SYNTHESIS OF Si/SiGe NANOWIRES FOR APPLICATION IN THERMOELECTRIC SYSTEMS

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Miniaturized electronics systems are more and more used in the new technological objects both in civil and military fields (Micro drones, biological sensors, micro-electro-mechanical systems (MEMS), power suppliers…). Thermoelectric microgenerators supply electric energy for microsystems from thermal energy conversion. Thermoelectric converters are light, reliable and wireless. So, they are a good alternative to micro-batteries, micro fuel cells and micro-turbines and give the advantage to use a renewable energy. The nanowires-based thermoelectric generators will address energy needs of wireless microsystems. They should also solve thermal problems in microelectronics (solution to low thermal dissipation in chips vias). [1]

Efficient energy converters are based on Peltier effect for cooling and Seebeck effect for energy production. Materials with high Seebeck coefficient, high electric conductivity and low thermal conductivity are required. Theoretical [2] and experimental studies [3] evidenced that nanowires and nanostructured materials as superlattices have a high potential in thermoelectricity. The use of those materials increases ZT value, the factor of merit which characterizes a thermoelectric material, and consequently, increases the converter efficiency. This augmentation results from two physical phenomena: high phonons scattering in superlattices interfaces which lowers the thermal conductivity, and charge carrier confinement, which modifies transport properties. Thanks to their structures, Si/SiGe multi-layers nanowires take advantage of the two physical phenomena.

The aim of the study is to use chemical vapor deposition technique to perform Si/SiGe nanowires for high efficiency thermoelectric converters (>10%). Silane and germane gases are decomposed in a thermal CVD reactor. N type or p type nanowires are obtained by mixing dopant gas with precursor gas. Si and SiGe nanowires have been first synthesized before to carry out Si/SiGe multi-layers nanowires. In thermal CVD, silicon nanowires growth is attributed to the VLS mechanism (Vapor-Liquid-Solid) developed by Wagner in 1964 [4]. For each nanowires type, a accurate morphological study is done thanks to SEM (Scanning Electron Microscopy). A growth parametric study will be perform in order to investigate the influence of each parameter on growth and to obtain specific nanowires for thermoelectric measures.

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References:

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[2]: L. D. HICKS, M. S. DRESSELHAUS, Thermoelectric figure of merit of a one-dimensional conductor, *Physical review B, 1993, Vol.47, N°24, 16631-16634*
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[4]: R. S. WAGNER, Vapor-liquid-solid mechanism of single crystal growth, *Applied physics lett., 1964, Vol 4, N° 5, 89-90*

Figures:

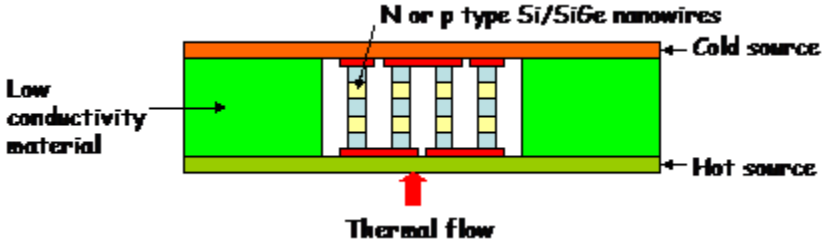

Figure 1: Concept of thermogenerator

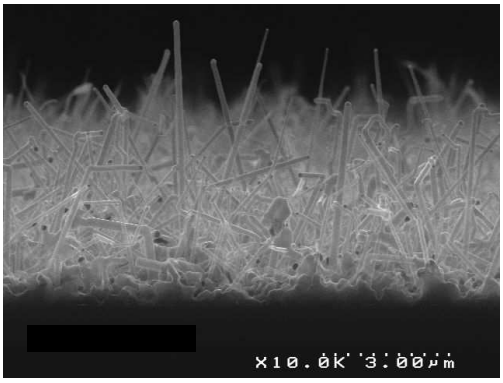

Figure 2: Silicon nanowires made in CVD reactor

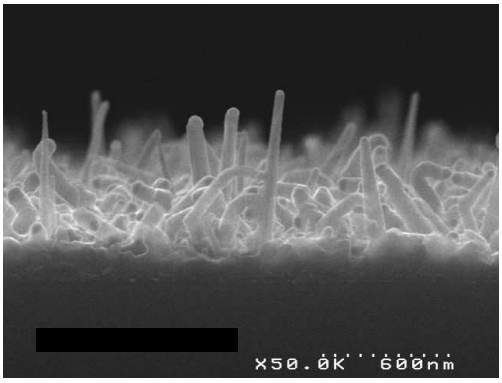

Figure 3: SiGe nanowires made in CVD reactor