Modelling of up-hill hydrogen diffusion in a duplex steel. Application to the "Kelvin Probe" experiment.

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The diffusion equation postulated by Fick in 1855 assumes that the diffusing particles (here hydrogen atoms) macroscopically move in the direction opposite to the concentration gradient. This equation predicts that the concentration should be homogeneous in any equilibrated system. However it fails to describe "up-hill" diffusion observed in certain situations in multiphase materials. For example in a duplex steel hydrogen tends to concentrate in the austenite phase because of its low solubility in ferrite. This situation can be correctly addressed considering that diffusion is driven by the chemical potential gradient not by the concentration gradient. In this study hydrogen diffusion in a duplex steel is modelled using a generalised Fick equation that allows the prediction of up-hill diffusion from the low solubility phase to the high solubility phase. The model is applied to the "Kelvin Probe" experiment (SKPFM: Scanning Kelvin Probe Force Microscopy) in which the diffusion of hydrogen is monitored over time in a cathodically charged duplex specimen covered with a "screen" of palladium. The model is used here as a tool to interpret the results obtained from the Kelvin Probe experiment developed in our research group.