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Oxygen deficiency in High-Tc YBCO thin films identified by positron annihilation spectroscopy

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The availability of high-quality superconducting materials with high critical temperature Tc is of major interest in all kinds of applications for resistivity-less electron transport. In high-Tc $YBa_2Cu_3O_{7-\delta}$ (YBCO) oxygen deficiency, i.e. an increase of δ, leads to a higher Tc or even to a loss of superconductivity. Both the deeper understanding of the Tc(δ) dependence and the precise adjustment of Tc require information about the oxygen vacancies on a microscopic level.

In our study we investigated single crystalline YBCO thin films in order to probe the oxygen deficiency δ using the mono-energetic positron beam at the high-intensity positron source NEPOMUC at FRM II [1]. The samples were produced by pulsed laser deposition which enables epitaxial growth of YBCO in single crystalline quality with well-defined stoichiometry on $SrTiO_3$ substrates. By combining transport measurements, X-ray diffraction and (coincident) Doppler broadening spectroscopy ((C)DBS) of the positron-electron annihilation line we succeeded in correlating the relevant parameters Tc, expansion of the c-axis, δ, and S-parameter of the DBS-measurements. Hence the variation of δ could be measured in a non-destructive by DBS for a set of differently produced YBCO thin film samples. Moreover, scanning with the positron beam allowed us to analyze the spatial variation of δ and hence the critical temperature Tc between 25 and 90 K.

Within this contribution the basic properties of positron annihilation studies will be briefly explained. The benefit of positron beam experiments for the development and improvement of functional materials for energy applications will be elucidated by selected studies.

Reference:

[1] M. Reiner, T. Gigl, R. Jany, G. Hammerl, and C. Hugenschmidt; Appl. Phys. Lett. 106 (2015) 111910

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