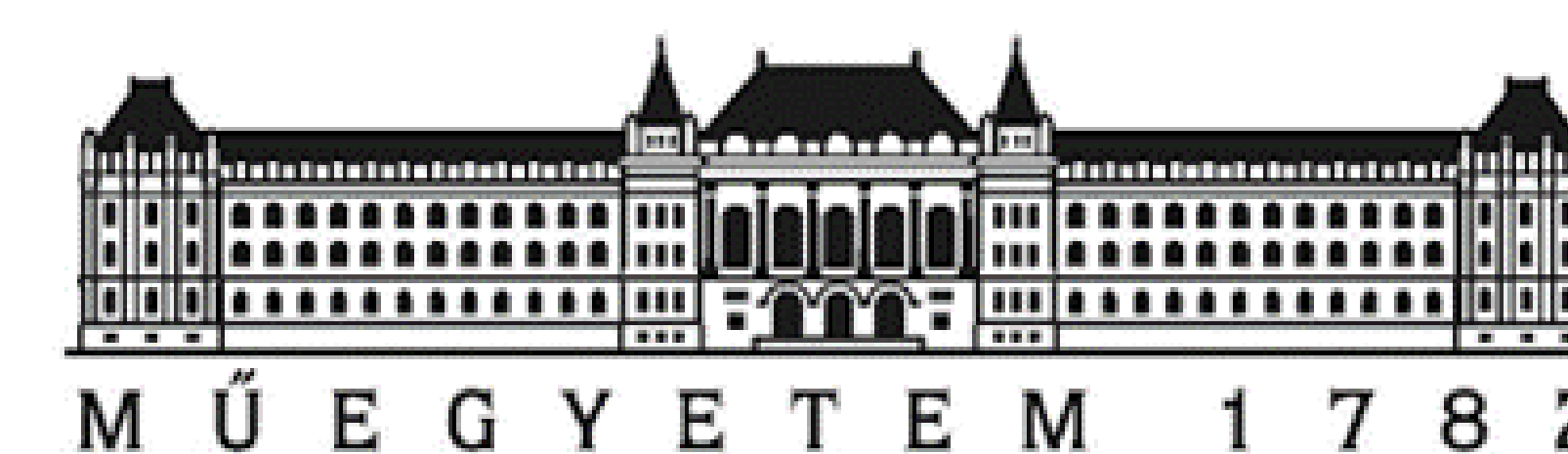


Optical Properties of Organo-Lead-Halide Perovskite Layers at Elevated Temperatures determined using Spectroscopic Ellipsometry

