diffusion-fundamentals
The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application
www.diffusion-fundamentals.org, ISSN 1862-4138; © 2005-2010

Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) ^{18}O-Tracer Investigations on Interface Diffusion in Y_2O_3/YSZ Multilayer Systems

*S. O. Steinmüller, H. Aydin, A. Rein, C. Korte**

Justus-Liebig-Universität Gießen, Physikalisch-Chemisches Institut,
Heinrich-Buff-Ring 58, 35392 Gießen, Germany

E-Mail: carsten.korte@phys.chemie.uni-giessen.de

Presented at the Bunsen Colloquium: Spectroscopic Methods in Solid State Diffusion and Reactions September 24th – 25th, 2009, Leibniz University Hannover, Germany

Internal and external interfaces of solids show different transport properties than the bulk phase. Ion conduction and diffusion parallel to grain boundaries or phase interfaces is in most cases strongly enhanced. Transport processes are decelerated perpendicular to grain boundaries or phase interfaces. Due to the high amount of interfaces in micro- and nanoscaled materials that can be found in a lot of technical applications interface diffusion becomes an important factor to the overall device properties. Furthermore interface diffusion will have a great influence to the stability of a micro- or nanoscaled system.

Transport processes in and/or along interfaces of ion conducting materials are not well understood. Space charge regions [1,2] are a common explanation in the literature for the extraordinary behavior of systems with a high interface density. Structural influences like elastic strain [3,4] or grain boundary diffusion are often neglected. Space charge region models are limitedly applicable to extrinsic systems like solid electrolytes.

In addition to existing studies about grain boundary conduction along interfaces in multilayer systems of yttria stabilized zirconia (YSZ) as an oxygen ion conductor and yttria as an insulator, we have investigated the interface diffusion with ^{18}O tracer atoms. Fig. 1 illustrates the experiment.

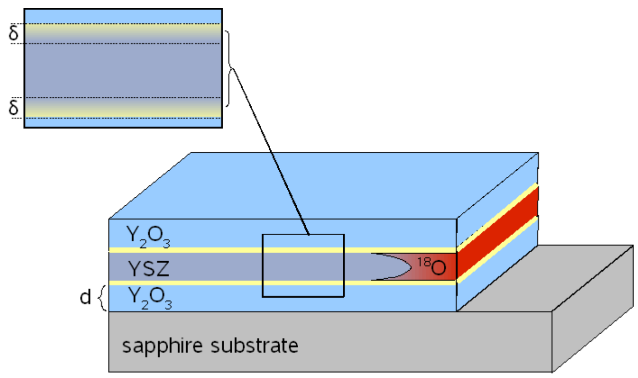

Fig 1 Schematic illustration of ^{18}O-tracer diffusion in a Y_2O_3/YSZ/Y_2O_3 layer system. The diffusion along the layer interfaces is faster than the bulk diffusion. The layer thickness *d* of YSZ and Y_2O_3 is the same. δ is assigned to the region between the layers of the ion conductor and insulator which corresponds to the interface.

Time of Flight-Secondary Ion Mass Spectroscopy can be used to obtain surface and three-dimensional information on samples [5,6]. Multilayer samples were prepared with Pulsed Laser Deposition (PLD) on sapphire substrates. To avoid oxygen diffusion perpendicular to the interfaces the samples were covered with a barrier layer after deposition.

We used gold, silica and platinum layers deposited by thermal evaporation, CVD and PLD. For the ^{18}O tracer experiment a slope cut was performed with an ion-beam. For the gold and silica covered samples ^{18}O is only penetrating the sample from the slope cut and along the interfaces towards the center of the sample.

The SIMS investigations were performed at the edge of the slope cut from the ion-beam. Fig. 2 shows a three-dimensional view of different planes of the investigated area. It was possible to determine diffusion coefficients from several measurements.

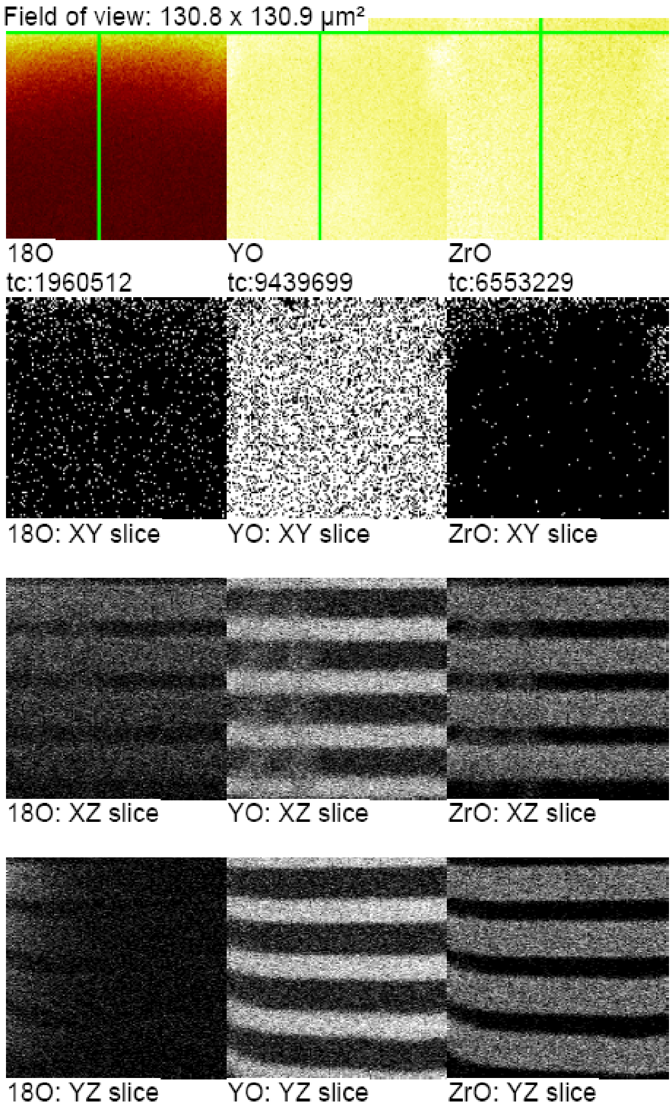

Fig. 2 Sample of a ToF-SIMS profile measurement of a multilayer system with a gold barrier layer. The signal intensities of ^{18}O, YO (Y_2O_3) and ZrO (YSZ) can be seen from a top view of the sample in the first line. Green lines show the position of the X and Y slices in the other lines. To show tightness of the barrier layer one XY slice inside an Y_2O_3 layer is also shown. The diffusion of ^{18}O parallel to the YSZ layers can be seen in the YZ slice.

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