Effect of growth conditions on lattice defects in strontium titanate ($SrTiO_3$)

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Perovskites are a group of semiconducting oxides with appealing properties. For example, perovskite solar cells are currently the fastest advancing photovoltaic technology [1]. The subject of this study, strontium titanate $SrTiO_3$, is the simplest representative of the perosvkite material family and can be considered as a model system for perosvkites. $SrTiO_3$ has gathered research interest due to its electrical properties [2]. The electrical and optical properties of perovskites are limited by the presence of lattice defects, and the dominant defects have not yet been identified. Growth conditions have already been reported to affect the optical properties and the dislocation density of $SrTiO_3$ [3]. In order to study the effect of growth conditions on the lattice defects of $SrTiO_3$, a set of differently grown $SrTiO_3$ samples were studied with positron annihilation spectroscopy. The samples were manufactured using edge-defined film-fed growth and Czochralski methods [3].

Positron annihilation spectroscopy is a non-destructive method which allows identification of vacancy-type defects [4], which are assumed to be the dominant point defects in perovskites. Positrons can be trapped in lattice vacancies. Positrons trapped in a vacancy have a lifetime specific for the type and the size of the vacancy, due to reduced electron density in the vacancy. Measuring positron lifetime yields information of the vacancy concentrations in the sample. The charge states of vacancies either enhance or reduce the trapping of positrons via the Coulomb interaction. The charge states can be identified with temperature- and illumination-resolved positron measurements, where the latter gives resolution for optically active defects.

Growth conditions were seen to affect the defect concentrations in $SrTiO_3$. Positron results suggest a relationship between oxygen concentration during growth process and oxygen vacancy concentration. The increased oxygen concentration reduces the concentration of oxygen vacancies in $SrTiO_3$. The results also suggest presence of Ti and Sr vacancies.

[1] National Renewable Energy Laboratory Best Research-cell Efficiencies, 2016
[2] J. Haeni, *et al.* Nature, 430, (2004), 7001
[3] C. Guguschev, Z. Galazka, D. Kok ,U. Juda, A. Kwasniewski and R. Uecker CrystEngComm 17 (2015) 25
[4] F. Tuomisto and I. Makkonen Reviews of Modern Physics 85 (2013) 4