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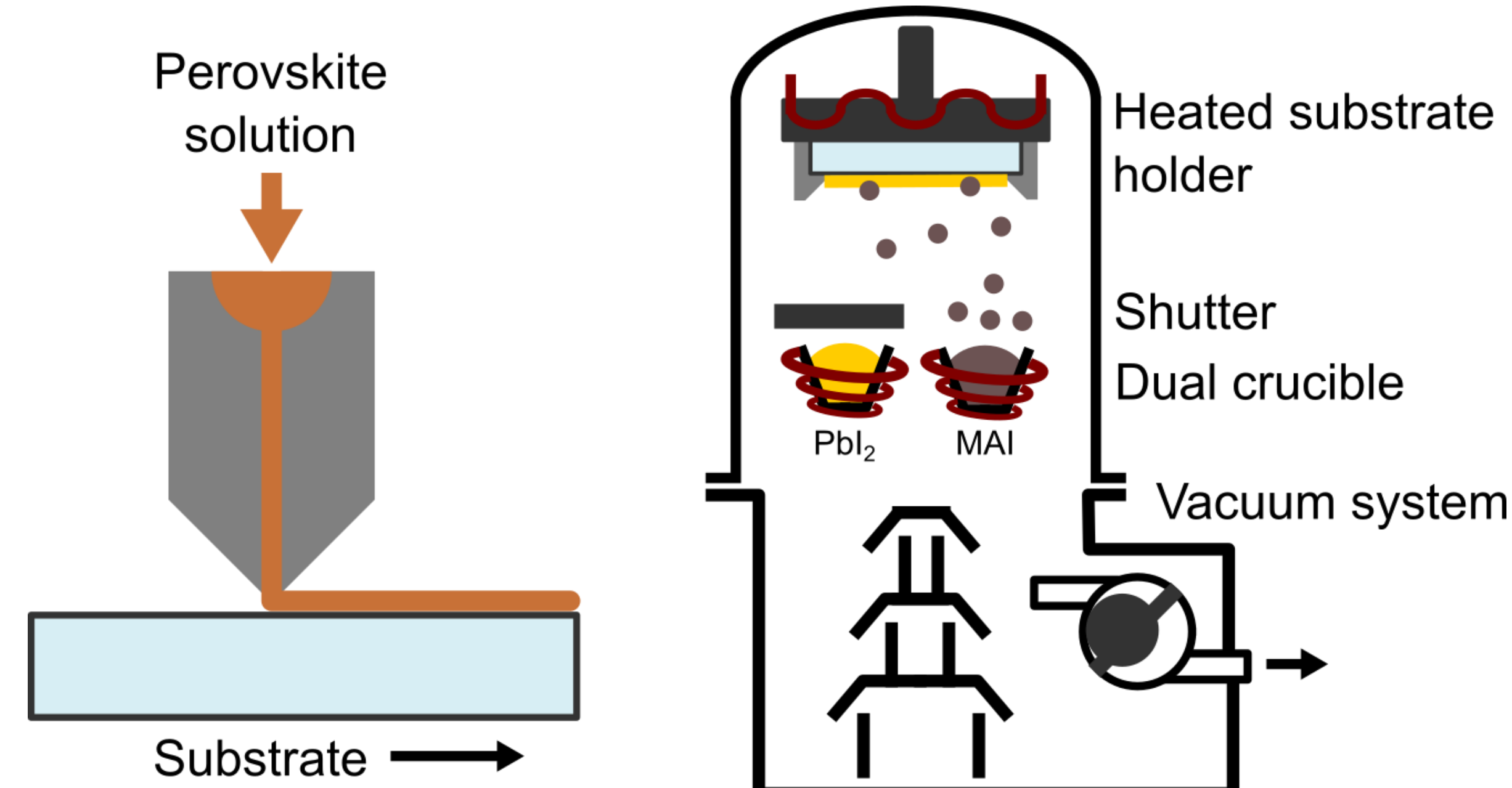
Introduction

Solar cells on the field operate at a wide range of environments. Temperatures can reach as high as 70 °C and sunlight spectrum varies, yet solar cells are usually only qualified at standard conditions (25 °C, 1000 W/m² intensity, AM1.5 spectrum). For the best efficiency and longevity, photovoltaic devices such as perovskite solar cells must be optimized based on an accurate understanding of environmentally dependent properties and effects. This is especially important for tandem cells due to their coupled nature. In this work we present a study of the temperature-dependence of optical parameters of MAPbI₃ perovskite, using spectroscopic ellipsometry (SE).

