REACTIVELY CO-SPUTTERED ALUMINA-STABILIZED ZIRCONIA – A BASE LAYER FOR EBPVD-TBC?

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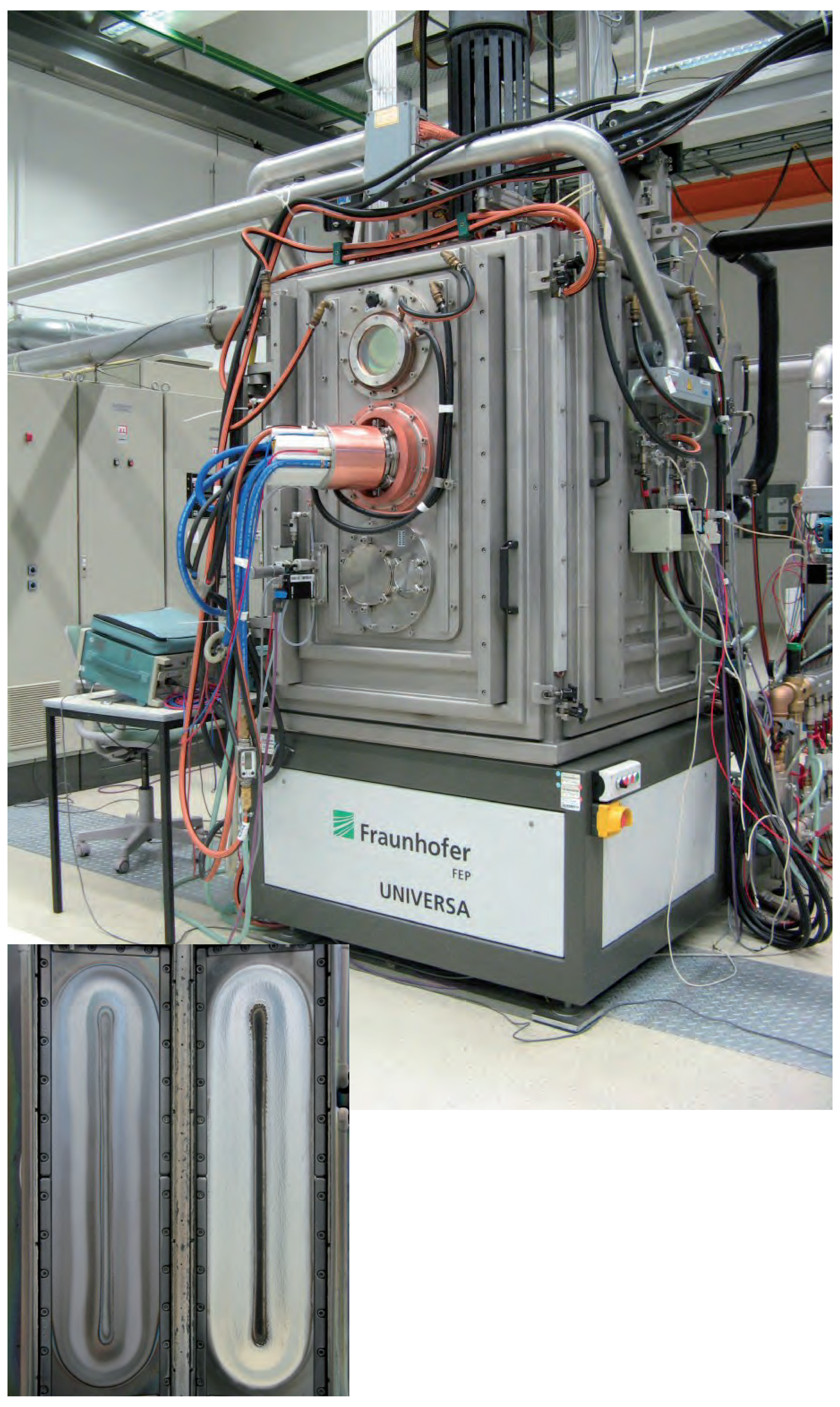
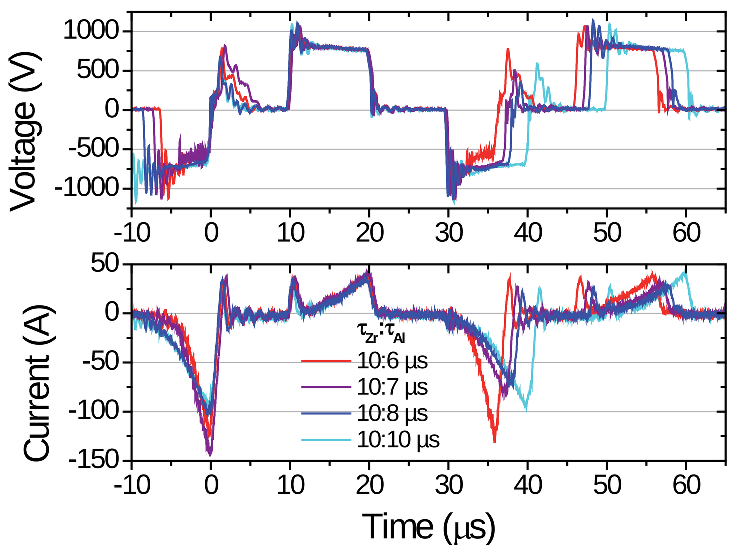
ABSTRACT

