Study of thermoelectric properties of $In_2O_3(ZnO)_n$ and ZnO nanowires

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Abstract

With the advancement of technology, the thermoelectric application of nano materials started from about 1992. The most important breakthrough came from the theory that is possible to increase ZT by using low dimensional materials predicted by Hicks and Dresselhaus [1], and the study about reducing thermal conductivity by scattering phonon between nanoscale interfaces published by R. Venkatasubramanian [2]. Based on both research and theoretical studies, there was explosive growth in the thermoelectric field of low dimensional nano materials.

This study is to investigate thermoelectric properties of individual $In_2O_3(ZnO)_n$ nanowire, and discuss the difference between ZnO and $In_2O_3(ZnO)_n$ nanowires .ZnO nanowires were grown by chemical vapor deposition (CVD). $In_2O_3(ZnO)_n$ nanowires were synthesized by solid state reactins.[3] We deposited indium particles on ZnO nanowires by thermal evaporation and then annealed them in oxygen atmosphere at 1173 K. To measure Seebeck coefficient, single $In_2O_3(ZnO)_n$ nanowire was placed on a device constituting of a pair of micro-heaters with a designed circuit for sensing the temperature difference between two ends of the nanowires. Combining Seebeck coefficient with electrical conductivity measured by four probe measurement, thermoelectric power factor can be derived. Then we made MOSFET devices by electron beam lithography system to measure mobility and carrier concentration of single nanowire.The morphology and microstructure of the nanowires were characterized by scanning electron microscopy and transmission electron microscopy. The influence of microstructure, chemical composition, and carrier concentration of the $In_2O_3(ZnO)_n$ nanowires on thermoelectric properties is discussed.

From the results, the conductivities and carrier concentrations of $In_2O_3(ZnO)_n$ nanowires are two order less than ZnO nanowires. And the Seebeck coefficients are three times more than ZnO nanowires.It reveals the improvement in Seebeck coefficient and the suppressing in electrical conductivity.

References

[1]L. Hicks and M. Dresselhaus, *Physical Review B,* **vol. 47**, *24*, pp. 16631-16634, 1993.
[2]R. Venkatasubramanian, *Physical Review B,* **vol. 61**, *4*, pp. 3091-3097, 2000.
[3]S. C. Andrews*, et al.*, *Chemical Science,* **vol. 2**, *4*, p. 706, 2011.

Figures

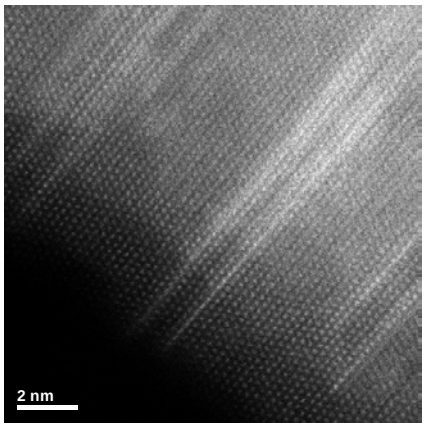

Fig1. STEM image of $In_2O_3(ZnO)_n$ nanowire

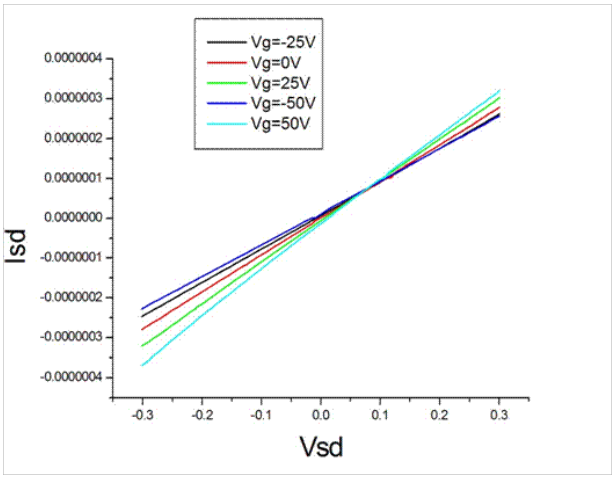

Fig2. source-drain current to source-drain voltage characteristics of $In_2O_3(ZnO)_n$ nanowire

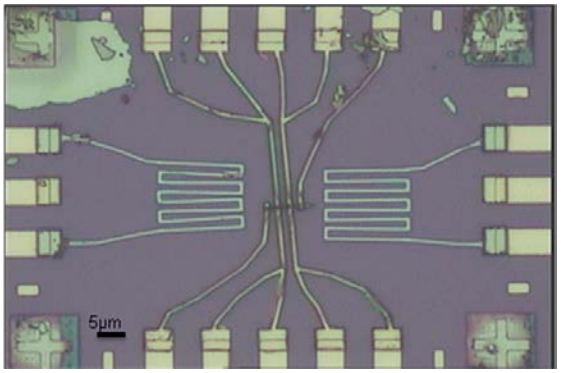

Fig3. OM image of Seebeck coefficient device

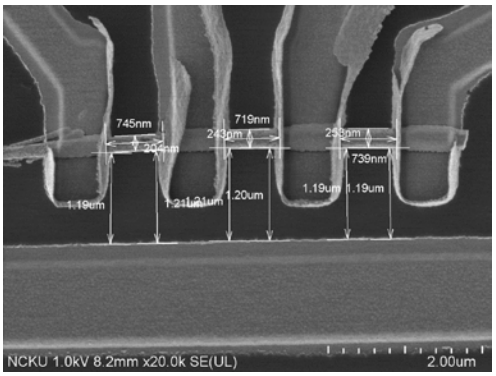

Fig4. SEM image of MOSFET device