While global warming and fossil fuel drain pose a problem, hydrogen could generate electricity without discharging CO₂ and also serve as a secondary energy carrier for electric power. Technology to store and transport hydrogen compactly and safely is indispensable in order to realize hydrogen energy society. Hydrogen storage materials are able to make hydrogen gas 1/1000 or less volume and carry it. Metal hydrides which interstitial sites are occupied by hydrogen atoms are one of the hydrogen storage materials; they are promising candidates to be applied to hydrogen storage tanks in fuel cell vehicles and stationary storage systems. When the metal hydrides are formed, lattice defects such as vacancy, dislocation and stacking fault are introduced due to large volume expansion. In LaNi₅-based intermetallics, misfit dislocations along a-planes and c-planes in the hexagonal unit cell are observed after hydrogenation [1,2]. Regarding Ti-V based BCC alloys, twin boundaries and stacking faults are formed parallel to (111) in FCC hydrides to accommodate anisotropic expansion along c-axis [3]. These lattice defects have a great effect on hydrogenation/dehydrogenation properties such as absorption pressure, kinetics and cycle ability. Formation of lattice defects are suggested to relate to microstructure evolution during hydrogenation/dehydrogenation. This study aims to elucidate the hydrogenation mechanism for storage materials with various crystal structures from the microscopic point of view, in order to improve the hydrogenation/dehydrogenation properties.

First, a new sample holder with an ex-situ cell for transmission electron microscope (TEM) has been developed. Commercially available Pd powder was observed by TEM after exposed to hydrogen in the ex-situ cell. Moreover, we have succeeded in high-resolution TEM observation on hydrogenation of MgNi films using environmental TEM with aberration corrected. As shown in Figs. 2, it is found that MgH₂ crystallization occurs following Mg₂NiH₄. This suggests that MgNi has a catalytic effect on hydrogenation of Mg. In the future, relation between the hydrogenation mechanism and Mg/Ni ratio of the Mg-Ni films will be revealed.

References

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Fig. 1: TEM images of Pd powder: (a) before hydrogenation (as-received); (b) after exposed to hydrogen of 0.01 MPa for 60 minutes. It is noted that crystals with the diameter more than 100 nm are observed.

Fig. 2: High-resolution TEM images of Mg6Ni films taken in the hydrogen atmosphere of 80 Pa: (a) 40 seconds; (b) 100 seconds passed after electron irradiation.