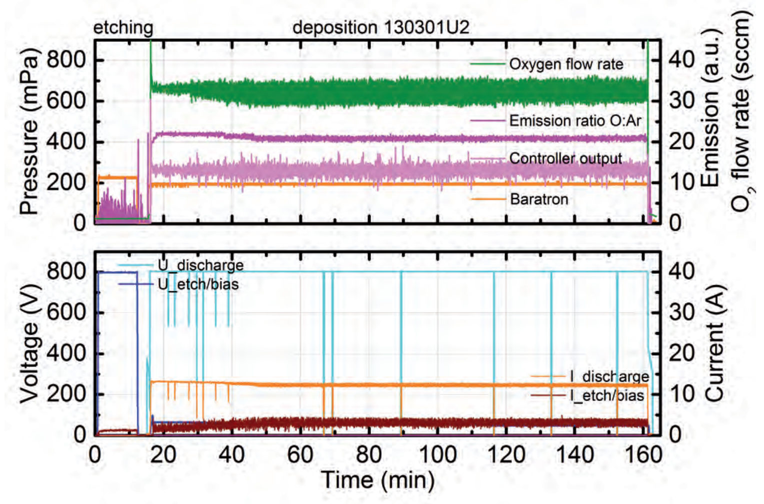
Reactive co-sputtering of elemental targets is a versatile technique to deposit ternary coatings of any composition. In the case of alumina-zirconia-coatings, tailored phase formation can be achieved by proper choice of deposition parameters and fine tuning of the composition through variation of pulse lengths. However, the high affinity of both metals to oxygen requires a rapid feedback control to stabilize the sputtering process in a transition state with non-poisoned target surfaces. In bipolar pulsed sputtering, the coupling of the targets through the common discharge allows establishing long-term stable deposition processes. The composition of the deposited films can be tuned by adjusting pulse lengths, and the entire range of mixed oxides is accessible. The formation of specific crystalline phases is observed for certain compositions which are especially promising for high temperature protective coatings. Alumina-stabilized tetragonal zirconia coatings could serve as a base layer for thicker EB-TBC coatings.

