HoN 나노입자 합성 및 자기열량 효과 연구

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The magnetic refrigeration involves an intrinsically small irreversibility and may provide refrigeration systems of good energy efficiencies especially at cryogenic temperatures. It is, therfore, encouraged to apply the magnetic refrigeration system to the hydrogen liquefaction process, which would be an essential part of infrastructure of the near future society driven by the hydrogen energy. For hydrogen energy system, liquefied hydrogen is suitable for storage and transportation, because it provides the highest hydrogen densities with respect to both mass and volume. In order to establish this refrigeration technology, it is necessary to obtain the efficient and reliable magnetic refrigerant that possesses a large magnetocaloric effect (MCE) around and above the boiling point of hydrogen.

Plasma arc discharge (PAD) with self-constructed equipment was performed to prepare rare-earth nitride nanoparticles. Holmium (Ho) was purchased from Kojundo Chemicals Co. (Japan) in granular type with average size of 3 mm. After removing oil on the surface of Ho granules, they were placed on Copper hearth as an anode. Tungsten needle was used as a cathode.

In order to synthesize nitride nanoparticles, N_2 was added to Ar atmosphere in different ratios from 30 to 70% considering partial pressure. As the partial pressure of N_2 was increased, HoN peaks became dominant and peaks from Holmium Oxide (Ho_2O_3) as impurity was dramatically decreased. Finally, when the partial pressure of mixed gas with 28000 Pa for N_2 and 12000 Pa for Ar was reached, typical X-ray diffraction pattern of HoN was obtained. Series of six sharp peaks exactly corresponded to each planes of crystallographic structure of bulk HoN. From TEM observation, HoN nanoparticles were agglomerated in spherical shape in Ar atmosphere. However, as the partial pressure of N_2 was increased, the morphology was changed to cubic in shape and mean size of nanoparticles was increased.

Data set of the magnetization measurements indicates field dependence of magnetizations at different temperatures. Magnetizations increased linearly with applied fields in the higher temperature region and magnetizations were almost saturated at 5 T. Magnetic entropy change (ΔS) of HoN nanoparticles showed the highest value of 25.2 $JK^{-1}kg^{-1}$ at 16 K which is comparable with that of intermetallic compounds having a transition temperature around 20 K such as $DyNi_2$, $HoAl_2$ and $Gd_{0.1}Dy_{0.9}Ni_2$. It implied that HoN nanoparticles are promising magnetic refrigerant materials for hydrogen liquefaction system.