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Nanostructured Poly-Si and Poly-SiGe Layers for Enhanced Energy Harvesting Applications

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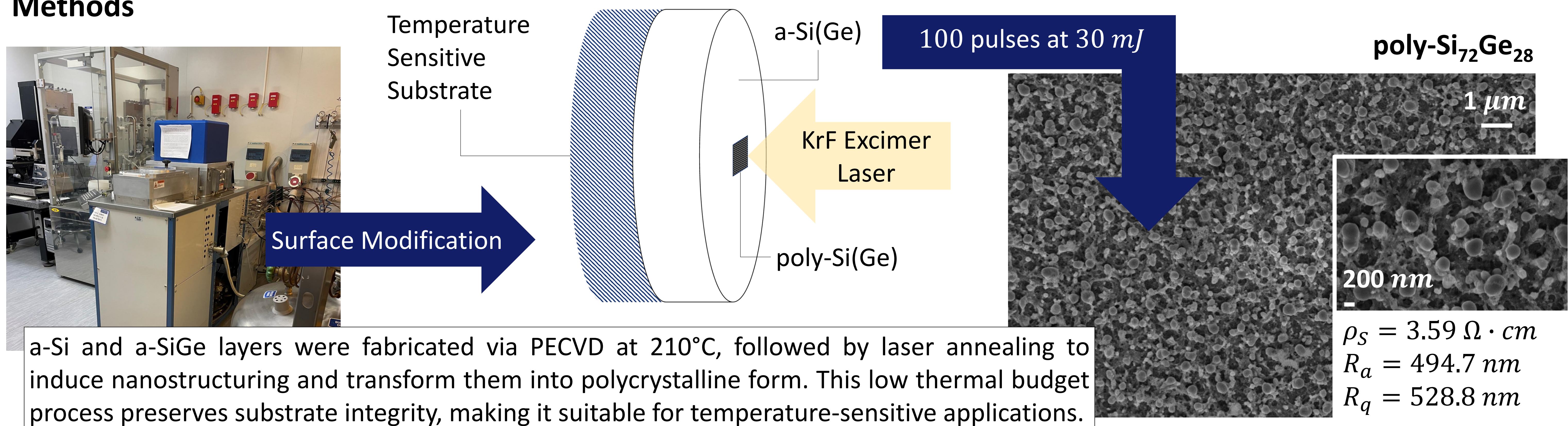
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Introduction

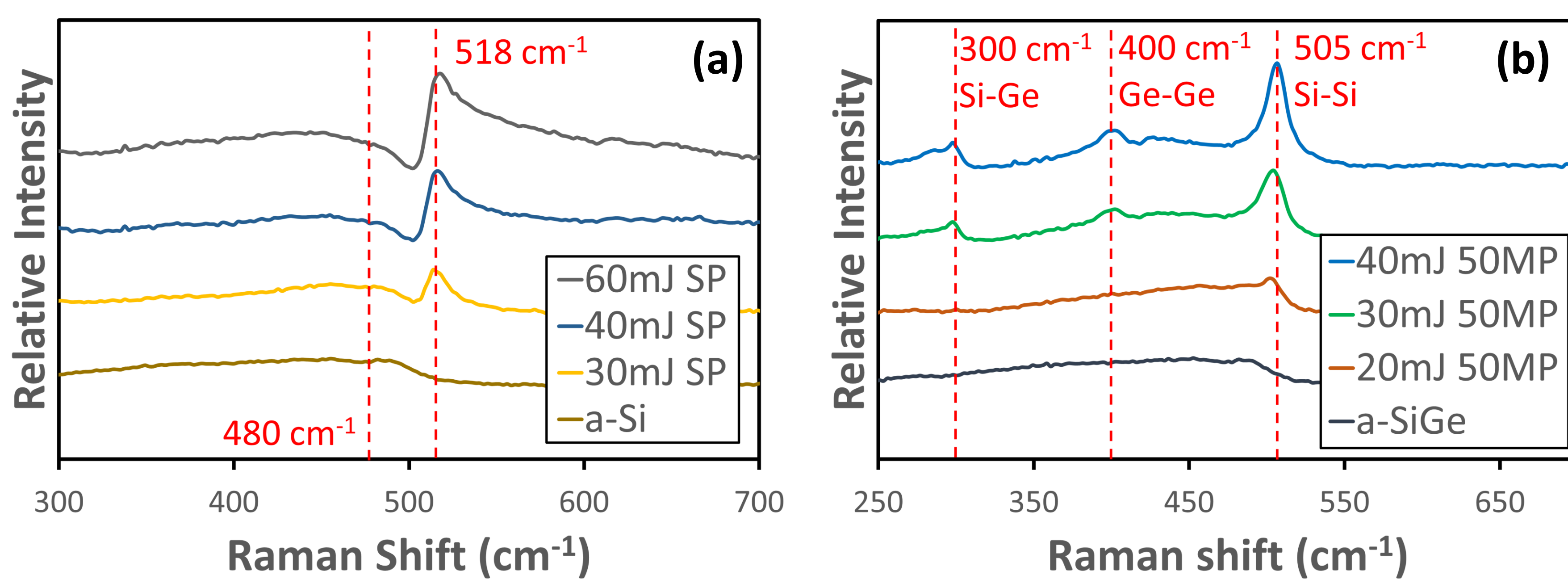
Energy harvesting focuses on capturing small amounts of energy from ambient sources, such as light, heat, and vibrations, to power low-energy devices. In this work we present a waste-free, low thermal budget fabrication method for nanostructured polycrystalline silicon (poly-Si) and silicon-germanium (poly-SiGe) layers. These nanostructured layers significantly improve optical absorption and, in the case of poly-SiGe, enhance thermoelectric performance, making them ideal for hybrid energy harvesting applications on temperature-sensitive substrates where efficient, low-cost, and high-output devices are needed.

