The Photopolymer Science and Technology Award

The Photopolymer Science and Technology Award No.02300 was presented to Kohei Goto, Yasutake Inoue, and Minoru Matsubara (Tsukuba Research Laboratories, JSR Corporation) for their outstanding contribution published in the Journal of Photopolymer Science and Technology, 14, 33-36 (2001), entitled “Low Dielectric and Thermally Stable Polyimides with Fluorene Structure (II) Relationship between Chemical Structure and Dielectric Constant”.

Kohei Goto received his MS degree from Kyoto Institute of Technology in 1972 and PhD degree from Kyushu University in 1989 for the study on the molecular composites (so-called a kind of nano-composites). He joined JSR Corporation in 1972 and began his research work from 1974 up to the present at Tokyo Research Laboratories, Yokkaichi Research Laboratories and Tsukuba Research Laboratories. He is now the research fellow in his Corporation. His research interest is development of new functional polymers including polyimides, which is one of his specialized fields. In his research activity on polyimides, Ichimura Foundation already awarded him for the development of low temperature processing alignment coating consisting of aliphatic polyimides for full-color active-matrix LCD in 1995.

Yasutake Inoue received his MS degree from Yamaguchi University in 1990. He joined JSR Corporation in 1990. After research experience of biomaterials for initial several years, he moved to a polymer research section and has been engaging in the development of low dielectrics including polyimides for semiconductor materials.

Minoru Matsubara received his MS degree from Tohoku University in 1984. He joined JSR Corporation in 1984. His professional backbone on research activity was biochemistry. He moved to polymer research section in 1994 after experience of biosynthesis of functional monomers using mutated microorganisms. His work was focused on the application of polyimides for microelectronics, especially for low dielectrics. Since 2000 he has been engaged in technical department at head office as a manager of quality assurance section.

Polymeric materials with lower dielectric constant (k) had been desired in electronics industry in terms of enhanced signal propagation speed and wiring density in devices. Low k laminates for print circuit board made possible to be commercialized as mobile-telecommunication usage at high frequency. Recently, interlayer dielectrics with lower k and superior thermal stability have been desired according to the roadmap by the semiconductor devices manufacturers. Considerable efforts have been expended to design and synthesize new polymers with k value lower than 2.5 and without out-gas even at 450°C, regardless organic or inorganic materials for this purpose.

Thermally stable polyimide is one of the candidates for organic materials. At that time among polyimides, fluorine-substituted derivatives exhibited lower k, such as k=2.5-2.8, and with both
specific chemical structure and higher fluorine concentration $k \approx 2.3$.

A Dr. Goto's group of JSR extensively investigated the polymer design for low dielectrics with keeping thermal stability in a series of polyimides and polyarylenes, respectively. In their polymer design, the basic concept was introducing bulky and thermally stable aromatic moieties, aiming to reduce polarity and density. Fluorenylidene moiety is an effective unit for exhibiting lower $k$ owing to cargo-structure, which serves to break long $\pi$ conjugation between adjacent aromatic rings, in addition to its bulky and thermally stable form (lower H/C atomic ratio). Those features result in low density and low dipole moment under applied electric field, which are favorable characteristics for low $k$.

They obtained the lowest $k=2.77$ without fluorine atom, and the lowest $k=2.46$ with fluorine atom among the thermally stable polyimides, selected from a series of methyl-, phenyl- and/or trifluoromethyl substituted fluorenylidene diamines and/or tetracarboxylic dianhydrides, including novel monomers. Moreover, they clarified that $k$ value of polyimides can be described as a function of imide weight fraction and F content (wt%). In conclusion, to achieve $k$ lower than 2.5, they pointed out that it is necessary to offer both lower than 12wt% of imide weight fraction and higher than 18wt% fluorine content.

Their important experimental results to design low $k$ polyimides with keeping thermal stability have been presented at the annual Conference of Photopolymer Science and Technology of the session of "Polyimide -Functionalization and Applications", Japan Polyimide Conference, and Polycondensation 2000, 2 issues of papers have been published in Journal of Photopolymer Science and Technology and 8 Kokai patents were disclosed by Japan Patent Office. These systematic conclusions contribute to bring useful directions to design low dielectrics in the field of microelectronics.

References

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