REACTIVE CO-SPUTTERING WITH VARIABLE PULSE LENGTH

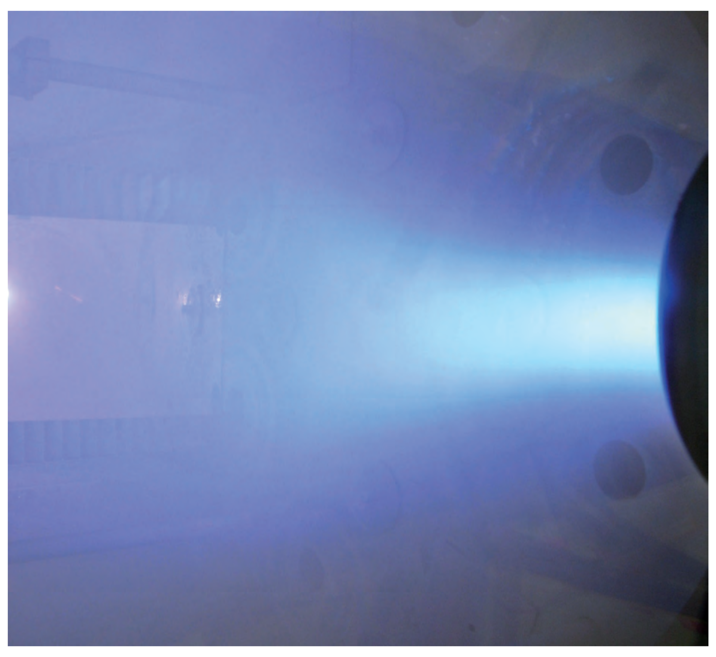


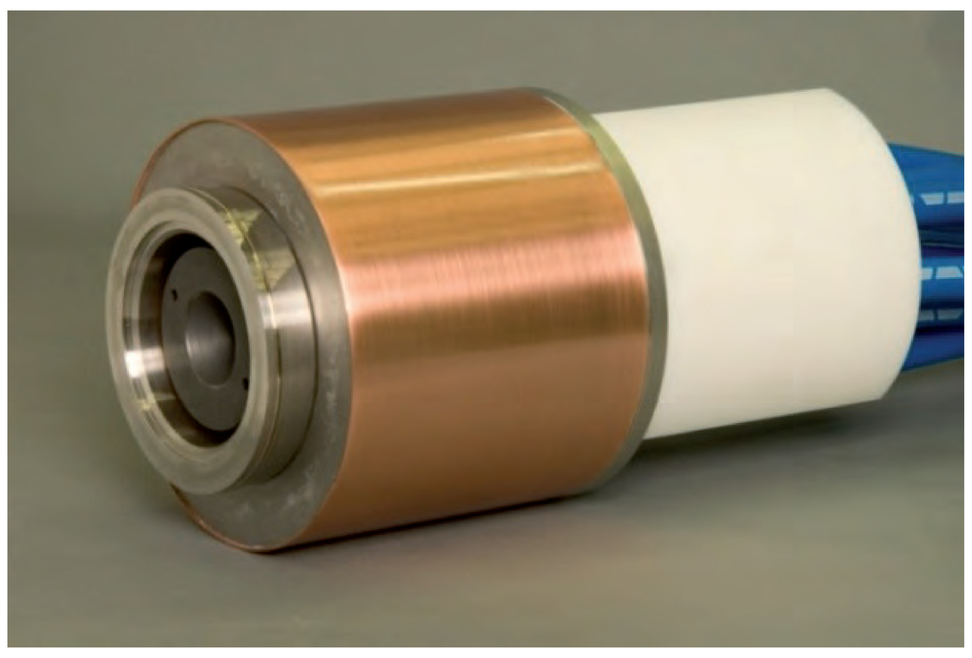
In a 1500 l batch coater equipped with four rectangular magnetrons (500 × 120 mm²), co-sputtering of metallic zirconium and aluminum targets in argon-oxygen gas atmosphere is realised, using a rapid feedback control that allows establishing long-term stable processes.



