Nanocomposites and nanomaterials

Nanopores evolution in $MgO\text{-}Al_2O_3$ ceramics testified by o-Ps-related PAL components

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The ortho-positronium (o-Ps)-related modes obtained after treatment of positron annihilation lifetime (PAL) spectra on four components are used for study of evolution of nanopores and free-volume entities in humidity-sensitive nanostructured $MgO\text{-}Al_2O_3$ ceramics (sintered at 1100 ºC, 1200 ºC, 1300 ºC and 1400 ºC) before/after drying and water-immersion treatment. It is established that water-sorption processes in ceramics lead to corresponding increase in the positron trapping rates of extended free-volume defects located as extractions of addition MgO and Al_2O_3 phases near grain boundaries. These phases and free-volume entities in ceramic structure serve as specific trapping centers for positrons penetrating ceramics.

It is demonstrated that Tao-Eldrup model can be adequately used for calculations of nanopores size in $MgO\text{-}Al_2O_3$ ceramics using o-Ps lifetimes defined from third and fourth components. It is shown that with increasing of ceramics sintering temperature, the free volume radius R_3 increases from 3.09 to 3.31 Å and R_4 left nearly at the same level (~18 Å) in the samples taken after initial drying. In water-immersed samples, both nanopore radii R_3 and R_4 decrease with amount of adsorbed water, these changed being harmonized with nanopore content. In final, after ceramics drying, the initial state of these nanopores is partially restored. Thus, both types of inner nanopores in $MgO\text{-}Al_2O_3$ ceramics are practically identical in respect to efficiency of water sorption, but primary functionality of these ceramics is defined by smaller nanopores due to their prevailing content. In addition, it should be noted, that porosimetry methods are limited to open pores, which should have an access to the environment to be determined. PAL spectroscopy can probe both open and closed pores in functional humidity-sensitive ceramics of sizes

ranging from atomic scale to several tens of nanometers.