Determination of the Vacancy Formation Enthalpy Revisited by Temperature Dependent Doppler-Broadening Spectroscopy

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The coincident Doppler broadening spectrometer (CDBS) at the positron beam facility NEPOMUC of the research neutron source FRM II enables both spatially resolved defect studies and temperature dependent measurements by using Doppler broadening spectroscopy (DBS) of the positron-electron annihilation line. In order to investigate the near-surface region and the bulk of a sample, the positron implantation energy can be varied between 0.1 and 30 keV. The lateral resolution could be improved to below 50µm by using an additional transmission positron remoderator inside the spectrometer [1]. Compared to conventional positron annihilation spectroscopy with ^{22}Na sources a further advantage of DBS using a positron beam is that no correction of the so-called source component is needed. With a heatable sample holder temperature dependent in-situ defect spectroscopy can be performed from room temperature up to 1000 K.

Since several decades, positron annihilation spectroscopy is known as powerful tool for the determination of vacancy formation enthalpy due to the unique sensitivity of positrons to open volume defects. Within this study the vacancy formation enthalpy of La (and Cu as reference material) was determined for the first time by temperature dependent DBS. Due to the high reactivity of the La surface all preparation was made under protective gas atmosphere. First, the as-received samples were annealed in situ, i.e. the decrease of the S-parameter indicated the annealing of lattice defects. During a second heating cycle the increase of the vacancy concentration was clearly observed from which the vacancy formation enthalpy could be calculated. In addition, a significant temperature dependence of the vacancy formation enthalpy in La was observed.

References

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