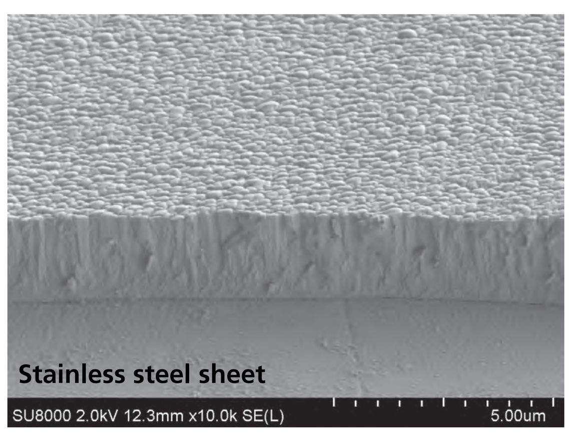


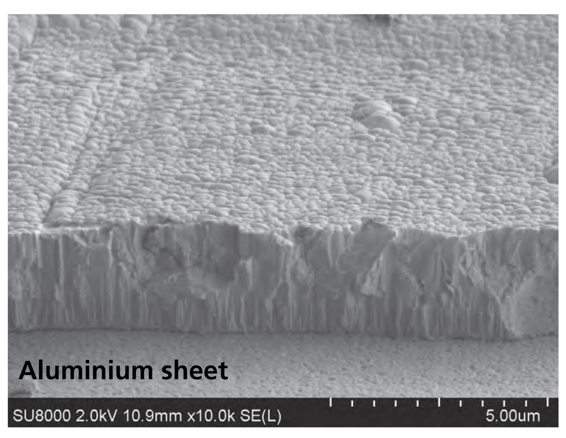
ARGON PLASMA ETCHING USING THE PLASMA SOURCE LAVOPLAS

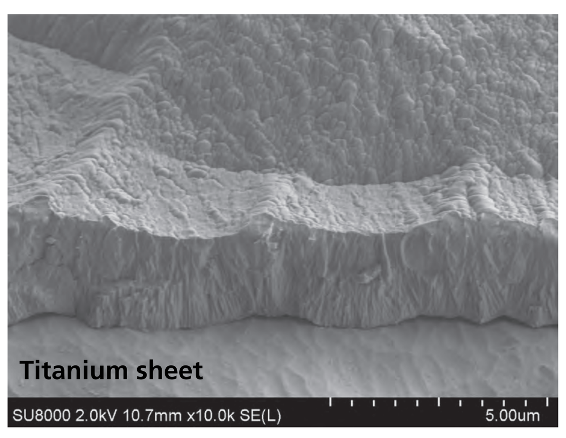




A magnetically enhanced hollow cathode plasma source is used for plasma etching of the substrates. With this flange-mounted device a plasma of density $n_e \approx 10^{12}\,cm^{-3}$ can be generated in a large volume which is useful for various plasma-assisted processes. E.g., etch rates of 20-30 nm/min are achieved on moving substrates. The efficient etching provides a good substrate-coating interface. ASZ coatings deposited at 450°C adhere well on various substrate materials, despite the differences in coefficients of thermal expansion (see below).

