永續科學研究計畫：

研發硫化亞錫作為下一世代熱電應用

Development of SnS for the next generation thermoelectric applications

總計畫主持人：

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計劃簡介：

熱電科技將熱能轉換成電能，也可利用電能達到冷卻效果，都是百年歷史的科技，過去曾經成功被應用到國防與外太空探測上，但是一直無法廣泛應用在日常生活上，主要是因為其效率偏低與材料成本過高。本計畫以低成本的硫化亞錫（SnS）作為研究重點，主要就是以民生應用為目標。

本團隊集合了物理所吳茂昆實驗室在材料合成的專長、陳洋元實驗室在熱電分析的經驗、雷曼實驗室在晶體成長的能力，與原分所陳貴賢實驗室在薄膜材料的研究、魏金明實驗室在理論計算模擬的協助，加上台大林麗瓊實驗室在材料分析上的配合，對Ｐ-型與Ｎ-型硫化亞錫進行深入探討，將其熱電轉換的優值指數 (figure-of-merit) 提升到 ZT～3.0 ，並且嘗試元件製作，往實際應用方向邁進。

Development of SnS for the Next Generation Thermoelectric Applications

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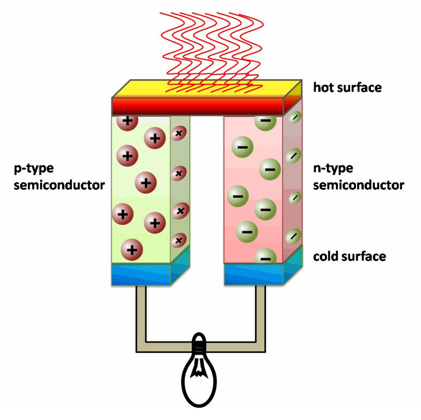
INTRODUCTION

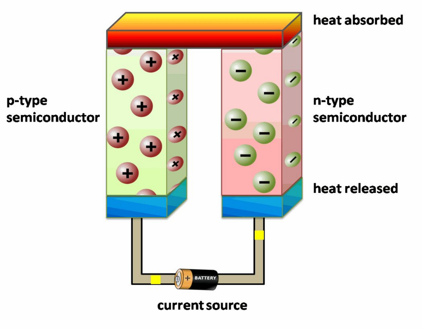
Thermoelectric power generation (Seebeck effect) and cooling (Peltier effect) have been discovered about 200 years ago. Substantial understanding and thermoelectric devices have been developed.

