Ordering Kinetics of Nanoporous FeCo During Liquid Metal Dealloying and the Development of Nanofacets

Collaborative Research Center on Energy Materials

This study investigates the surface morphology and ordering kinetics of three-dimensional interconnected nanoporous FeCo. The ordering kinetics were accelerated by the surface-diffusion-driven coarsening in the nanoporous structure. Post-heat treatment led to the development of precise nanofacets via the preferential growth of surface planes.

It is interesting to study nanofacets because the surface structure has a significant effect on the physical properties of nanomaterials. However, it is still a challenge to synthesize well-defined nanofacets on a large-scale because of the tendency of nanomaterials to agglomerate.

In 2011, liquid metal dealloying (LMD) was reported and provided a means for overcoming the elemental limitation of chemical dealloying [1]. An example of a carefully designed LMD system is three-dimensional interconnected nanoporous (3DNP) FeCo. The order-disorder transition between the B2 and disordered *bcc* structures should result in structural variations. In the present study, the ordering behavior of 3DNP FeCo was investigated during the LMD process. The findings of ordering and coarsening phenomena were then practically applied for surface reconstruction.

The synthesized porous FeCo exhibited significant variations in surface morphology depending on the LMD temperature. At 600 °C, truncated cubic ligaments had flat surfaces of particular facets (Fig. 1a). The ligament surfaces become roughened at 700 °C (Fig. 1b). Stepped surfaces were observed at 800 °C (Fig. 1c), which is above the order-disorder transition temperature (T_c) of FeCo (730 °C).

In chemically ordered materials, the faceted surfaces depend on the degree of order, the energy of the facet(s), and surface-termination. Interestingly, the ordering kinetics of 3DNP structures differ from those of the bulk materials. When the dealloying time is increased from 3 min to 36 min at 600 °C, the ordered (100) peak is intensified, and the ordering parameter (S) increases drastically at the beginning of the LMD process (Fig. 2a). The bulk FeCo plate exhibited slower ordering kinetics than the nanoporous FeCo.

The theoretical ordering kinetics based on

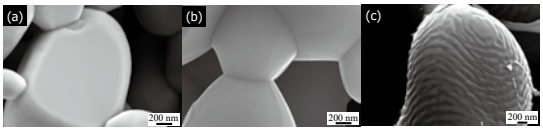

Fig. 1 Surface structures of porous FeCo prepared by LMD at (a) 600 °C, (b) 700 °C, and (c) 800 °C.

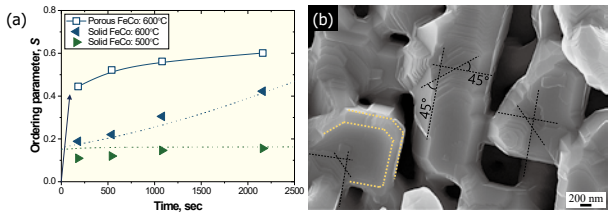

Fig. 2 (a) Ordering kinetics of porous FeCo and bulk FeCo samples. (b) Developed nanofacets on porous FeCo after post-heat treatment.

vacancy concentration agreed well with the experimental results of the bulk samples. However, there was a large disparity with the ordering kinetics of the 3DNP structure. The surface diffusivity was usually faster than the bulk diffusivity. In other words, the surface diffusion accelerated long-range ordering from the beginning of dealloying and formed a nanocube.

Precise nanofacets were developed on ligaments with equimolar composition in large-scale bulk-porous FeCo samples at 600 °C after heat treatment (Fig. 2b). The preferential growth of delicate steps and ledges verified the surface diffusion formation mechanism of the nanofacets [2].

References

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Hidemi Kato (Corresponding Author, Non-Equilibrium Materials Research Laboratory)
E-mail: hikato@imr.tohoku.ac.jp
Tetsu Ichitsubo (Head of Collaborative Research Center on Energy Materials)
E-mail: tichi@imr.tohoku.ac.jp
URL: http://www.imr.tohoku.ac.jp/en/about/divisions-and-centers/facilities/05.html