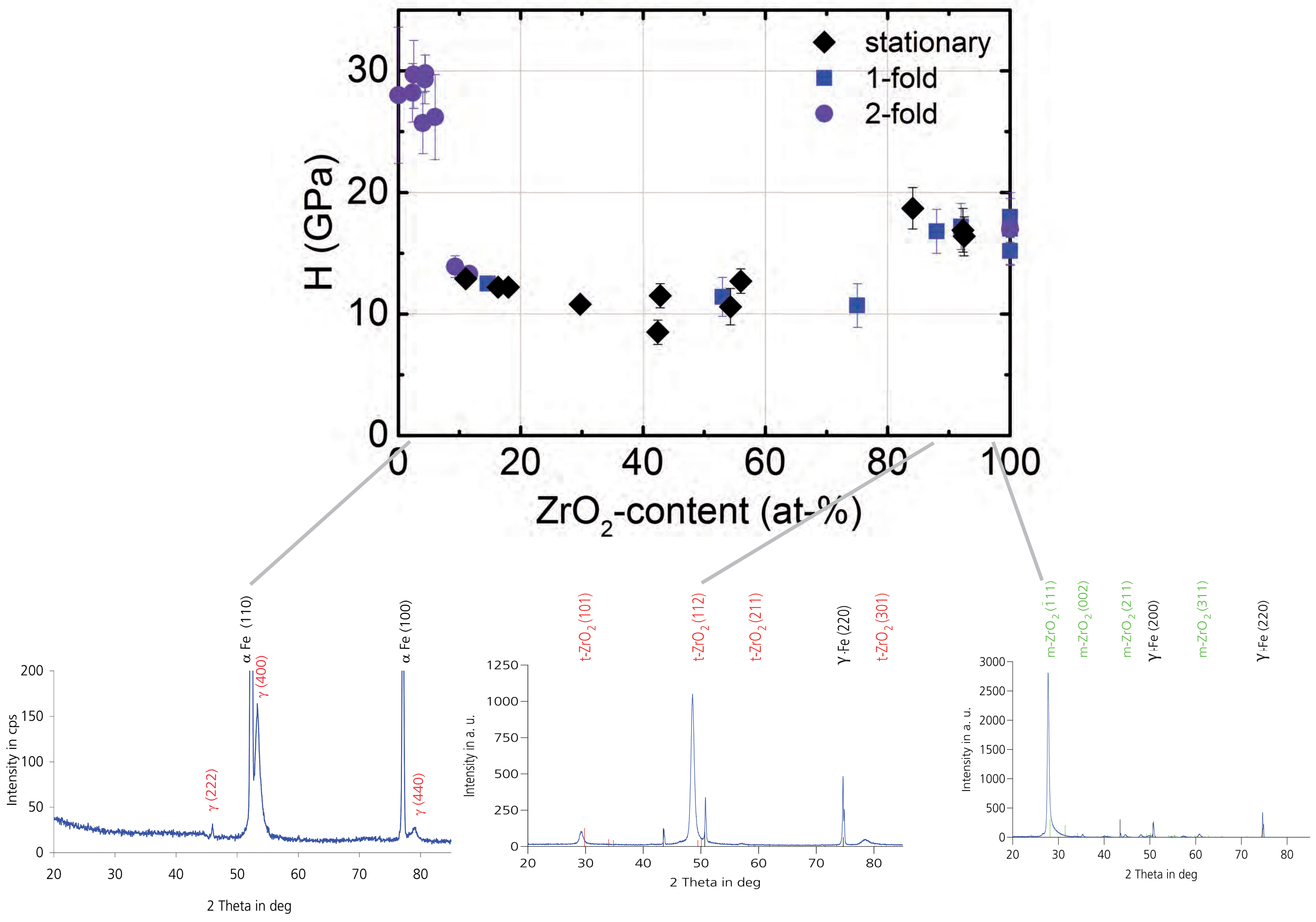




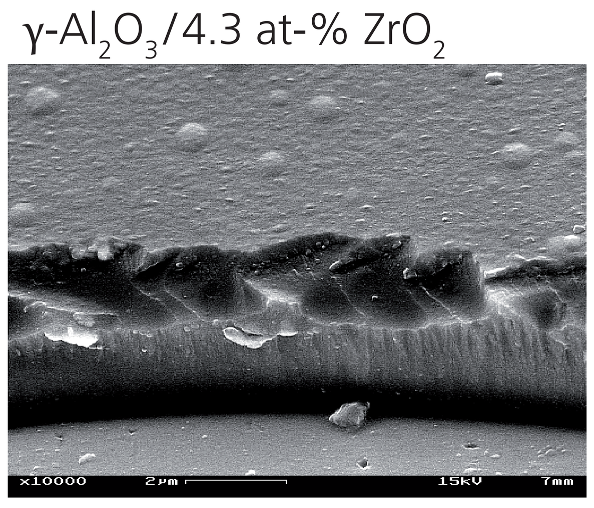


PHASE FORMATION IN Al-Zr-O SPUTTERED LAYERS

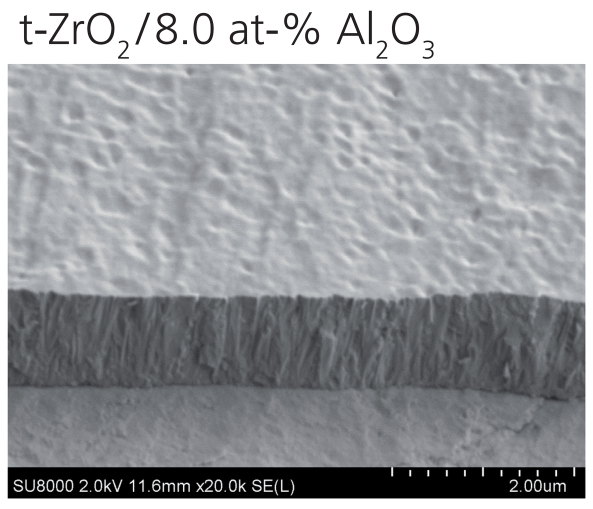
Various crystalline phases can be synthesized when either alumina or zirconia is dominant in the coatings. In a broad range of intermediate compositions the coatings are amorphous. While the alumina rich coatings are γ-crystalline, monoclinic and tetragonal phases are observed in the zirconia-rich case. At alumina contents of around 8 at-% the layers exhibit highly oriented tetragonal cristallinity.



