An Autonomous Materials Platforms for Identifying Inorganic Photovoltaics Beyond Lead Halide

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1. Introduction

Silicon photovoltaics are approaching practical single-junction efficiency limits, motivating the development of tandem architectures in which silicon is paired with an additional absorber. Lead halide perovskites have demonstrated strong performance in this role, but concerns related to stability and toxicity have prompted the search for alternative materials.

Inorganic, solution-processable absorbers offer a promising pathway toward stable and scalable tandem photovoltaics, yet their vast chemical design space makes efficient discovery challenging. In this work, we present an autonomous materials discovery platform that accelerates the identification of such absorbers by integrating robotic ink formulation, thin-film fabrication, and automated structural, optical, and electronic characterisation. The platform enables systematic exploration of candidate materials relevant to tandem silicon solar cells.

2. Autonomous PV Materials Discovery

The proposed autonomous platform integrates robotic experimentation and automated characterisation into a closed-loop workflow for photovoltaic materials discovery. The system combines robotic ink formulation, solution-based thin-film deposition, and rapid structural, optical, and electronic measurements, enabling consistent and reproducible evaluation of candidate absorber materials.

Materials exploration begins with automated preparation and deposition of precursor inks spanning targeted regions of inorganic chemical space. Thin films are subsequently characterised to assess crystallinity, optical absorption, and key electronic properties relevant to photovoltaic performance. This integrated pipeline allows unpromising candidates to be efficiently screened out, focusing experimental effort on the most promising materials.

By operating autonomously with minimal human intervention, the platform enables sustained exploration of large design spaces that would be impractical using manual approaches. In addition to accelerating experimental throughput, the workflow standardises fabrication and measurement conditions, improving comparability across experiments. We demonstrate how this approach facilitates efficient identification of inorganic absorbers for tandem silicon photovoltaics while revealing practical constraints related to ink stability, film formation, and structure–property trade-offs.

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