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Study of Compacting Methods for Nanostructured Thermoelectric Materials Based on Si-Ge and Half -Heusler Alloys.

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Recent methods of compacting nanopowders of thermoelectric materials of silicon germanium and Half-Heusler (HH) compounds based on Ni(Ti,Zr,Hf)Sn are presented. Half-Heusler alloys are known to be intermetallic compounds with quite large Seebeck coefficient and semiconducting transport properties. This makes them a potential candidate for thermoelectric applications. In this study we compare compacting methods applied to raw materials as a function of crystal structure. The results suggest that the thermal conductivity can be reduced by increasing the phonon scattering via nanostructuring. The effect of spark plasma sintering (SPS) and hot pressing on Gleeble system was analyzed by TEM and SEM methods.

Keywords: Thermoelectric materials, Silicon, Germanium, Si-Ge, Half-Heusler, Nanostructured, SPS, Gleeble, Compacting.

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1. INTRODUCTION

Improvement of the quality of the thermoelectric material is achieved by the use of nanostructured powders of the initial elements and subsequent compaction of the powder in a bulk material suitable for production of thermoelectric elements. Compacting nanopowders to bulk nanostructured materials is a difficult task for many scientific groups. In the nanostructured material, there is an enhanced scattering of phonons (carriers of heat) at grain boundaries, atomic defects and nanoparticles, which results in reduction of thermal conductivity. Since the electrical conductivity is decreased slightly, this ultimately improves the efficiency of the thermoelectric material.

2. EXPERIMENTAL RESULTS

This work presents results of comparing nanopowders of Si-Ge and Half-Heusler alloys by two methods, which allow one to save highly dispersed structure in the bulk material. The work contains results of microscopic studies of powders and sintered samples. Microphotograph of the nanopowders of Si-Ge is presented in Fig. 1 [1].

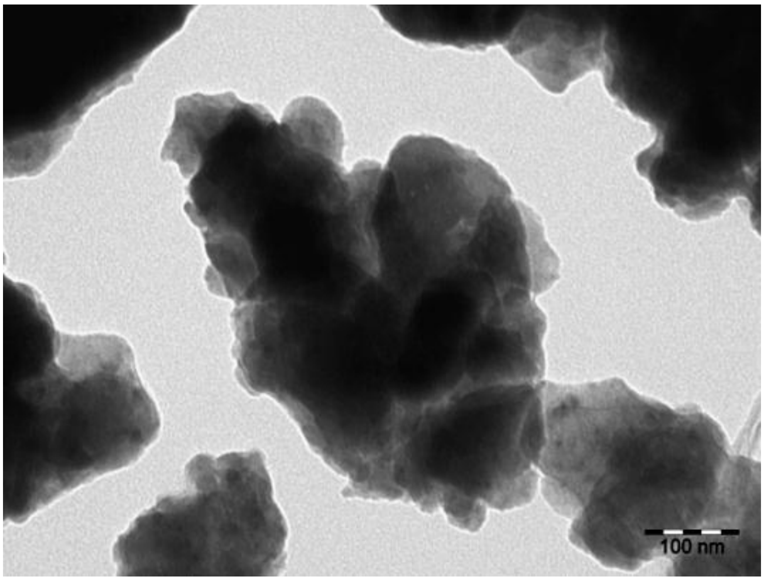

Fig. 1 – TEM Microphotograph of Si-Ge nanopowder

The powder was prepared by mechanical alloying in a high speed planetary mill under argon atmosphere. For homogeneity of synthesized powders, the Half-Heusler compounds were pre-alloyed before milling. Microstructure of sintered samples of Si-Ge is presented in Fig. 2 and Fig. 3 [2].

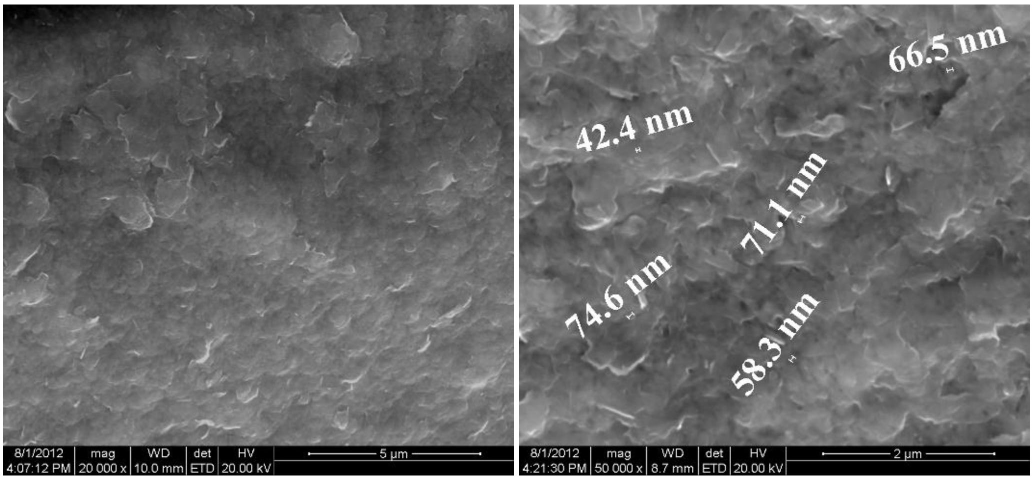

Fig. 2 – SEM microphotographs of Si-Ge samples sintered my SPS method

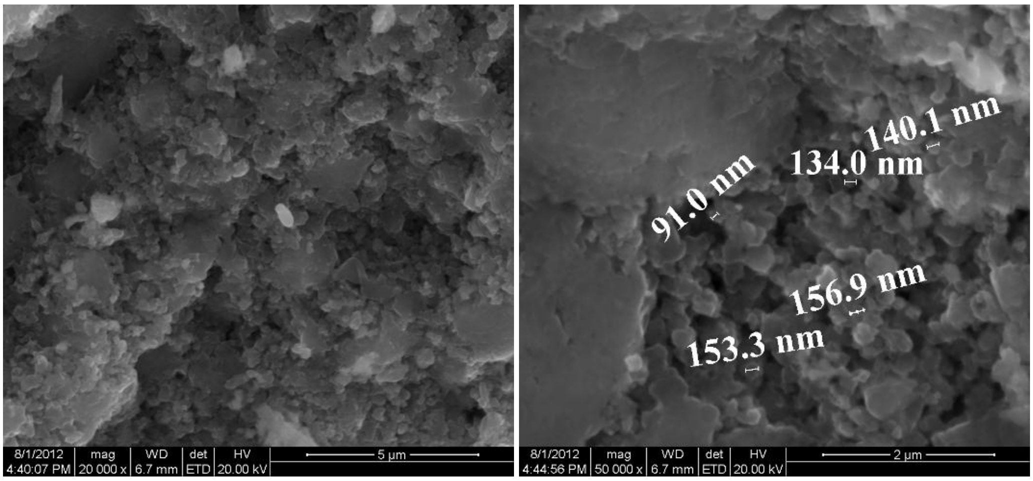

Fig. 3 – SEM microphotographs of Si-Ge samples sintered by HP on Gleeble 3800

We study evolution of structure after sintering, as well as comparison of the structure of the bulk materials compacted by a spark plasma sintering and the mechanical analyzer Gleeble 3800. The latter method allows sintering in extremely short period of time, preventing recrystallization growth of particles in the sample. Optimization of compacting parameters for a specific material allows one to get a highly dispersed nanostructured material that significantly increases thermoelectric figure of merit.

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