EXPERIMENTAL INVESTIGATION AND THERMODYNAMIC MODELING OF THE ZrO2-TiO2-MgO SYSTEM

Saenko I.,* Ilatovskaia M., Fabrichnaya O.

TU-BAF, Freiberg, Germany

**Ivan.Saenko@iww.tu-freiberg.de*

Composite materials based on high-alloyed steels reinforced by zirconia ceramics are of particular interest due to the wide range of their possible technological applications especially in automotive production. An example of these composite materials is the high-alloyed austenitic stainless TRIP-steel (Transformation Induced Plasticity) reinforced by MgO-stabilized zirconia (Mg-PSZ). That composite material exhibits extraordinary high values of specific energy absorption in compression [1]. The Mg-PSZ shows a martensitic transformation of tetragonal to monoclinic phase during deformation resulting in additional strength increase [2]. Minor addition of TiO_2 improves mechanical properties of the composite due to increase of bonding between the zirconia particles and the TRIP steel [3]. Additionally, materials based on the ZrO_2-TiO_2-MgO system are of particular interest due to their dielectric properties [4]. Therefore, the aims of this work are experimental study of phase relations and thermodynamic database development for the ZrO_2-TiO_2-MgO system.

Preliminary phase diagram of the ZrO_2-TiO_2-MgO system was presented by Coughanour et al. [4] in 1955 and new experimental study was necessary. Samples were prepared using the co-precipitation method. Phase assemblages stable after long heat treatment were identified by X-ray powder diffraction. Temperatures of invariant reactions were determined by differential thermal analysis. Sample microstructures were investigated using scanning electron microscopy combined with dispersive X-ray spectrometry.

Based on the obtained experimental data, isothermal sections of the ZrO_2-TiO_2-MgO system at temperatures 1530, 1680 and 1880 K were established. Wide extension of stability of $Zr_{1-x}Mg_xO_{2-x}$ phase with fluorite structure into ternary system was found. Very limited solubility of MgO was found in beta $(Zr_xTi_{1-x})_2O_4$ and tetragonal $(Zr_{1-x}Ti_x)O_2$ phase, while more substantial solubility of ZrO_2 was found in the intermediate compounds of the TiO_2-MgO system (Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$). Low temperature ternary compound similar to δ-phase $Y_4Zr_3O_{12}$ was revealed at 1530 K. Differential thermal analysis indicated that this phase was stable up to 1664 K. Temperatures and compositions of three eutectic reactions were determined. Thermodynamic parameters of the ZrO_2-TiO_2-MgO system were optimized using CALPHAD approach based on

the obtained experimental results.

---

1. Biermann, H., et al., Adv.Eng.Mater., Vol.11 (2009):1000-1006
2. Martin, S., et al., Steel Research int., Vol.82 (2011):1133-1140
3. Weigelt C., et al., Ceram. Int., Vol.41 (2015):2328-2335
4. Coughanour L.W., et al., J. Res. Nat. Bur. Stand., Vol.54 (1955):191-199