1821 Thomas Seebeck

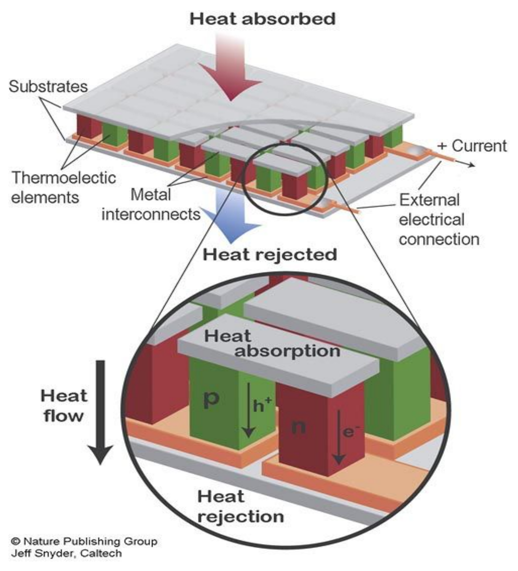


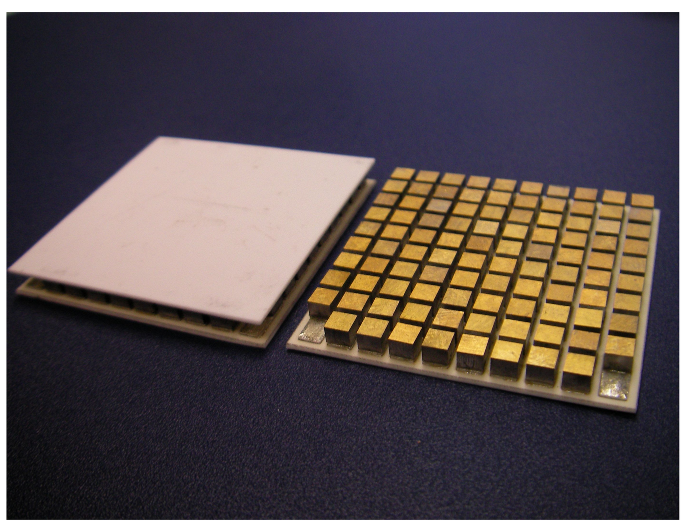
Hear→Electricity

1834 Jean Charles A. Peltier



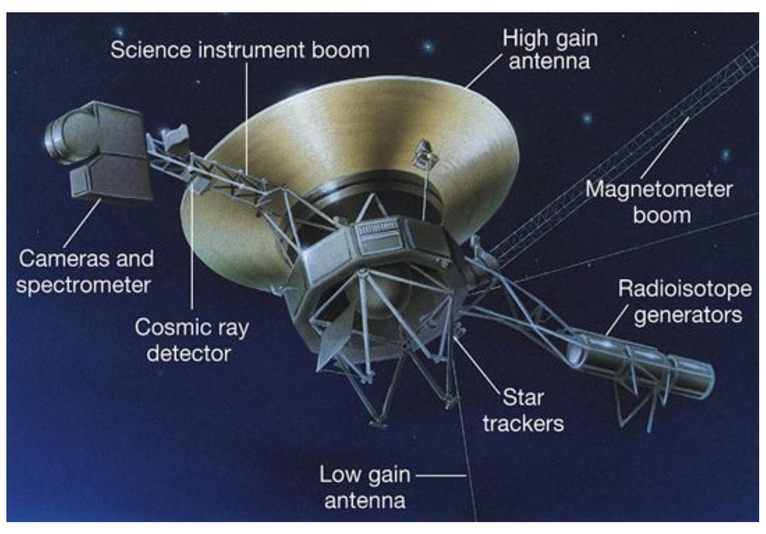
Electricity →Cooling

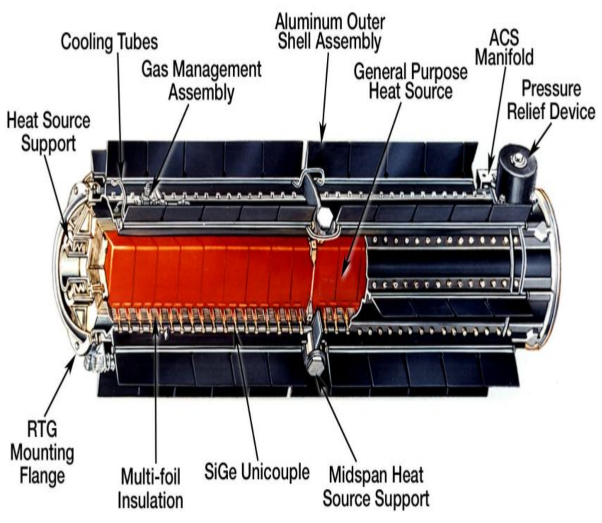


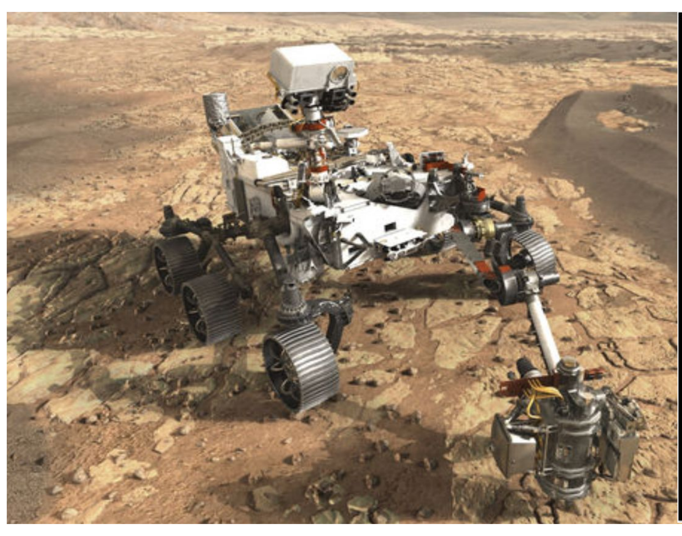


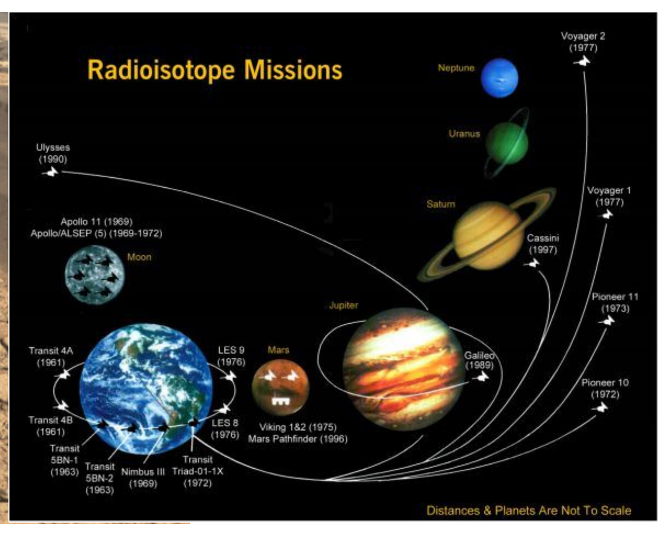
APPLICATIONS

Thermoelectric power generation has been demonstrated to be reliable in NASA's space missions and and future Mars rovers.









