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Precipitates in metals that dissolve on cooling and form on heating: an example with hydrogen in alpha-zirconium

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Abstract

Einstein's theory for Brownian motion and Gibbs' Phase Rule along with diffraction of high intensity X-rays have been used to provide an interpretation of precipitation and dissolution in metals using hydrides in alpha-zirconium as an example. Hydrides precipitated, and dissolved during cooling, and at some temperatures, their amounts increased with heating. Hydrides were seen to precipitate without exothermic signals both above and below the solvus temperature, and on heating, were found to be stable above the solvus temperature. Hydrides were inferred to form composites with the delta phase surrounded by gamma phase. These results are interpreted with Cottrell atmospheres of hydrogen atoms that relieve the stress around dislocations, and hydrogen clouds from stresses around hydrides making them stable against dissolution leading to maxima in the amounts of hydrides with change in temperature. A vertical line corresponding to ZrH is suggested to be added to the equilibrium phase diagram to comply with the Phase Rule.

Keywords: precipitation; dissolution; diffraction; hydrides; zirconium; Cottrell atmospheres, hydrogen clouds, elastic stress concentration factor