Chemical synthesis of $SnS_{0.9}Se_{0.1}$:Na,Ag nanoparticles and evaluation of thermoelectric properties of sintered pellets

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Tin monosulfide (SnS) is attracting much attention as eco-friendly and low-cost thermoelectric materials due to nontoxic and abundant elements. Unfortunately, in general, dimensionless figure of merit *ZT* ($ZT = \sigma S^2 T/\kappa$; σ, *S*, κ, are the electrical conductivity, Seebeck coefficient and thermal conductivity, respectively) of SnS is quite low due to low carrier concentration. However, this can be improved by controlling the nanostructured defect and impurity doping, and we have succeeded in significantly enhancing the *ZT* value by sintering chemically-synthesized Ag and Se co-doped SnS nanoparticles (NPs).[1)] On the other hand, alkali metals are the most common p-type dopant for tin monochalcogenides. Zhou *et al*. fabricated Na-doped SnS pellets using a hot-melting method and reported an increase in carrier concentration from 8×10^{17} cm^{-3} to 2×10^{19} cm^{-3}.[2)]

In this presentation, we report the synthesis method of Ag, Na and Se co-doped SnS NPs and the evaluation of thermoelectric properties of their sintered pellets. $SnS_{0.9}Se_{0.1}$:Na,Ag NPs were synthesized by a hot injection method and sintered by hot press. **Fig. 1a** shows the TEM image of the as-synthesized NPs. As can be seen from the TEM image, the NPs are nearly spherical in shape, and the atomic concentrations of Sn, S, Se, Na, and Ag in the NPs were measured to be 51.8, 41.4, 5.2, 0.8, and 0.8 at%, respectively, by SEM-EDS. XRD patterns of NPs and pellet are shown in **Fig. 1b**. The XRD peaks of the NPs and pellet correspond well to the cubic and orthorhombic phases of SnS, respectively, indicating that a phase transition from the cubic to the orthorhombic phase occurs during sintering.

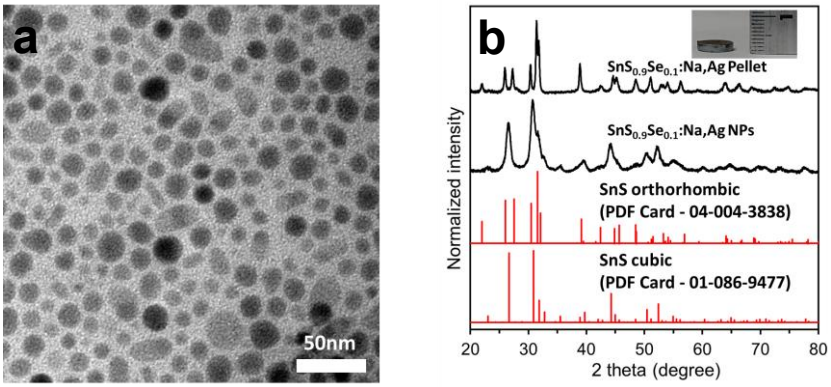

Fig. 1. (a) TEM image of $SnS_{0.9}Se_{0.1}$:Na, Ag NPs, (b) XRD patterns of NPs and pellet. Inset is a photo of the pellet.

1) Kobayashi, K. *et al*., *ACS Appl. Energy Mater*. (2024), **7**, 4484. 2) Zhou, B. *et al*., *ACS Appl. Mater. Interfaces* (2017), **9**, 34033.