Improved Thermoelectric Properties by Control of Nanoparticles in Thin Film

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Nanoparticles (NPs) and their separation distances play important roles in functional nano-composite structure. To achieve nanoscale controlled structure, Bio Nano Process (BNP) has been proposed [1]. In the BNP, ferritin is used to carry NPs in order to make nano-composite structure. Ferritin protein is consisted of 24 polypeptide subunits. The inner and outer diameters of the ferritin protein shell are about 7 nm and 12 nm. We have been developing a process to make two dimensional array of ferritin with NP on a surface.

Recently, nanostructures have been introduced into thermoelectric (TE) materials to achieve a high performance of TE material. It should be expected that TE material with NPs will have novel improvement due to the effect such as scattering phonon [2], energy filtering and modulation doping. However, it is difficult to control the nano-structures in TE materials. Therefore, we have utilized BNP to fabricate the NPs in uniform size and control distribution of NPs [3]. We use PEG-ferritin (ferritin modified by polyethylene glycol) for control NPs distribution. In order to control the distance of the NPs, PEGs with molecular weights of 10k was modified on ferritin. The process detail is that, at first, BiTeSb thin film was deposited on substrate. After film deposition, the samples were treated by UV-Ozone for 10 min at 115°C. Then put the samples into pure water to store before next step of experiment. After spin dry process, the PEG-ferritin (0.05 mg/ml) with FeOx core were drop on the samples and held for 5 min. then the protein shells were removed utilizing the UV-Ozone treatment (Fig. 1). Finally, the BiTeSb thin film was fabricated on NPs. Through the optimization of NPs in thin film, thermal conductivities will decrease, on the other side, Seebeck coefficient and resistance will not changed a lot. Consequently, figure of merit can be enhanced.

Figure 1: SEM images of ferritin nanoparticles (FeOx core) on BiTeSb surface.

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