

## Impact of titanium doping on Al self-diffusion in alumina

**P. Fielitz<sup>1\*</sup>, S. Ganschow<sup>2</sup>, K. Kelm<sup>3</sup>, G. Borchardt<sup>1</sup>**

<sup>1</sup>Technische Universität Clausthal, Institut für Metallurgie, Clausthal-Zellerfeld, Germany

<sup>2</sup>Leibniz-Institut für Kristallzüchtung, Berlin, Germany

<sup>3</sup>Deutsches Zentrum für Luft- und Raumfahrt, Institut für Werkstoff-Forschung, Köln, Germany

\*peter.fielitz@tu-clausthal.de

$\alpha$ -Al<sub>2</sub>O<sub>3</sub> is an important refractory material which has numerous technical applications: as an in situ growing self-healing oxide scale, as a massive material and as reinforcement fibres in composites. For modelling diffusion controlled processes (creep, sintering, alpha-alumina scale growth on aluminium bearing Fe or Ni base alloys) it is necessary to study self-diffusion of the constituent elements.

However, the aluminium diffusivity is difficult to measure [1, 2] because aluminium has no natural tracer isotope, and the only suitable radiotracer is <sup>26</sup>Al, which raises two difficulties. First, <sup>26</sup>Al is artificial and causes very high production costs, and second, it has a half-life time of  $7.4 \times 10^5$  years and consequently a very low specific activity, which makes it difficult to apply classical radiotracer methods. We applied Secondary Ion Mass Spectrometry (SIMS) to measure <sup>26</sup>Al depth profiles resulting from diffusion experiments [3]. This avoids the problems related to the radioactivity measurement, reduces the necessary amount of <sup>26</sup>Al per experiment considerably, and yields a much higher spatial resolution.

In this work, we studied the impact of titanium doping on Al self-diffusion in single crystalline alumina. Single  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> crystals intentionally doped with different amounts of Ti (about 300, 600, 900 and 1200 wt. ppm) were used in this study. It could be shown that Al self-diffusion increases with increasing titanium doping.

The single crystals were grown by the Czochralski technique with rf induction heating. Due to a very low segregation coefficient of Ti in Al<sub>2</sub>O<sub>3</sub>, the doping level of the melt was about 10 times higher than the desired concentration in the solid. Such high Ti amounts entail growth instabilities and therefore the crystal pulling rate was decreased preventively with increasing Ti concentration. The incorporation of Ti was analyzed using a micro-XRF spectrometer.

### References

- [1] A. E. Paladino, W. D. Kingery: *Aluminum ion diffusion in aluminum oxide*. J. Chem. Phys. **37**, 957–962 (1962).
- [2] M. Le Gall, B. Lesage, J. Bernardini: *Self-diffusion in  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> I. Aluminium diffusion in single crystals*. Phil. Mag. A **70**, 761–773 (1994).
- [3] P. Fielitz, G. Borchardt, M. Schmücker, H. Schneider: *Al-26 diffusion measurement in 2/1-mullite by means of Secondary Ion Mass Spectrometry*. Solid State Ionics **177**, 493–496 (2006).

