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Recent progress in perovskite crystal growth at the IKZ

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Summary

Growth of high-quality perovskite substrate crystals is a prerequisite for epitaxial applications to create unique physical properties of strained and unstrained thin films, which is currently a hot topic in materials physics. Thus, perovskite substrates with tailored lattice constant are required to address approaches to novel high temperature superconducting, thermoelectric, piezoelectric and multiferroic applications, including sensors, transducers, capacitors, transistors, memory devices and data storage.

The work at IKZ is based on our long-standing experience in the bulk growth of rare earth (RE) scandates, grown from the melt at temperatures above 2100°C using iridium crucibles [1]. These compounds have pseudocubic lattice parameters in the range of 3.93 Å ($DyScO_3$) to 4.02 Å ($PrScO_3$) as shown in Fig. 1. As the RE ions are mutually interchangeable and the corresponding scandates form nearly ideal solid solutions with negligible segregation, virtually any lattice constant in the above range can be prepared, just controlled by the mixture of the RE ions. While (Sm,Gd)ScO_3 and (Nd,Sm)GdO_3 crystals were demonstrated already some years ago [2], the solid solutions (Tb,Dy)ScO_3 and (Gd,Tb)ScO_3 were recently added to the portfolio.

In order to prepare perovskites with larger lattice parameter, novel solid solutions in the system $LaLuO_3$–$LaScO_3$ have been exploited, enabling substrates with pseudocubic lattice constants in the range of 4.09–4.18 Å [3].

Finally, we have investigated the growth of $SrTiO_3$ single crystals with low defect density from the melt, as crystals grown by the Verneuil (flame fusion) method are commercially available but for some applications insufficient in crystalline quality. Czochralski growth from the melt at around 2080°C is not useful due to excessive self-absorption of radiated heat [4]. On the other hand, a combination of top seeded solution growth (TSSG) using TiO2-rich melts below 1540°C for obtaining seeds, and edge-defined film-fed growth (EFG) from the stoichiometric melt using an iridium shaper led to growth of $SrTiO_3$ single crystals with 15 mm in diameter and up to 50 mm in length, with virtually no mosaicity and dislocation densities in the 10^5 cm^{-2} range [5–7]. More details are presented in the references.

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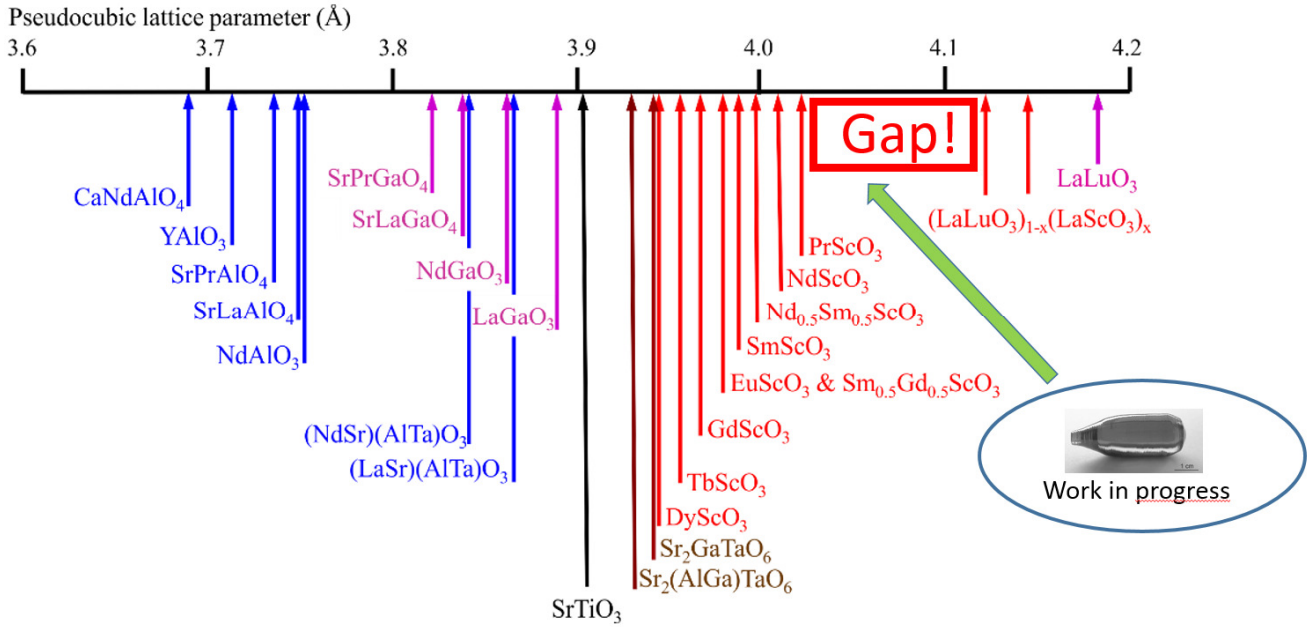

Fig. 1: Well-established perovskite substrate crystals grown at IKZ.