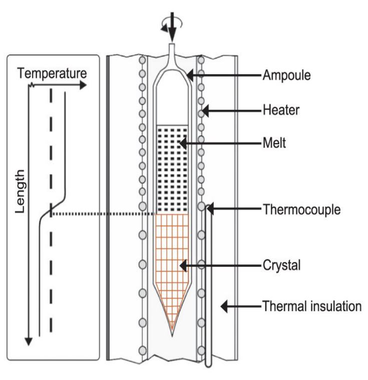
HOLDBACKS

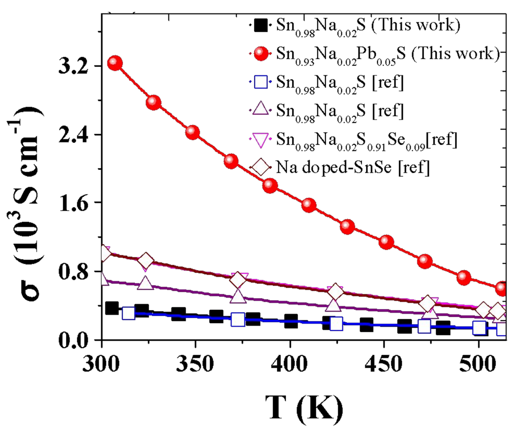
Due to the cost of the TE materials, thermoelectric devices are only implemented in niche applications such as space missions and defense industries.

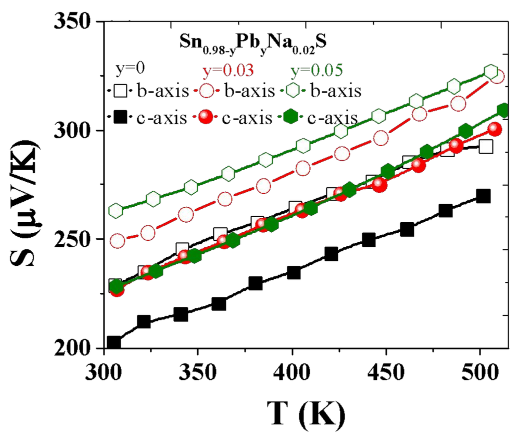
Recent TE cooler and wine cheerer have been available on the market, but with limited revenue. Low-cost and high-performance materials are needed to contribute to the energy arena.

