A novel nanometer-level amorphous carbon coating method by direct pyrolysis of coronene without solvent and its application to the $LiFePO_4$ cathode for Li-ion battery

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We developed a novel and simple nanometer-level amorphous carbon coating method for boron particles by direct pyrolysis of coronene ($C_{24}H_{12}$) without solvent [Nanotechnology. 26 (2015) 045602]. We used coronene as a carbon source for MgB_2 superconducting wires [Supercond. Sci. Technol. 27 (2014) 085012] and obtained enhanced critical currents and uniform microstructures of MgB_2 wires by this coronene addition. After many investigations, we found that the uniform microstructure obtained is because coronene has a melting point (438 ℃) lower than its decomposition temperature (about 600 ℃), which enables coronene (above melting point) to cover boron particles uniformly without the need for a solvent. Carbon coating with a complete shell-core encapsulated structure was formed after thermal decomposition of coronene because the diffusion and penetration of liquid coronene can extend to the boundaries of boron particles and inside of agglomerated nanoparticles. This is difficult to be realized by the deposition process such as CVD. From the formation mechanism of this carbon coating, we considered that this method can be applied to any particles if they keep stable and do not react with coronene below the temperature of coronene decomposition. Thus, this carbon-coating method is expected to be applied in many technology fields with low cost.

Recently, we found from Raman spectrum that this amorphous carbon layer has more sp^2 (graphitelike) bonds than sp^3 (diamondlike) bonds, which suggests that this method produces mostly conductive amorphous carbon. Thus, we applied this carbon coating to $LiFePO_4$ particles, a promising cathode material for Li-ion battery. We successfully obtained the uniform carbon coating for all $LiFePO_4$ particles as shown in **Fig. 1**. We fabricated coin-type Li-ion batteries using these carbon-coated $LiFePO_4$ particles (cathode) and graphite particles (anode). The weight of $LiFePO_4$ was about 31 mg. Charging and discharging characteristics of Li-ion batteries fabricated with carbon-coated $LiFePO_4$ (CLFP) and non-carbon-coated $LiFePO_4$ (LFP) are compared in **Fig. 2**. Charging and discharging curves are obtained with constant currents of 2.25 and 0.9mA, respectively. The Li-ion batteries fabricated with this carbon-coated $LiFePO_4$ show higher capacity than those fabricated with non-coated $LiFePO_4$. We are now trying to further enhance the capacity of Li-ion battery by modifying the starting materials (such as size of $LiFePO_4$ particles, thickness and conductivity of coated carbon) and optimizing the experimental conditions.

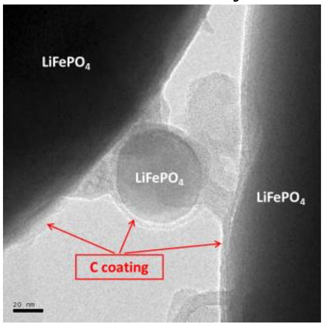

Fig. 1 TEM image of $LiFePO_4$ with carbon coated laver.

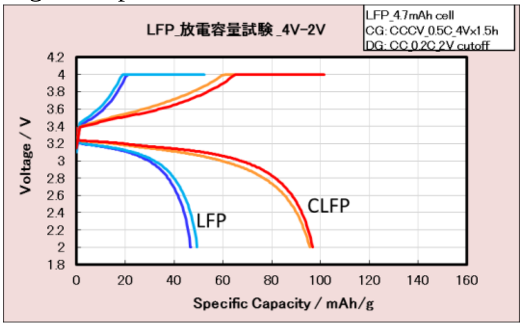

Fig. 2 Charge/discharge curves of Li-ion battery.

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