Functionalization of Intergranular Regions inside Alkaline Earth Oxide Nanoparticle derived Ceramics

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There is an increasing awareness in the field of nanocrystalline ceramics that the controlled manipulation of matter with different impurity ions and at an atomic level affects composition, energetics and, thus, the functional properties of constituent grains and grain boundaries. Consequently, a fundamental understanding of impurity segregation and influence of surrounding atmospheres during processing is needed for efficient grain boundary engineering. [1, 2]

We used nanocrystalline powders of MgO with defined concentrations of impurities such as Ba^{2+}-ions as starting material for ceramic processing to study the impact of gas adsorption during nanoparticle processing. The transformation of Ba-functionalized particle surfaces into functional interfaces and grain boundaries was achieved by uniaxial dry pressing and sintering (1373 K).

Using complementary structure analysis techniques (X-ray Diffraction and Transmission Electron Microscopy) we addressed an apparent grain growth effect that occurs at room temperature. The phenomenon was rationalized by the size dependent dissolution properties of Ba-admixed MgO nanoparticles in the presence of water vapor. Electron microscopy measurements on ceramic samples revealed the annealing induced growth and reorganization of particles and grains and the simultaneous formation of a granular microstructure. Photoluminescence emission features that are specific to the surface excitonic properties of highly dispersed alkaline earth oxides were used as a diagnostic tool [3] and could have been retained during consolidation and sintering.

[1] N. Nafsin, R. H. Castro, J. Mater. Res. 2017, 1, 166–173.

[2] M. Niedermaier, C. Taniteerawong et al., ChemNanoMat 2019, 5, 634–641.

[3] A. Sternig, J. Bernardi et al., J. Mater. Sci. 2015, 24, 8153–8165.