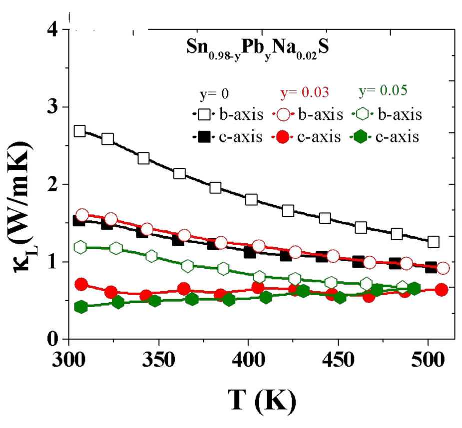
OUR APPROACHES

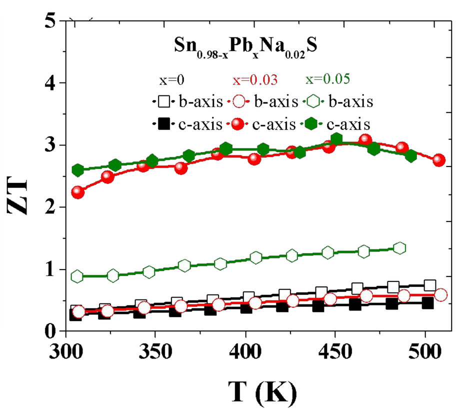
Design and synthesis of high performance TE materials based on low-cost earth-abundant materials such as Tin Sulfide (SnS). We applied Bridgeman single crystal growth method, solid state reaction technique, magnetron sputtering, spark plasma sintering (SPS), and various doping technique to produce SnS of different thermoelectric properties.