Sample preparation

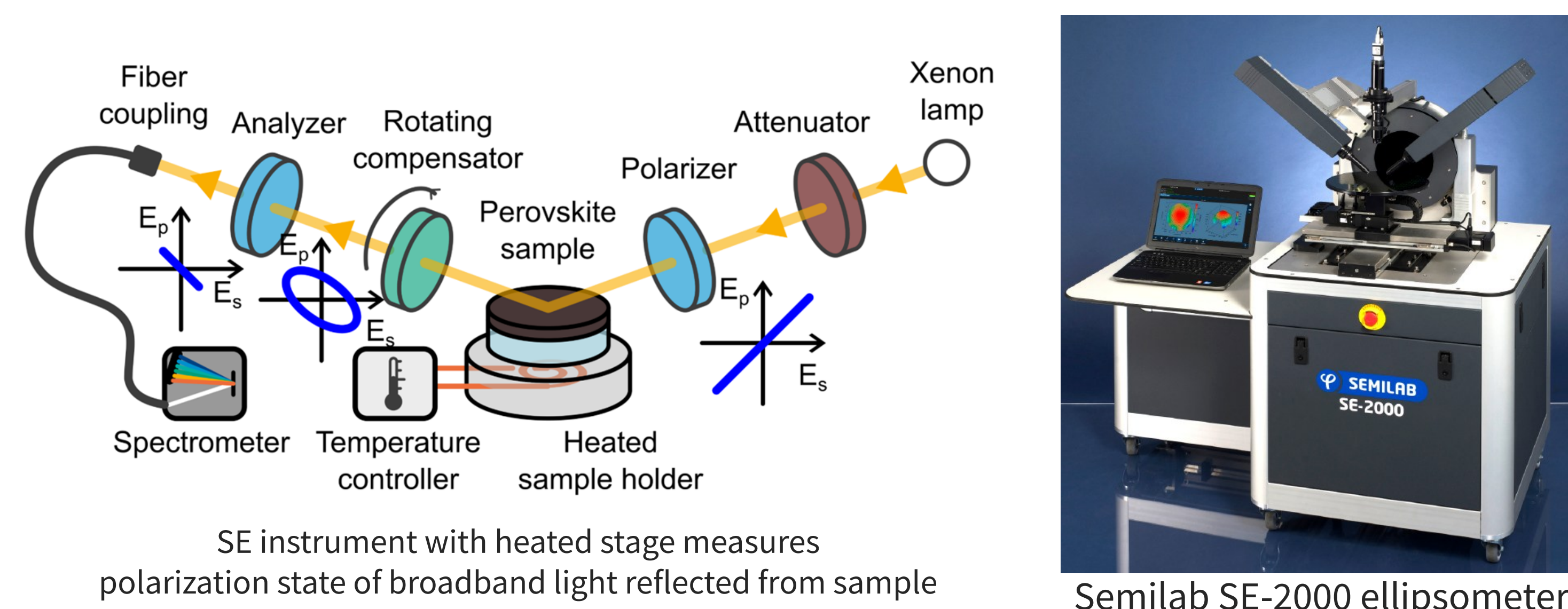
Two types of methylammonium-lead-triiodide (MAPbI₃) perovskite samples on glass substrates examined:

- a) Manufactured by industry partner using slot-die coating b) Prepared in our research lab using sequential vacuum evaporation [2]



Spectroscopic ellipsometry (SE)

SE measures polarization change of reflected light → $\Psi(\lambda)$, $\Delta(\lambda)$
Temp.-dependent behavior is studied using open-air heated stage.



Optical model → initial parameters → fit → thickness, $n(\lambda)$, $k(\lambda)$ → $\alpha(\lambda)$
Non-contact, non-destructive, fast, absolute method for thin film characterization [1].

