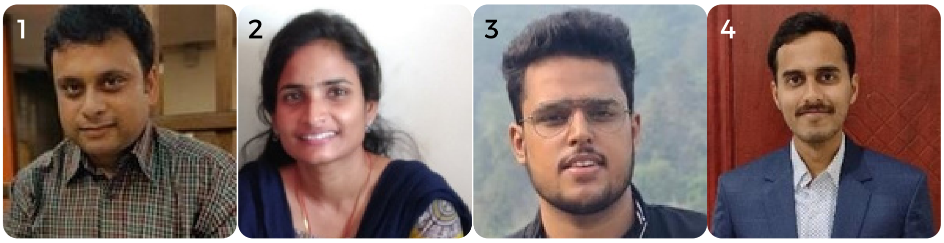
Recycling of precious & critical materials from end-of-life Solar Panels



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The transition of humanity from the Iron Age to the Digital Age has happened due to development in electronics. Due to quick development in technology and shortened product lifetime, rate of electronics being produced and used (e-wastes) are at the rise. To improve the functionality, performance, and miniaturisation of electronics, many precious materials as well as hazardous elements are employed in them. A significant quantity of resources from the earth's core are needed to create these electronic products.

Fig. 1: End-of-life Solar Panels (picture taken from the internet)

It is necessary to treat these devices properly after they reach the end of their useful lives. The concentration of metals in many components is significantly higher than present in their natural ore, therefore it may be more practical and environmentally friendly to extract them from the e-waste. Additionally, if not correctly handled, heavy metals and poisonous substances can pollute the environment and endanger human health.

Earth's resources are also finite, so it is important to reintegrate them into the economy. This could be achieved by recycling. But the research on cost-effective and environmentally safe recycling technologies is still in its infancy. Here at the combinatorial materials lab, research on developing cost-effective and environmentally safe recycling techniques on end-of-life solar panels is successfully carried out.

Crystalline solar panels have a lifespan of 25-30 years. It is projected that 12.3 million metric tonnes of solar panel waste would have reached their end-of-life by 2040. Generally, the solar panel contains very high-grade silicon (5N or more), high-quality glass, and useful metals like copper, silver, etc. Solar panels consist of critical and precious metals which could be recycled to promote Circular Economy and Urban Mining.

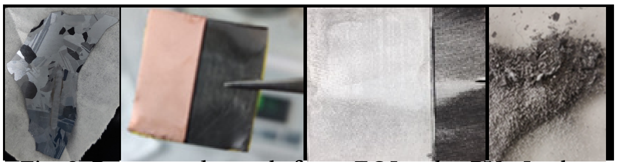

Fig. 2: Recovered metals from EOL solar PVs. In the Combinatorial Materials Lab, MSME, IITH

Combinatorial Materials Lab mainly focuses on metals recovery from end-of-life solar panels and interconnects. The lab could successfully be able to recover high-grade silicon and other materials from EOL solar chips and copper, silver, tin, and lead systematically from the photovoltaic interconnects (or PV ribbon) of spent crystalline solar modules through sequential hydrometallurgical and electrowinning methods with minimum or no wastage.

Our work could recover high-grade silicon, pure copper, and silver with >99.9% purity from the end-of-life solar panels as well as the segregation of critical materials like lead and tin. This work was also presented in 2 conferences: IIM-ATM 2022 at Hyderabad and Met-waste2023 at IIT-BHU and at Innovation Day 2023 of IIT Hyderabad. Recycling and recovery of these end-of-life solar panels is crucial and important to address the 'Waste-2-Wealth' initiative. Moreover, under India Semiconductor Mission (ISM), to make India a global hub for electronics manufacturing and design, the recycling of end-of-life solar panels can provide significant contributions towards resource management, especially in producing high-grade silicon and recovery & reuse of precious and critical materials for specific applications.

Proper e-waste resource engineering and management is required to address the challenges of end-of-life solar photovoltaics. A technology (TRL 4) on sequential recoveries of tin, silver, copper, lead, and silicon is achieved through combined Hydro- & electro-metallurgical routes from the EOL Si PVs and their Interconnects.

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