SUBSTRATE CRYSTALS FOR ADVANCED FUNCTIONAL OXIDES

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At the IKZ, we develop new substrate crystals for the preparation of oxide thin films with high structural quality in close collaboration with various partners from academia and industry. In this presentation, we will provide details on recent substrate crystals grown by IKZ that aid the development of heteroepitaxial advanced functional oxide layers. Some of them are also intended to be used in non-linear optical or scintillator applications.

One renowned class of materials established by IKZ are the rare-earth scandates $REScO_3$. The pseudocubic lattice parameters with RE = Dy to Pr range between 3.95 and 4.02 Å and vary in about 0.01 Å steps as the RE series is traversed. A fine-tuning of the pseudo-cubic lattice parameter between nearly all endmembers is also possible by the growth of solid solutions [1]. $REScO_3$ crystals enabled research on artificially strained oxide films that show interesting ferroelectric, superconducting, ferromagnetic, piezoelectric, multiferroic, or electron transport properties.

Recently, perovskite substrates with higher lattice constants up to 4.16 Å are demanded e.g. for thin films of $BiFeO_3$, $EuTiO_3$, $BaSnO_3$ or PZT. We have extended our accessible lattice parameter range with $(La,Nd)(Lu,Sc)O_3$ (see Fig 1c) and $La(Lu,Sc)O_3$ mixed crystals that can be prepared by the Czochralski method in iridium crucibles, albeit at temperatures well above 2100°C. A particular IKZ-Cornell development to provide lattice-matched substrates for $BaSnO_3$ (4.116 Å) was the double perovskite Ba_2ScNbO_6, grown from the melt (Fig. 1e-f) by a novel crystal growth technique [2].

Other perovskite substrate crystals such as $SrHfO_3$ and $SrZrO_3$ (around 4.10 Å) require temperatures above 2300°C for melting and thus are prepared by crucible-free methods which utilize Xenon lamp optical floating zone furnaces [3]. Doped with rare earth ions these compounds are also attractive for optical and scintillator applications, but the growth method leads to a limited achievable diameter and to increased internal stress in the crystals.

Thin films of pyrochlore structure are a matter of research because they show frustrated magnetic and spin effects. Also here, substrates with tailored lattice parameters are required to prepare films of high structural quality. Some of the pyrochlores grown at IKZ are also interesting for use as optical scintillators or optical isolators. For example, a very strong focus is currently on the crystal growth development of $Tb_2Ti_2O_7$ [4], since reasonably long bulk crystals can be only prepared by employing the edge-defined film-fed growth (EFG) technique. This activity is embedded in a BMBF funded ZIM project in collaboration with our partners at Electro-Optics Technology GmbH. Finally, we also briefly show results on Nb_2O_5 and Sr_2GaNbO_6 (SGN) substrate crystals grown by a conventional (i.e., halogen lamp) optical floating zone method.

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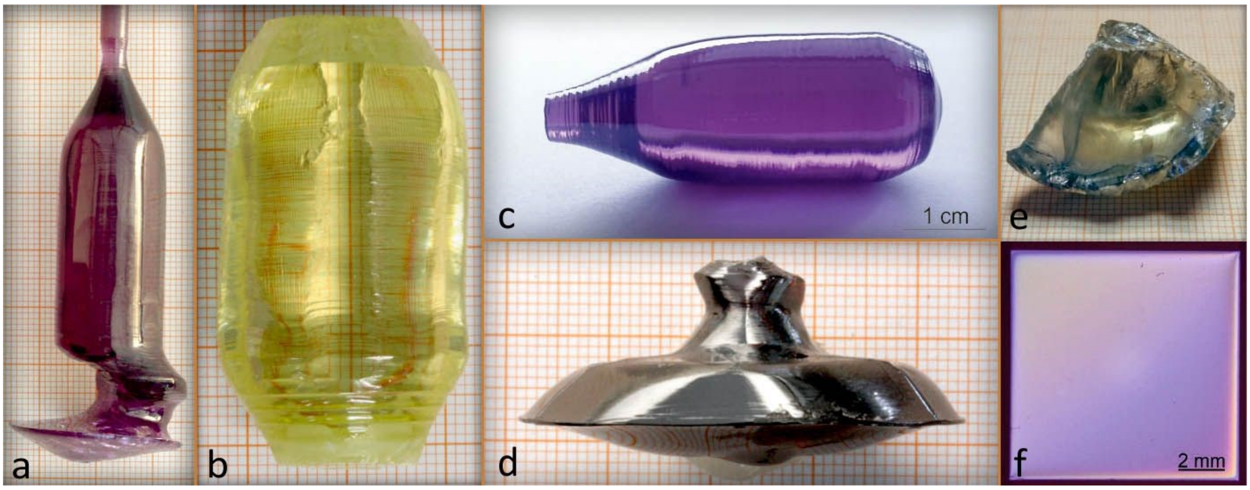

Fig. 1 Selection of some substrate crystals grown at IKZ: (a) $(Nd,Sr)(Al,Ta)O_3$, (b) $(Mg,Zr):SrGa_{12}O_{19}$, (c) $(Nd,La)(Lu,Sc)O_3$, (d) $Tb_2Ti_2O_7$ and (e-f) Ba_2ScNbO_6.