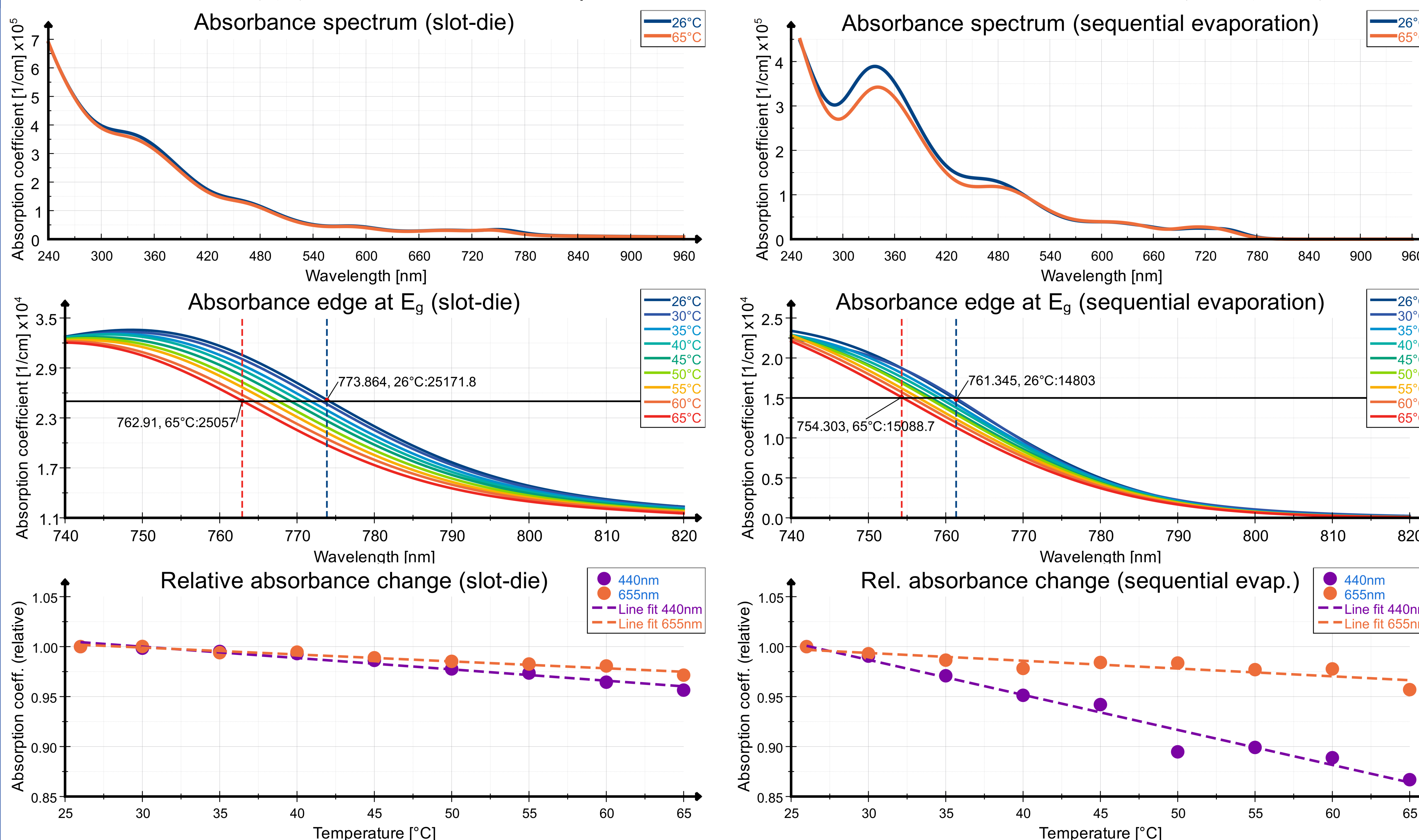
Results and discussion

Samples measured from room temperature (26°C) to 65°C on UV-VIS-NIR region

Glass substrate modeled using *Cauchy* dispersion law | MAPbI₃ modeled using *Tauc-Lorentz* laws for band-gap and several *Gaussian* laws for absorption region | surface roughness modeled by *EMA* method [5].

Band-gap determination refined using geometric critical point analysis [3], $\alpha(T)$ calculated for select wavelengths.

- ~6-10nm blueshift in band-gap → -0.15 nm/K...-0.25 nm/K; slightly lower for evaporated MAPbI₃.
- ~4-10% decrease in absorption coeff. → -0.1 %/K...-0.25 %/K; temp. dependence depends on the preparation.
- Slot-die MAPbI₃ Band-gap is close to literature value of 1.56–1.59 eV (800 nm) → reliable method
- Conclusions from $\alpha(\lambda, T)$ are consistent with temperature coefficients from I-V measurements of cells (V_{oc} ↑, I_{sc} ↓) [4]



CONCLUSION: SE is able to detect even small differences between similar sample types. Therefore, it is suitable for accurate characterization of temperature-dependent optical properties of perovskite photo-absorbers in a simple way, without requiring fully enclosed chambers or complete device fabrication.

References

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