11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Synthesis and TEM characterization of ceria nanoparticles

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Abstract – Nanocrystalline ceria has been synthesized at low temperature in an aqueous solution reaction. In addition, the particles have been doped with either La and Gd. HRTEM has been used to study surface facets and dynamic surface structure under the electron beam. Spectrometry in the TEM has been used to particle chemistry as influenced by dopants.

Ceria is a ceramic material with growing importance for applications as widely diverse as catalysis and chemical-mechanical polishing (CMP). In the present study, nanocrystalline ceria has been synthesized at low temperature in an aqueous solution reaction. In addition, the particles have been doped with either La and Gd. The pure and doped particles are all cubic in crystal structure and 10-25 nm in size. However, while the pure and La-doped ceria are cuboidal in morphology, the Gd-doped particles are irregular in shape. HRTEM imaging combined with image simulation indicates that atomic level steps are present on the surfaces of the particle. The nanoparticles are, in fact, predominantly faceted parallel to 111 and 100 crystallographic planes and dynamic interchange is found to occur between the two possible surface facets during observation in the TEM. The surface energies of the two surface orientations have previously been calculated to be quite similar in magnitude. Chemical imaging and spectroscopy indicates that the dopants are distributed homogeneously throughout the particle and that the Ce is present in both the +3 and +4 oxidation states. No preferential segregation either of the dopant or the oxidation state has been identified. The implications of these observations and the possible use of this processing technique will be discussed.