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Time-resolved High-temperature X-ray Diffraction Studies of Cerium Oxide Nanoparticles

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Beamline(s): X7B

Introduction: Cerium oxide is an important material for catalysis, solid oxide fuel cells, and semiconductor devices. The lattice parameter of ceria nanoparticles was found to increase with decreasing the particle size. [1] Time-resolved high-temperature X-ray diffraction (XRD) studies can help to test possible theories and origins of such a lattice-parameter change.

Methods and Materials: Ceria nanoparticles are prepared by mixing cerium nitrate with an ammonia agent. XRD measurements are performed at X7B beamline at NSLS.

Results: When 6 nm ceria is sintered from 25 to 900 ^{o}C with a constant heating rate, the particle size increases from 6.7 to 16 nm, and the lattice parameter changes accordingly (Fig. 1a). Compared with previous results, Fig. 1b, this total lattice parameter increase is attributed to the increase of thermal expansion, offset by the small decrease of lattice parameter due to the increase of particle size. When treated with different gas environments at high temperature, smaller ceria nanoparticles show larger oxygen storage capacity than that of the larger particles (Fig. 2).

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References: 1. F. Zhang et. al. “Cerium oxide nanoparticles: size-selective formation and structural analysis”, Appl. Phys. Lett. **80**(1), 127-129.

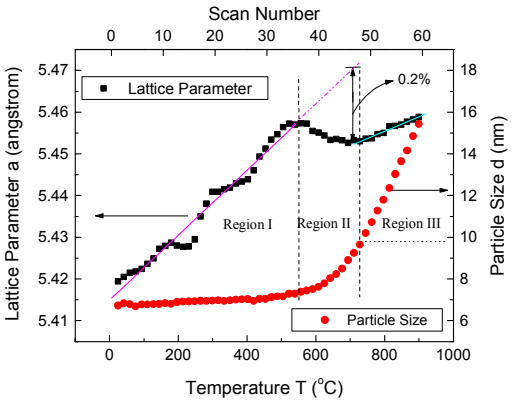

Fig. 1a Lattice parameter and particle size change of 6.7 nm ceria while sintered from room temperature to 900^{o}C.

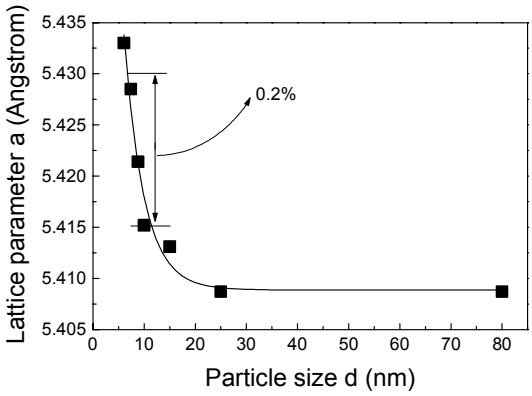

Fig. 1b Lattice parameter change of ceria with decreasing particle size, measured at room temperature (Ref. 1).

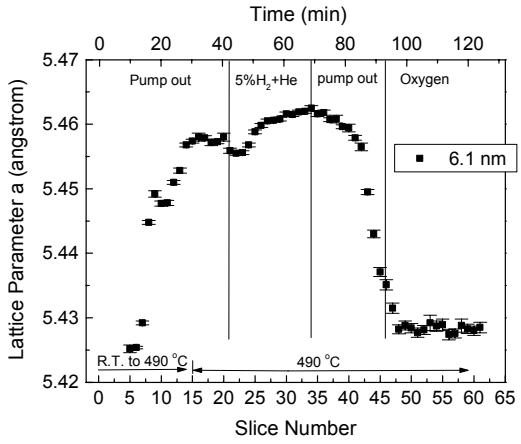

Fig. 2a 6.1 nm ceria treated with different gas environments in sequence at 490 ^{o}C

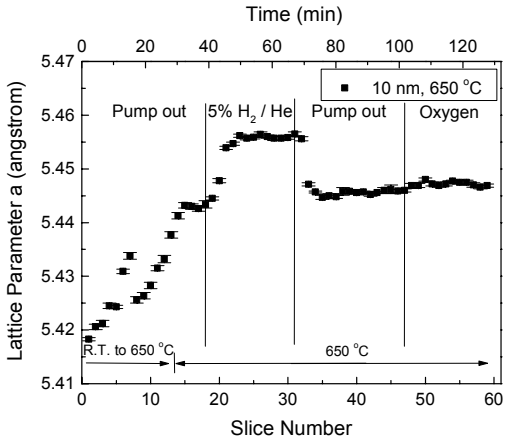

Fig. 2b, 9 nm ceria treated with different gas environments in sequence at 650 ^{o}C