Characterization and Manufacturing of Pellets for Combinatorial Pulsed Laser Deposition (Champion)

Supervisors

Supervisors: Prof. Dr. Holger von Wenckstern, Dr. Kevin Gregor Both, Magnus Andreassen, Andreas Rosnes

Background of Candidate

The candidate preferentially has an interest in materials properties, with some laboratory experience. A curiosity for the structural properties of materials is advantageous. Experiences with 3D printing, XRD, SEM, solid state synthesis, and sol-gel synthesis are desirable.

Number of Projects and Project Period

One project; 6 weeks; starting 26.06.2023, ending 04.08.2023

Project Description

Pulsed laser deposition has been used to deposit thin films as part of research of functional layers and renewable energy devices [1]. Not only showed these materials promising improvements of efficiency, but also a shift from scarce materials to more abundant elements can be seen. However, traditional single compound targets in a traditional pulsed laser deposition instrument suffer from limited throughput and require an individual target for each variation of thin film composition. In contrast, combinatorial pulsed laser deposition allows the study of a wide compositional space within a single thin film [2] with much higher chemical resolution but strongly reduced consumption of source material.

With the introduction of the combinatorial pulsed laser deposition instrument at MiNaLab, the demand for segmented targets has increased significantly. Targets with two, three, and four differently composed segments are considered, and the first of these have been synthesized in our labs already (see fig. 1 and fig.2). However, a systematic study of the synthesis route and subsequent characterization has not been conducted.

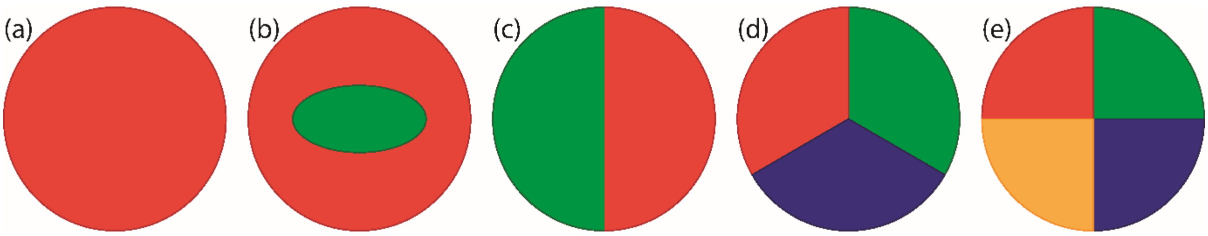

Figure 1: Different target geometries are shown, where (a) is a standard target, (b) and (c) dual targets, (d) a trifold target and (e) a fourfold target.

The segmented targets are essential for the combinatorial pulsed laser deposition process. The stoichiometry of the target determines the stoichiometry of the thin film, and with that its chemical and physical properties. Pulsed laser deposition is utilized in a plethora of projects, all related to renewable energy, and novel functional materials within this area of research. Whether the thin films are used in photocatalytic devices, photovoltaic devices, or utilized as catalyst, the combinatorial approach significantly increases the efficiency of studying a wide compositional space.

The project aims to standardize the synthesis route of segmented targets and to catalogue best approaches and recipes. In addition, the spatial characterization, especially of the interfacial region between two segments, will contribute to every study using the combinatorial approach. An example of a region of interest is seen in fig. 2, where the darker region (in the $SrTiO_3$ highlighted by arrows) at the interface indicates a chemical and/or structural difference. The project is separated in three different parts, described below.

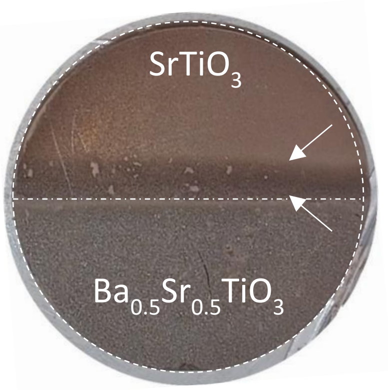

Figure 2: $SrTiO_3$ (top) and $Ba_{0.5}Sr_{0.5}TiO_3$ (bottom) combined to a twofold azimuthally segmented target. Arrows indicate region to be investigated.

Part I

The **synthesis** of segmented pellets will be tackled, where the student will create pellets consisting of two, three, and four segments. Special attention will be given to the plastic pre-molds, determining the shape of segments, the pressing of the compound pellet, and the sintering conditions. The pressing procedure and sintering conditions will determine the strain and stress within the final pellet. The latter also contributes to the diffusion of constituents. The sol-gel method will be used if the desired compound is not available as powder.

Part II

The **characterization** of the pellets is an essential step within this work. Not only will it teach the student how to use the SEM and XRD, but it will result in determining if the materials diffuse into each other during sintering, creating a mixed interface. The student will not only study the surface, but also cut the pellets to study the interface throughout the pellet. This will result in a three-dimensional study of the interfacial region between individual segments of the pellets, determining the sharpness of the interface throughout the pellet.

Part III

The final part is the creation of a small **project report** and a **standard operating procedure** to make segmented targets. The report will entail the details of the synthesis and the characterization, while the standard operating procedure will be a generalized version of the procedure of best practices. The report not only serves as base for the presentation, but also as start of a database with specific procedures for materials combinations.

[1] Both, Kevin G., et al. "Ni-doped A-site excess SrTiO3 thin films modified with Au nanoparticles by a thermodynamically-driven restructuring for plasmonic activity." *Catalysis Today* (2022).

[2] von Wenckstern, Holger, et al. "A Review of the Segmented-Target Approach to Combinatorial Material Synthesis by Pulsed-Laser Deposition." *physica status solidi (b)* 257.7 (2020): 1900626.