Evaluation of hydrogen effect on austenitic stainless steels

Arnaud Macadré

Dept. of Mechanical Engineering

Yamaguchi University

Ube, Japan

Hydrogen, while a very promising energy vector, causes drastic reductions (called hydrogen embrittlement, HE) in the mechanical properties of metals, particularly steels. Austenitic stainless steels, due partly to their face-centered cubic structure, can have a relatively higher tolerance to HE, but are still not immune. Concerning austenitic steels, two points will be addressed: ① the mechanical stability of the austenite (*i.e.* the ability to not transform into another phase, martensite, under load), which is usually deemed important for applications in hydrogen environment, as phase transformation creates new interfaces susceptible to fracture; ② the quantitative evaluation of hydrogen-assisted deformation.

① High mechanical stability requires alloying with expensive elements, which in turns delays and hinders the deployment of the material and components. To prevent phase transformation in a metastable austenitic stainless steel, we added nitrogen to a metastable steel (SUS304), and evaluated its performance with tensile tests, after exposure to various hydrogen gas pressures. The addition of nitrogen almost completely prevented phase transformation, and increased the resistance to hydrogen.

② Hydrogen enhances deformation, and makes it easier for dislocations to move and multiply. We applied a recent method of X-ray diffraction data processing to quantify the dislocation density and evolution in a stable austenitic stainless steel (SUS316L) that was exposed to various hydrogen gas pressures and subsequently deformed. The dislocation density measured by X-ray diffraction increases in similar ways, regardless of hydrogen presence, but reaches a higher plateau with hydrogen. Additionally, the ratio of screw-to-edge character of dislocations changes drastically when the hydrogen gas pressure is high, showing quantitatively that dynamic recovery becomes extremely difficult.