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Search for vacancies in concentrated solid-solution alloys

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Concentrated solid solution alloys (CSA) with no principle alloying element but a single randomly populated crystal structure exhibit attractive material properties, e.g., high ductility at low temperatures or high irradiation resistance. To understand such phenomena in these alloys, often also named high-entropy alloys, assessment of atomic transport including formation and migration of vacancies is indispensable. Here results of positron annihilation lifetime spectroscopy (PALS) are reported to quantify the concentration of quenched-in thermal vacancies for CSAs with fcc structure after quenching from temperatures close to their onset of melting. This vacancy concentration decreases with increasing number of components. For alloys with 3 constituents in non-equimolar fractions (CrFeNi) vacancy concentrations in the 10^{-5} range were determined. However, for alloys with 4 (CoCrFeNi) and 5 constituents (CoCrFeMnNi, AlCoCrFeNi) a vacancy-specific positron lifetime was not detected. Thus, the concentration of quenched-in vacancies must be 10^{-6} or less. This indicates either a vanishingly small fraction of vacancies present at very high temperatures or generated vacancies are inherently unstable. For an unambiguous proof, in-situ positron studies during heating and cooling between room temperature and high temperatures are necessary. Such experiments are planned using a positron beam in the longstanding collaboration with Chr. Hugenschmidt (NEPOMUC beamline at FRM II).

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