

## Nanopore structure of siloxane-silica CVD films elucidated by the low-energy AMOC technique with a radioisotope-based pulsed positron beam

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The positronium (Ps) lifetime technique is well documented as a sensitive tool for probing nanometer-scaled open-space in various oxides and polymers [1,2], in order to elucidate their macroscopic properties such as molecular permeability [3] and ion transport [4]. Our group has so far reported on the usefulness of this technique for investigating free-volume holes/nanopores in a variety of functional materials like separation membranes [4,5], hydrophilic polyolefins [6], and silica films [7]. In 2003, our group proved that the positron and Ps momentum distributions for polymers associate with their constituent elements [8], suggesting that Ps may be useful for probing the chemistry of free-volume surfaces. For instance, the chemical environment from a nanoscopic viewpoint has been investigated for bulk polymers by means of the positron age-momentum correlation (AMOC) technique, which demonstrated the applicability of AMOC to the chemical analysis around the free volumes [9].

In this work, an energy-tunable AMOC measurement system with a radioisotope-based pulsed positron beam was developed for investigating functional thin materials. Positron annihilation lifetime spectroscopy (PALS) was performed using a positron pulsing system (FUJI IMVAC Inc., Japan) with a time resolution of about 250 ps (FWHM), and Doppler broadening of positron annihilation radiation (DBAR) was measured using a high-purity Ge detector with an energy resolution of 1.63 keV at 1.33 MeV and an efficiency of 39 %. In order to obtain AMOC data, coincidence signals from PALS and DBAR were stored in a PC using a digital signal-processing module developed by TechnoAP, Japan. As the first application, siloxane-silica hybrid thin films, fabricated through plasma-enhanced chemical vapor deposition [7], were examined using the developed system. The effect of the siloxane monomer content on the free-volume structure was discussed based on the AMOC data. Details of the measurement system and obtained results are presented at the workshop.

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