The Photopolymer Science and Technology Award

The Photopolymer Science and Technology Award No.032200, the Best Paper Award 2003, was presented to Kentarou Tamaki, Tomohiro Utaka, Hideaki Takase, Yuuichi Eriyama, and Takashi Ukachi (Tsukuba Research Laboratories, JSR Corporation) for their outstanding contribution published in the Journal of Photopolymer Science and Technology, 15, 103-108(2002), entitled "Photolithographic Properties of Photosensitive Sol-Gel Materials and Their Application to Optical Waveguide".

Kentarou Tamaki received his M. Sc. degree from University of Tsukuba in 1999 and joined JSR Corporation. Since 2000 he has been engaged in the research and development of photosensitive sol-gel materials for opto-electronic fields. His current research is the development of polymeric waveguide materials and their applications to optical devices.

Tomohiro Utaka received his M. Sc. degree from Tokyo Institute of Technology in 1995 and joined JSR Corporation. After experiencing the development of polymer materials for producing components used in the liquid crystal display at Display Research Laboratories, he moved to Tsukuba Research Laboratories of JSR Corporation in 1998 and has been engaged in the development of optical materials including siloxane and acrylic polymers.

Hideaki Takase received his M. Eng. degree from Tohoku University in 1992 and joined JSR Corporation. He has been engaged in the development of radiation curable materials for electronic and optical uses. He worked as a Visiting Scientist at Queen's University, Kingston, ON. from 1999 for two years. His current research is the development of polymeric waveguide materials and their applications to optical devices.
Yuuichi Eriyama received his B. Eng. degree in fiber industrial chemistry from University of Shinshu in 1978, M.Sc. and Ph. D. in chemistry from Tohoku University in 1980 and 1983. He conducted research on the industrial applications of organosilicon compounds at Tokyo Research Laboratory of JSR Corporation. From 1985 to 1986, he stayed for one year at MIT, Boston, MA as a Postdoctoral Research Associate. He studied organosilicon chemistry with Prof. S. Masamune. He is now the technical manager of Tsukuba Research Laboratories of JSR Corporation. His current research is the development of optical functional materials and their applications.

Takashi Ukachi received his B. Eng. degree in biophysics and bioengineering from Osaka University in 1976 and his Ph. D. degree in material science from Kyushu University in 1994. He started his professional career at Tokyo Research Laboratory of JSR Corporation where he had been engaged in development of radiation cureable polymers for electrical and optical uses. From 1988 to 1990, he spent two years at Cornell University, Ithaca, NY as a Visiting Scientist to carry out the research on nonlinear optics. He is now the research director of Tsukuba Research Laboratories of JSR Corporation. His current research interests include the development of optical and electrical functional polymers and their applications.

Sol-gel technology is a well developed method for preparing metal oxide glasses or ceramics starting from metal alkoxides. It has been widely investigated and utilized in several applications including protective coatings, fiber, and fine ceramic particles. Since the 1980s, organic and inorganic hybrid materials made by using the sol-gel process have been developed. The characteristic features of the hybrid materials, such as excellent optical transparency, high thermal stability, and productivity, were realized by utilizing the features brought by the organic and inorganic parts respectively. Recent attention on the organic-inorganic hybrid materials has directed to the development of new attractive materials by controlling micro- and/or macro- level structures. In particular, the organic-inorganic hybrid materials have been applied for opto-electronic fields because various functions or properties can be introduced in addition to the excellent optical transparency and high thermal stability. As one of the optical functions, an introduction of photosensitive groups such as (meth)acrylate or epoxide into the polymers has been investigated and the products have been commercially available.

On the other hand, UV-curable materials have been widely used for coatings, inks, adhesives and photo-resist. Photosensitive polysiloxanes having acrylic or epoxy functional groups have been developed for optical coatings on plastic substrates. The acrylate or epoxide functional polysiloxanes contributes especially to produce anti-reflection films for display instruments because of the advantages which allow us to cure the materials with a fast cure rate at relatively low temperature.

The research group led by Dr. Ukachi has recently proposed new organic-inorganic hybrid materials which are patternable through all-wet photolithographic technique. Note that the organic-inorganic hybrid materials based on polysiloxane backbone can give crosslinked networks through the sol-gel reaction involving hydrolysis and poly-condensation induced by UV irradiation. One of the outstanding features for the polymers is that photo-crosslinking without photopolymerization of acrylate or epoxide is achievable. The developed organic-inorganic hybrid materials, therefore, can provide high durability as well as excellent optical transparency because C-C bondings as formed in the acrylate or epoxide functional polysiloxanes are not included in the crosslinked networks.

His research group has reported the application of the polysiloxane based hybrid materials to the optical waveguides. Polymer waveguides have attracted considerable attention due to their flexibility, low fabrication cost and in addition to these, various functionalities, electro-optic (EO) or
thermo-optic (TO) effect which can be expected to introduce. In particular, the use of polymer waveguides for optical devices of telecommunication has been widely investigated and found that the high thermal resistance as well as excellent optical transparency in the near-infrared region were strongly required, since the telecommunication signal processing requires low propagation loss at 1.31 µm and 1.55 µm. Certain polymer waveguides such as fluorinated polyimides or fluorinated (meth)acrylates have been proposed. The polysiloxane based hybrid polymers, which Dr. Ukachi's group developed, are also considered to be one of the suitable materials. The hybrid materials, especially, allow us to produce a fine pattern with all-wet photolithographic technique, which is suitable for the fabrication of a core part in the waveguides, by controlling photo acid generators and amines as acid diffusion inhibitors. As a result, the hybrid materials need no dry etching process, while polyimides or other materials require the cost and time consuming dry etching process. The optical waveguides fabricated by the hybrid materials show low propagation losses at 1.31 µm and 1.55 µm as well as high thermal decomposition temperature. Furthermore, the polysiloxane based hybrid materials are amorphous without any orientation, so that the polarization dependent losses are not observed.

The systematic research conducted by Dr. Ukachi's group contributed to provide the new materials in the fabrication of the optical waveguides through all-wet photolithographic technique.

References

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