

New Sulfidation Technology, n-Type SnS Thin Films and Solar Cells

- Safe, Low-Temp, and Impurity-Free Sulfurization Technology
- Innovative n-Type SnS Thin Films for Next-Gen Solar Cells

Overview

Thin-film solar cells using SnS (tin sulfide) offer the following advantages:

- Free of toxic elements such as Cd and Te.
- Composed of abundant and inexpensive elements (Sn and S).
- Efficient light absorption at a thickness of just 2–3 μm (compared to $\sim 500 \mu\text{m}$ for silicon).
- A conversion efficiency of 25.3% has been reported for homo p-n junctions.

However, achieving high-efficiency SnS solar cells with a homo p-n junction requires n-type SnS thin films, which have been technically challenging to fabricate.

In this invention, inventor successfully synthesized n-type SnS thin films for the first time using a novel sulfurization technique based on sulfur plasma. This breakthrough is expected to enable the realization of homojunction SnS solar cells in the future.

Product Application

- Solar cells and photodetectors
- Novel Sulfidation Technology (Next page)

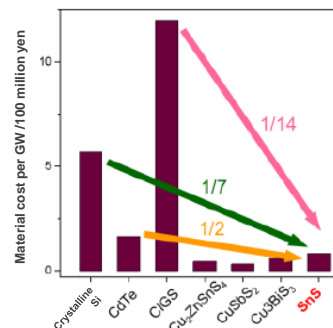
IP Data

IP No. : PCT/JP2021/017400
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Admin No. : T20-154

Features・Outstandings

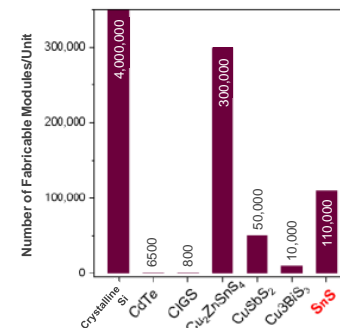
〈SnS as a Solar Cell Material〉

Material cost of 1 GW module
assuming 20% conversion efficiency



T. J. Whittles, "Electronic Characterization of Earth - Abundant Sulfides for Solar Photovoltaics" 2018
*Calculated as 1 pound =150 yen

Number of producible 1GW modules
estimated from resource reserves



T. J. Whittles, "Electronic Characterization of Earth - Abundant Sulfides for Solar Photovoltaics" 2018

SnS is low-cost and abundant.

〈n-type SnS thin films〉



	Conventional method	This technology With S Plasma
Type	P Type	N Type
S/Sn ratio(EPMA)	1.079	1.085
Conductivity Scm ⁻¹	1.8×10^{-4}	0.1
Mobility cm ² V ⁻¹ s ⁻¹	1.8	0.23
Carrier density cm ⁻³	6.1×10^{14}	2.6×10^{18}
Cl concentration	4.6×10^{18}	3.7×10^{18}

60-70% of the doped Cl generates carrier electrons,
→ Successfully achieved n-type conductive SnS thin films.

Contact

Tohoku Techno Arch Co., Ltd.

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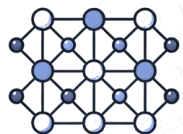
New Sulfidation Technology

Back ground

Solar cell



2-D materials



LIB materials

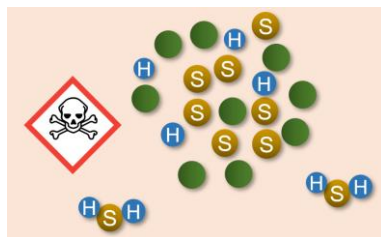
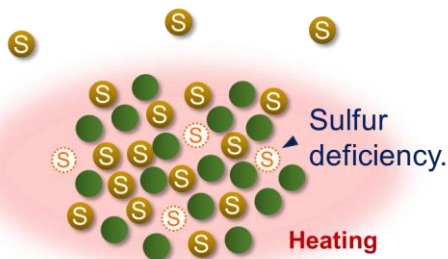


Phosphors



Sulfides are widely used in solar cells, materials science, phosphors...

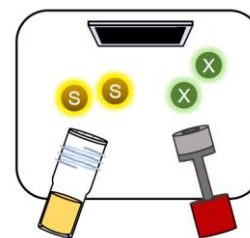
Challenges



1. Sulfur (S) has a high vapor pressure, making **S deficiency**
2. The H₂S sulfurization method faces:
 - **High toxicity**, requiring **complex and hard-to-manage**.
 - Risk of **hydrogen impurities**.

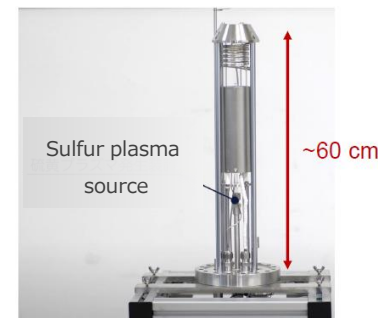
Technology

Development of sulfidation technology using sulfur plasma



Sulfur plasma source

Sputtering cathode

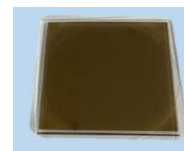


- High safety and compact equipment.
- Free from impurities.

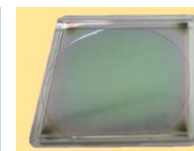
Application



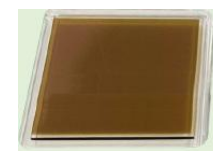
SnS



WS₂



ZnS



Cu₂S

- **Reactive sputtering** with metal targets.
- **Crystalline sulfides thin films** can be deposited at RT.

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