Methods

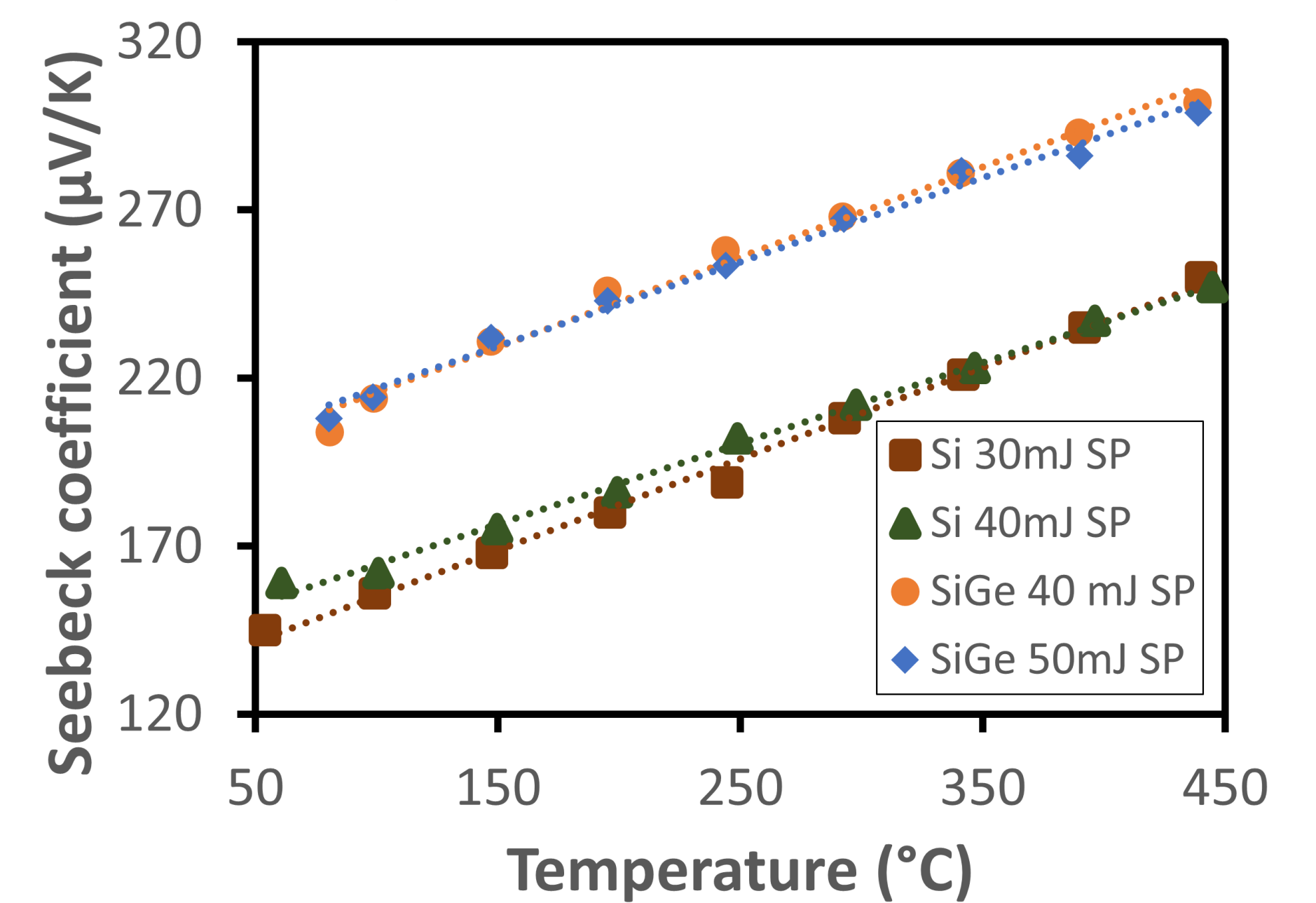


Results

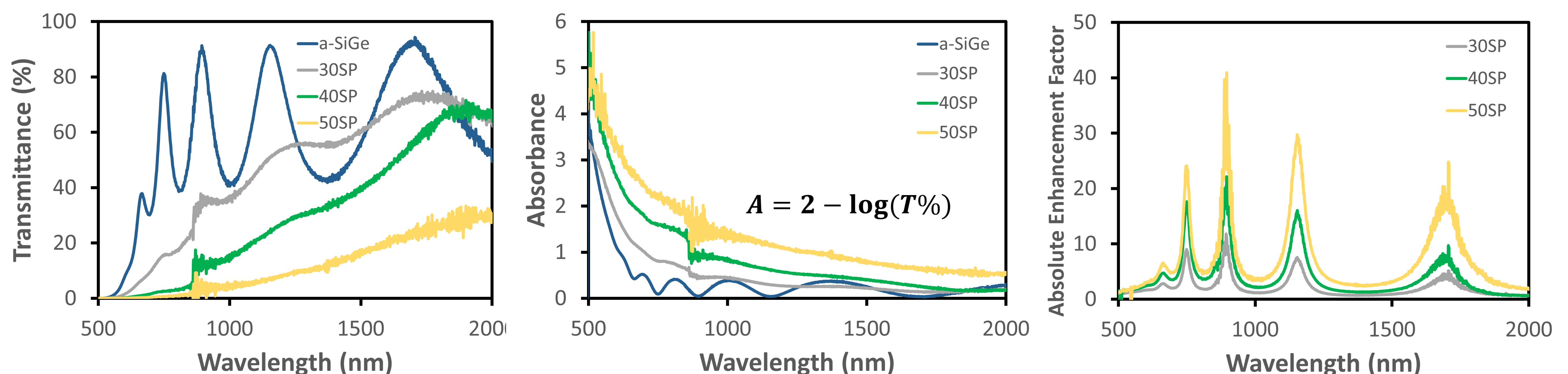
Raman spectra of (a) a-Si and (b) a-SiGe layers, and polycrystalline layers annealed with (a) single (SP) and (b) multiple pulses (MP) at varying energies.



Seebeck coefficient in nanostructured Si and Si₇₂Ge₂₈ layers exceeds conventional methods, which peak at 160 μV/K at 900°C.¹ (Measurements use ULVAC ZEM-3)



Optical spectra reveal that increasing laser energy reduces transmission at longer wavelengths, due to higher absorption by crystalline Si(Ge) compared to its amorphous form.^{2,3} (Spectra are collected using the UV-Vis-IR Perkin Elmer Lambda 1050+)



Conclusions

Surface nanostructuring of a-Si and a-Si₇₂Ge₂₈ with a KrF excimer laser enhances optical absorption and thermoelectric properties. Adjusting laser parameters produced polycrystalline layers, with poly-Si₇₂Ge₂₈ showing a 43-fold increase in absorption at 880 nm and a Seebeck coefficient rise from 215 μV/K at 100°C to 300 μV/K at 450°C, indicating potential for hybrid energy harvesting.

References:

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2. Hernández-Como, N. *et al.* Simulation of Hetero-Junction Silicon Solar Cells with AMPS-1D. Solar Energy Materials and Solar Cells 2010, 94, 62–67.
3. Cao, Y. *et al.* Size-Dependent and Enhanced Photovoltaic Performance of Solar Cells Based on Si Quantum Dots. Energies 2020, 13, 4845.