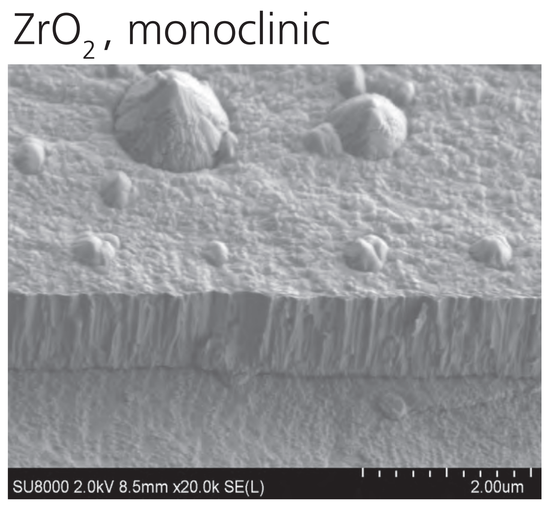
γ-Al_2O_3/4.3 at-% ZrO_2



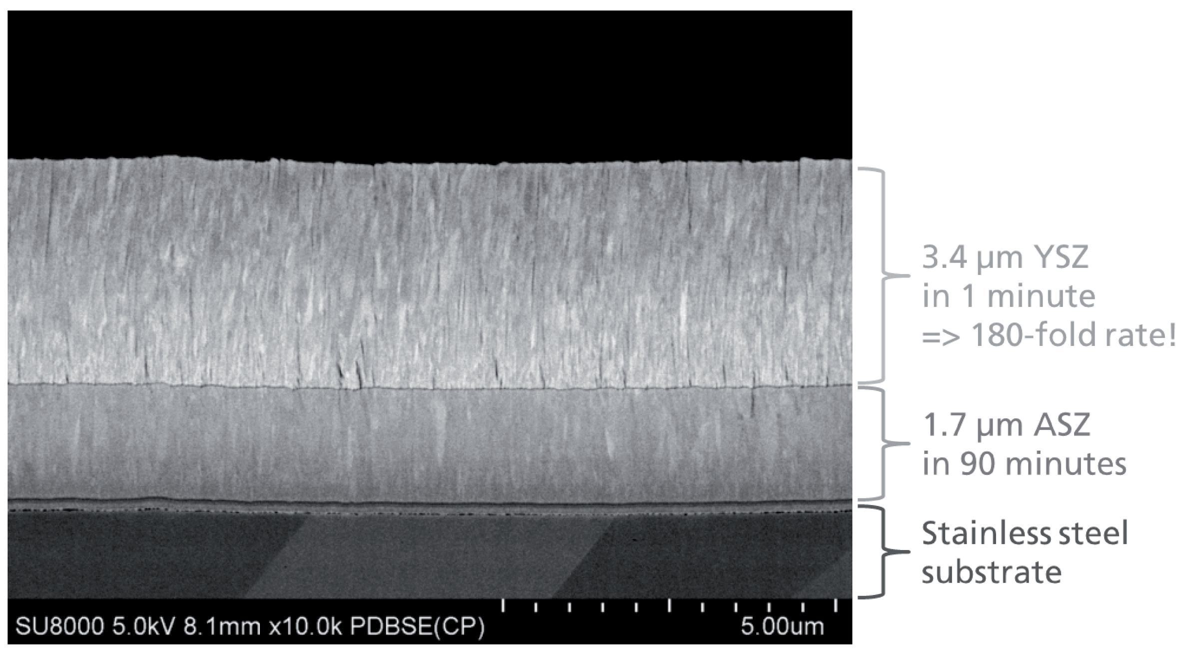
t-ZrO_2/8.0 at-% Al_2O_3



ZrO_2, monoclinic



Cross section of a sputtered zirconia base layer and an EB-PVD top layer



So far, the coatings are deposited in different devices. In future, a direct process sequence in one coating device is envisaged. This will open up more possibilities to work on the interface and on the phase matching of the thin dense underlayer and a much thicker top coating.

CONCLUSIONS AND OUTLOOK

Alumina-stabilized tetragonal zirconia layers have been synthesized by means of reactive co-sputtering of aluminum and zirconium targets. Dense and adherent coatings have been deposited on various different substrate materials. Good adhesion is provided by efficient plasma etching using the plasma source LAVOPLAS.

In a certain compositional range, alumina-stabilized tetragonal zirconia can be synthesized that exhibits good crystallinity. The coating has been used as a base layer for reactively deposited electron beam evaporated YSZ-coatings. In the future, a direct process sequence in one coating device shall allow tuning of the interface as well as matching the composition and the phase of the coatings.

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