Analysis and Applications of Anisotropic Structure and Properties of Polyimides Generated under Extreme Conditions

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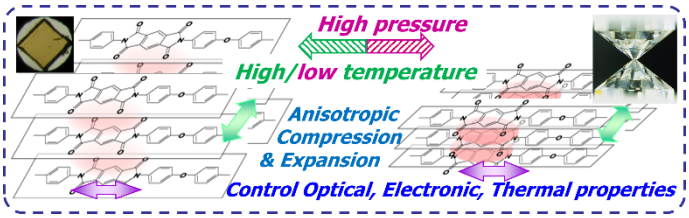

Anisotropic deformation of ordered structures of polyimides by application of high pressure or high/low temperature.

Polyimides (PIs) have been widely used in the fields of electronics, optics, aerospace, and automobiles fulfilling increasing need for materials applicable to harsh conditions, such as elevated temperature, pressure, light flux, and AC/DC voltage. We have been applying a variety of *in-situ* spectroscopic and diffraction techniques to observe anisotropic changes in the structures and physical properties of aromatic/semi-aliphatic PIs under 'extreme conditions', i.e., very high pressure and/or low to high temperature. The anisotropic changes caused by pressure and temperature generated in the ordered structures, aggregation states, electronic structures, and local motions of PIs have been observed, and the effects of compression / expansion processes on the intermolecular interactions and photophysical processes have been evaluated. For instance, the structural changes in the repeating units of PI chains and the intermolecular distances caused by the applications of high pressure in a high-pressure optical cell (up to 4,000 atm) or diamond anvil cell (up to 80,000 atm) and large temperature changes (–196 ~ 350 °C) in a variable temperature stage were observed using wide-angle X-ray diffraction and originally developed spectroscopic systems. Recently, we discussed the lattice deformation with an increase in pressure or temperature of rigid-rod PI, which was enhanced with an increase in the weight density of the lattice. This unique behavior is caused by the suppression of lattice deformation by means of "misfit strain". These findings were compared with the optical absorption / excitation / emission spectra, luminescence lifetimes with photo-excitation dynamics, near-, mid-, and far-infrared spectra, and refractive index/birefringence observed under extreme conditions. Moreover, based on these findings, we have developed novel polyimide materials exhibiting unique optical, dielectric, electronic, and thermal functionalities.

Keywords: Polyimide, Extreme condition, Ordered structure, Anisotropic property

References

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