolym. Sci. Technol.*, **9**, 447-456 (1996).

Masao Kato

Department of Materials Science and Technology
Science University of Tokyo