Detection of hydrogen in steel with an N-15 nuclear resonance

J.-S. Larochelle, A. Désilets-Benoit, E. Martel, G. Borduas, S. Roorda

sjoerd.roorda@umontreal.ca

Département de physique, Université de Montréal, Pavillon Roger-Gaudry, Case postale 6128, succursale Centre-ville, Montréal (Québec), H3C 3J7, Canada

We have used a 6.385 MeV ^{15}N nuclear resonance to detect hydrogen in steel that had been electroplated with a protective Cd surface coating to better understand the parameters leading to hydrogen embrittlement. The narrow energy range of the nuclear reaction allows a high depth precision within a total depth of 2 micron while the high cross section yields a high signal to noise ratio [1,2].

At room temperature we observe a rapid decline in hydrogen concentration during the measurement, indicative of beam-induced hydrogen detrapping and mobility [3,4]. It appears that the hydrogen concentration falls off as a simple exponential decay with ion fluence, however it settles at a finite hydrogen concentration different from 0. In spite of the hydrogen loss, we have been able to detect small concentrations of hydrogen which has diffused into the bulk of the steel sample. We also looked at the system at liquid nitrogen temperature to observe in more detail the temperature dependence and asymptotic behaviour of the hydrogen loss and will report on these studies.

[1] P. Trocellier and C. Englemann, “Hydrogen depth profile measurement using resonant nuclear reaction : an overview”, *Journal of Radioanalytical and Nuclear Chemistry*, vol 100, No 1, pp. 117-127, 1985

[2] M. Castellote et al., “Hydrogen embrittlement of high-strength steel submited to slow strain rate testing studied by nuclear resonance reaction analisys and neutron diffraction”, *Nuclear Instruments and Methods in Physics Research, Section B : Beam Interactions with Materials and Atoms*, vol. 259, No 2, pp. 975-983, 2007

[3] B. Pantchev, P. Danesh, B. Schmidt, D. Grambole and W. Möller, “Ion beam-induced hydrogen migration in SiO2/a-Si:H/SiO2 layer stack”, *Semiconductor Science and Technology*, Vol 24, No 3, 035012, 2009

[4] K. Takeyasu, M. Matsumoto and F. Fukutani, “Temperature dependance of hydrogen depth distribution in the near-surface region of stainless steel”, *Vacuum*, vol. 109, pp. 230-233, 2014