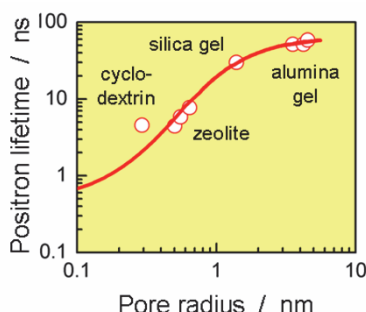
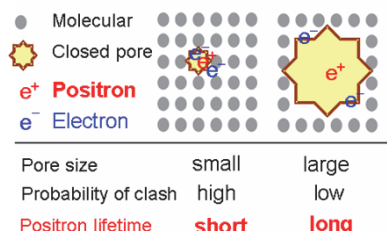


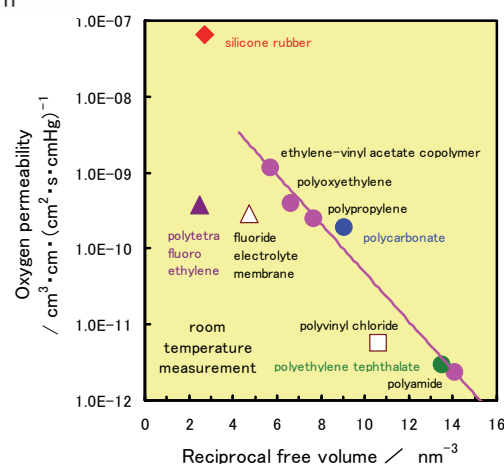
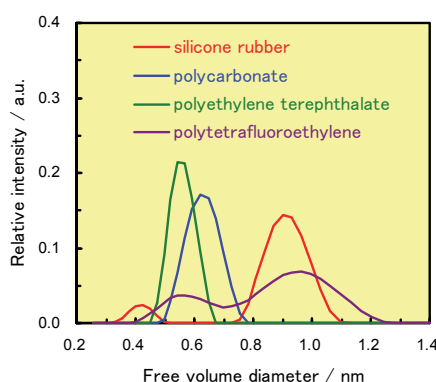
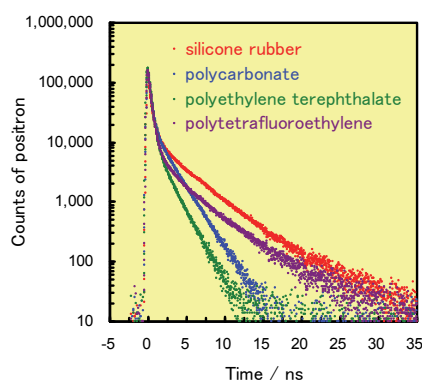
# Pore size evaluation by positron annihilation lifetime spectroscopy

Positron annihilation lifetime spectroscopy (PALS) is a measurement method for sub-nm  $\sim$  nm scale pore size distribution of polymer, inorganic, semiconductor, metal *etc.* Positron beam equipment is useful for thin films on substrates as well as bulk materials.

## Principle of positron annihilation method



## Relationship between free volume and oxygen permeability



Positron annihilation lifetimes and free volume size distributions are dependent on the type of polymers.

Oxygen permeability is closely correlated with reciprocal free volume in polymers.

## Pore size of inorganics

Positron annihilation lifetimes in inorganics (SiO<sub>2</sub>, SiN, Al<sub>2</sub>O<sub>3</sub> *etc.*) are related to size of skeletal structures. Positron annihilation lifetimes and pore size distributions are dependent on the type of SiO<sub>2</sub> glasses.

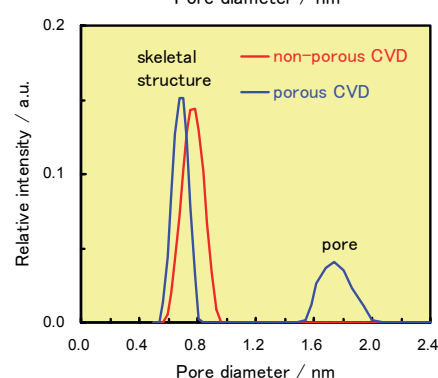
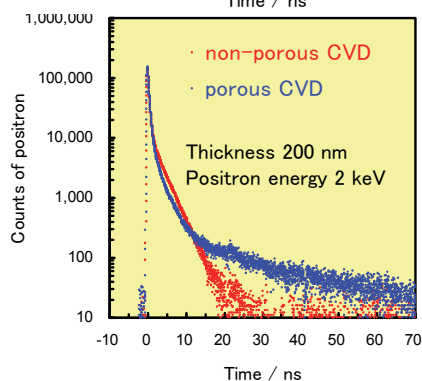
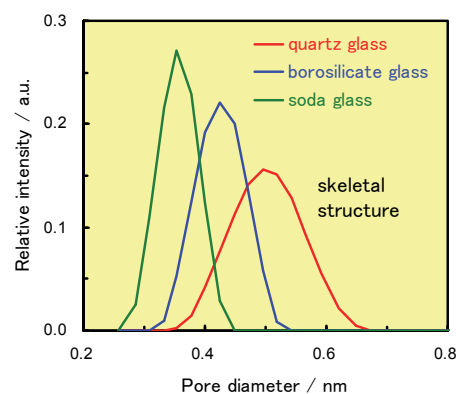
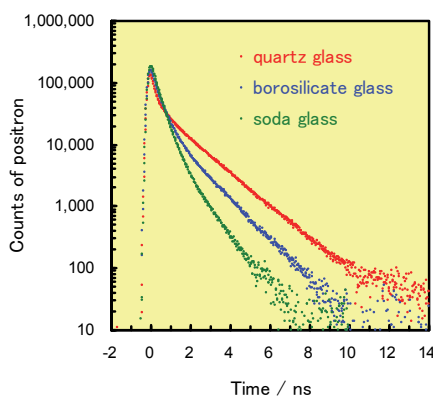
## Pore size of thin films

Pore size of thin films on Si wafers or substrates can be determined by positron beam method with controlled positron energy. Pore size distributions of non-porous and porous CVD (chemical vapor deposition) films\* obtained from TEOS (tetraethoxysilane) are clearly different.

film thickness (Si wafer) : > 100 nm  
 film thickness (glass substrate) : > 300 nm  
 Specimen size : 14 – 15 mm square  
 Positron energy : 1 – 10 keV  
 Positron depth : about 100 nm – 5  $\mu$ m

## <Other measurement example>

Reverse osmosis (RO) membrane, photoresist, metal, semiconductor *etc.*



\*Preparation of CVD films :  
Joint research with NMIJ, AIST, Japan.