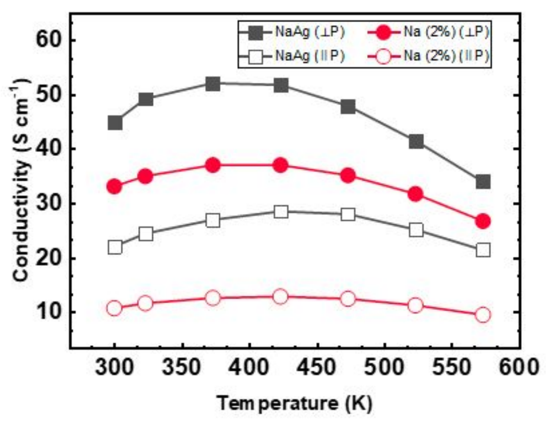


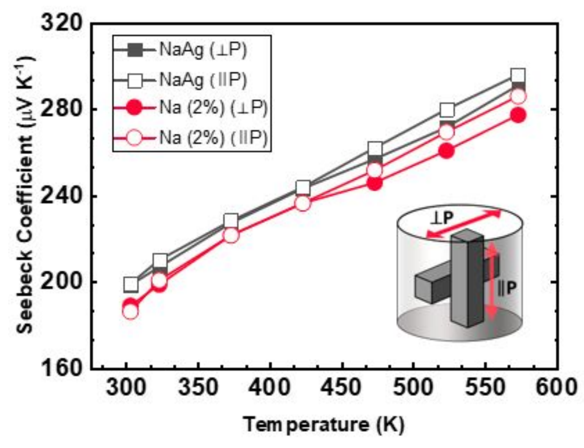


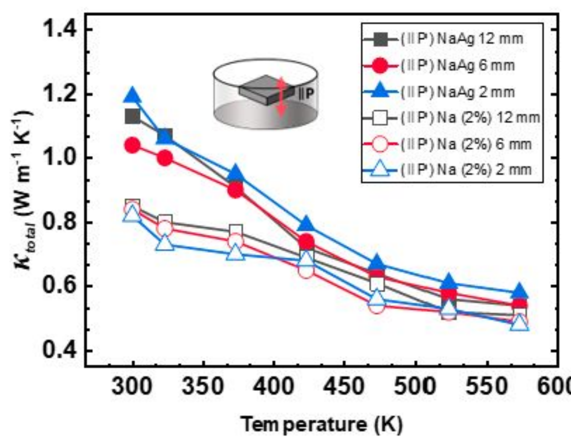


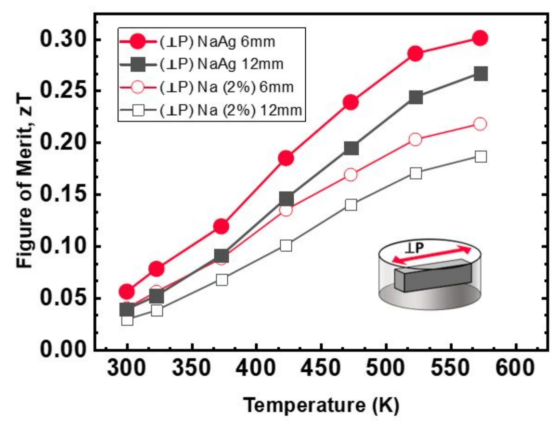
Results

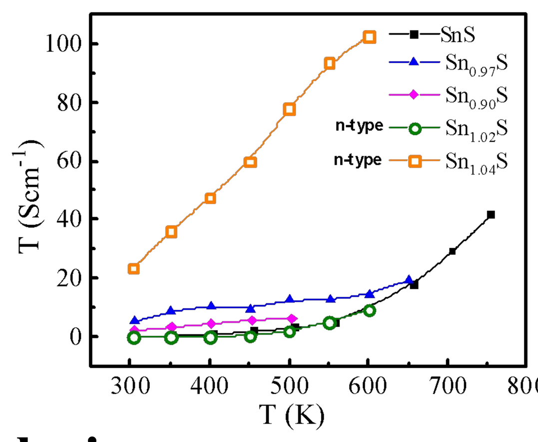
- Single crystal growth: High performance p-type SnS with ZT~3.0 has been achieved via Na and Pb co-doping.
- Polycrystal growth: Significant enhancement in ZT up to 0.3 has been demonstrated via Na and Ag co-doping.
- N-type SnS growth: Up to ZT~0.35 has been achieved via S-poor/Sn-rich sample using SPS technique.

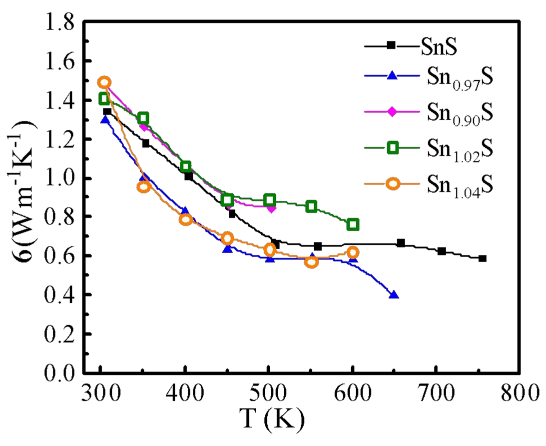


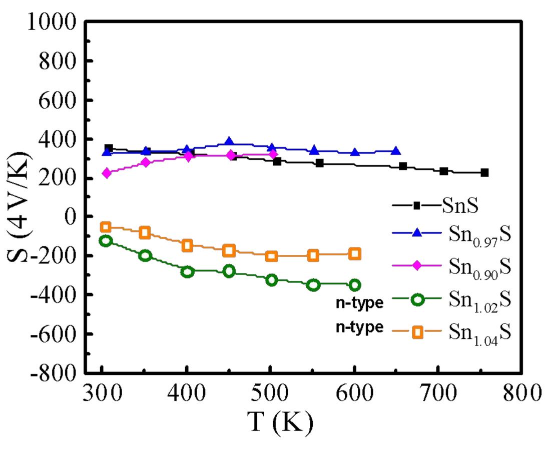


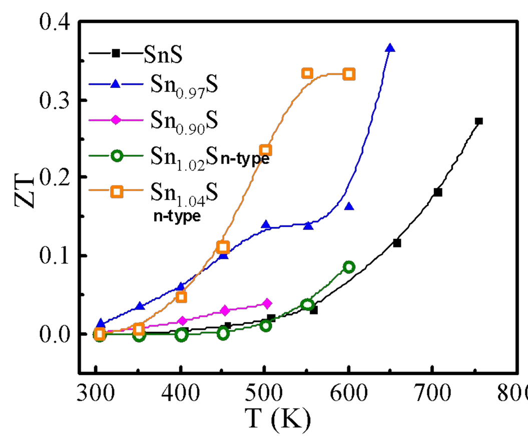












Conclusions

- Record high thermoelectric performance of ZT~3.0 near room temperature has been demonstrated via co-doping of SnS, which is very attractive for TE cooling applications.
- Major progresses has been achieved in polycrystalline and n-type SnS, which important for future device fabrication.
- Further device fabrication is underway for power generation and cooling applications.

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