Fall 10-7-2015

Effect of hydrogen on the nucleation and motion of dislocations

Mohammad Zamanzade
Saarland University, m.zamanzade@matsci.uni-sb.de

Jorge Velayarce
Saarland University

Christian Motz
Saarland University

Oscar Torrents Abad
INM

Afrooz Barnoush
Norwegian University of Science and Technology

EFFECT OF HYDROGEN ON THE NUCLEATION AND MOTION OF DISLOCATIONS

Mohammad Zamanzade, Saarland University, Institute of Material Science and Methods, Germany
m.zamanzade@matsci.uni-sb.de
Jorge Rafael Velayarce, Saarland University, Institute of Material Science and Methods, Germany
Oscar Torrents Abad, INM - Leibniz Institute for New Materials and Saarland University, Germany
Afrooz Barnoush, Norwegian University of Science and Technology, Trondheim, Norway
Christian Motz, Saarland University, Institute of Material Science and Methods, Germany

Key Words: Hydrogen, Nanoindentation, Compression, Bending, Intermetallic

Conventional mechanical tests are costly, time consuming, and due to their large scale, not very successful in obtaining mechanistic information. In contrast, the local method like nanoindentation, compression or bending test of micro pillars have comprehensive ranges of possibilities to achieve an essential understanding about the influence of substitutional atoms and/or interstitial atoms (e.g., hydrogen and nitrogen) on the mechanical properties like Young´s modulus, Gibbs free energy for homogeneous dislocation nucleation, dislocation line energy and also friction stress. These methods allow us to measure the mechanical behavior in simulated environments and atmospheres close to the routine industrial applications.
Nanoindentation was applied for studying the sensitivity of various materials like nickel, Cu, steels and iron aluminides to hydrogen embrittlement, as it offers sufficiently high resolution in determining load and displacement and works effectively non-destructive. Nevertheless, the method of in-situ nanoindentation suffers from the complexity of the stress field below the nanoindenter. Furthermore, a novel method was developed where miniaturized compression samples are machined using focused ion beam (FIB) milling and loaded in a nanoindenter system equipped with a flat diamond punch. This method is able to probe mechanical properties on the micrometer and sub-micrometer scale under nominally uniaxial loading. Additionally, very small volume of pillar guarantees a fast and homogeneous distribution of hydrogen. More recently the influence of hydrogen on the elastic properties and interaction of dislocations was studied using the in-situ bending test of micro pillars (see Figure 1). The advantage of the bending test is the presence of high tensile stress in the pillar during the test. It is in contrast to other techniques like in-situ nanoindentation or micropillar compression tests with the compressive stress field which works as driving force for the hydrogen diffusion out of the highly stressed region.

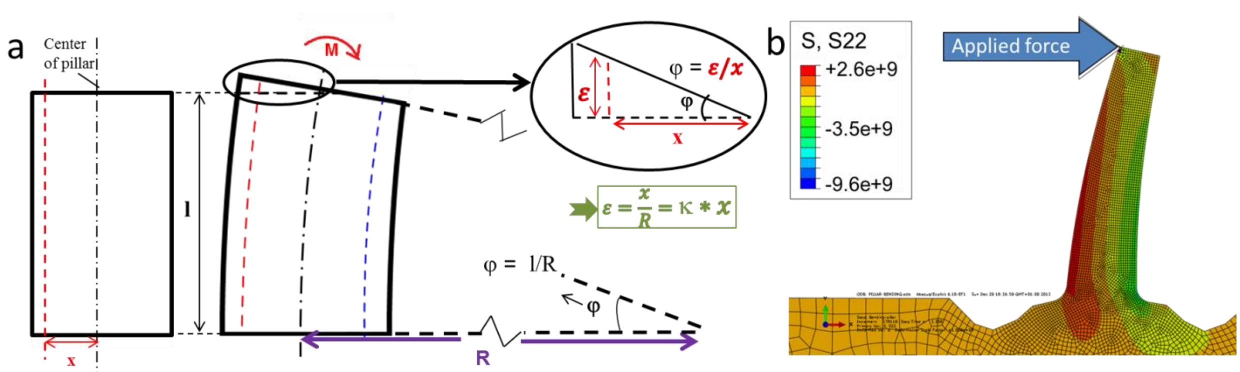

Figure 1- a) Geometric set up of a bended pillar. b) Stress distribution for the vertical stresses (S22) along the micro pillar based on Abaqus simulations.