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### ► To cite this version:

Sibel Nar, Arnaud Stolz, Denis Machon, Eric Bourhis, Pascal Andrezza, et al.. Characterization and Seebeck coefficient of mesoporous silicon: effect of nanographene incorporation. 19th European Conference on Thermoelectrics (ECT 2023), Sep 2023, Prague, Czech Republic. hal-04229869

**HAL Id: hal-04229869**

**<https://hal.science/hal-04229869v1>**

Submitted on 5 Oct 2023

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# Characterization and Seebeck coefficient of mesoporous silicon: effect of nanographene incorporation

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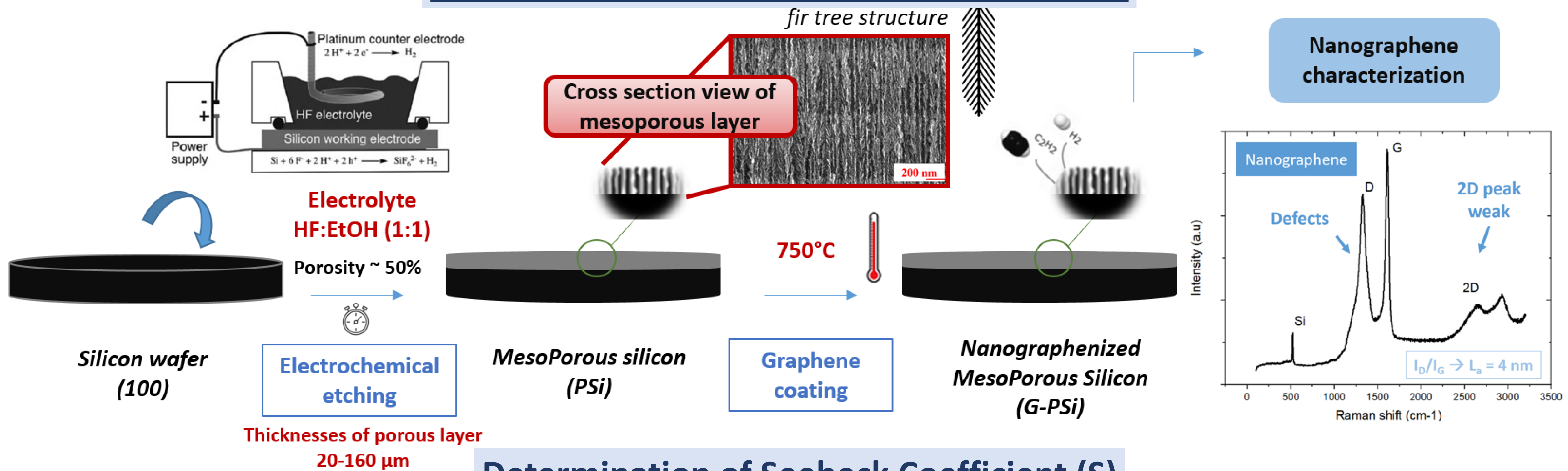
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## Context

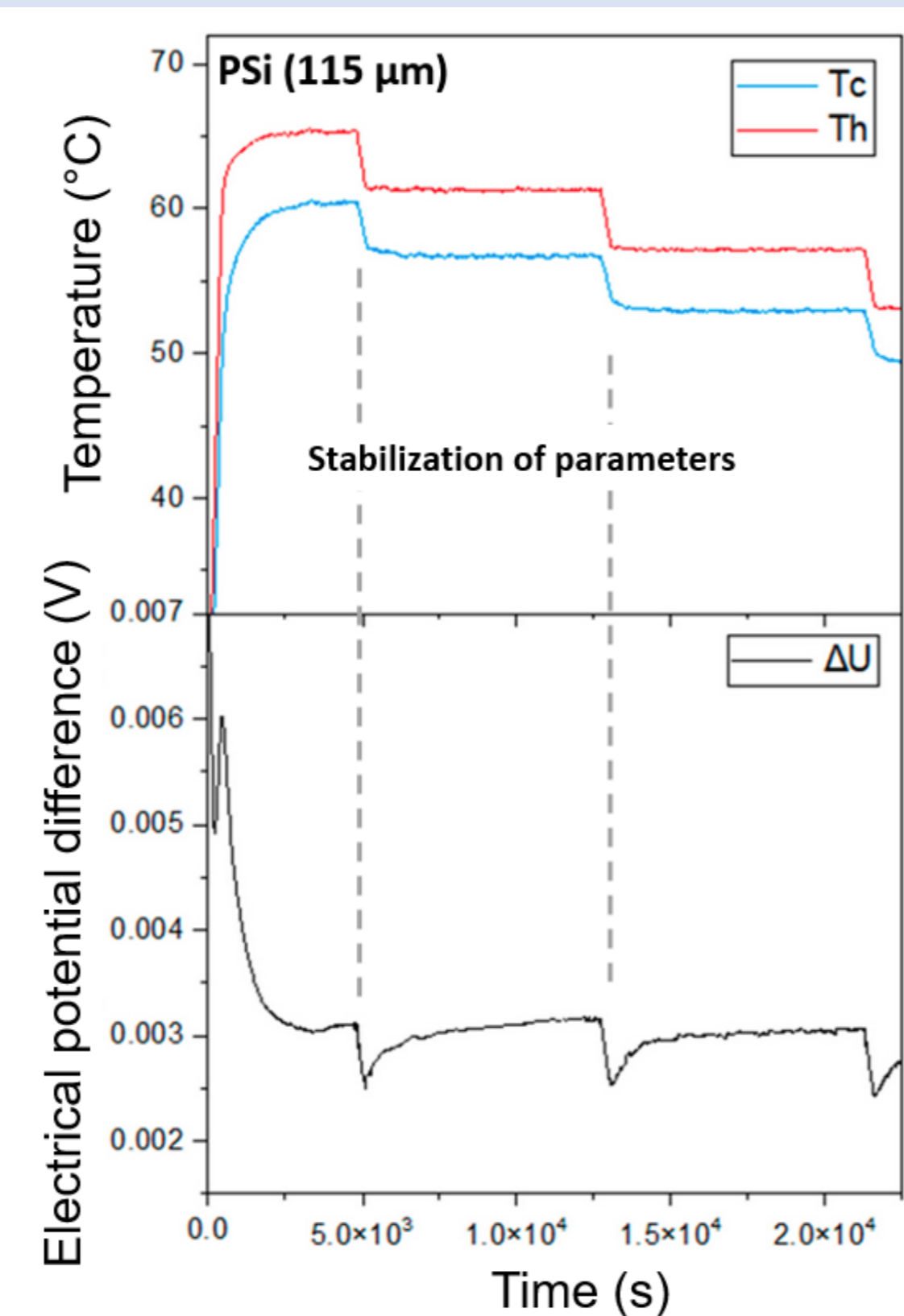
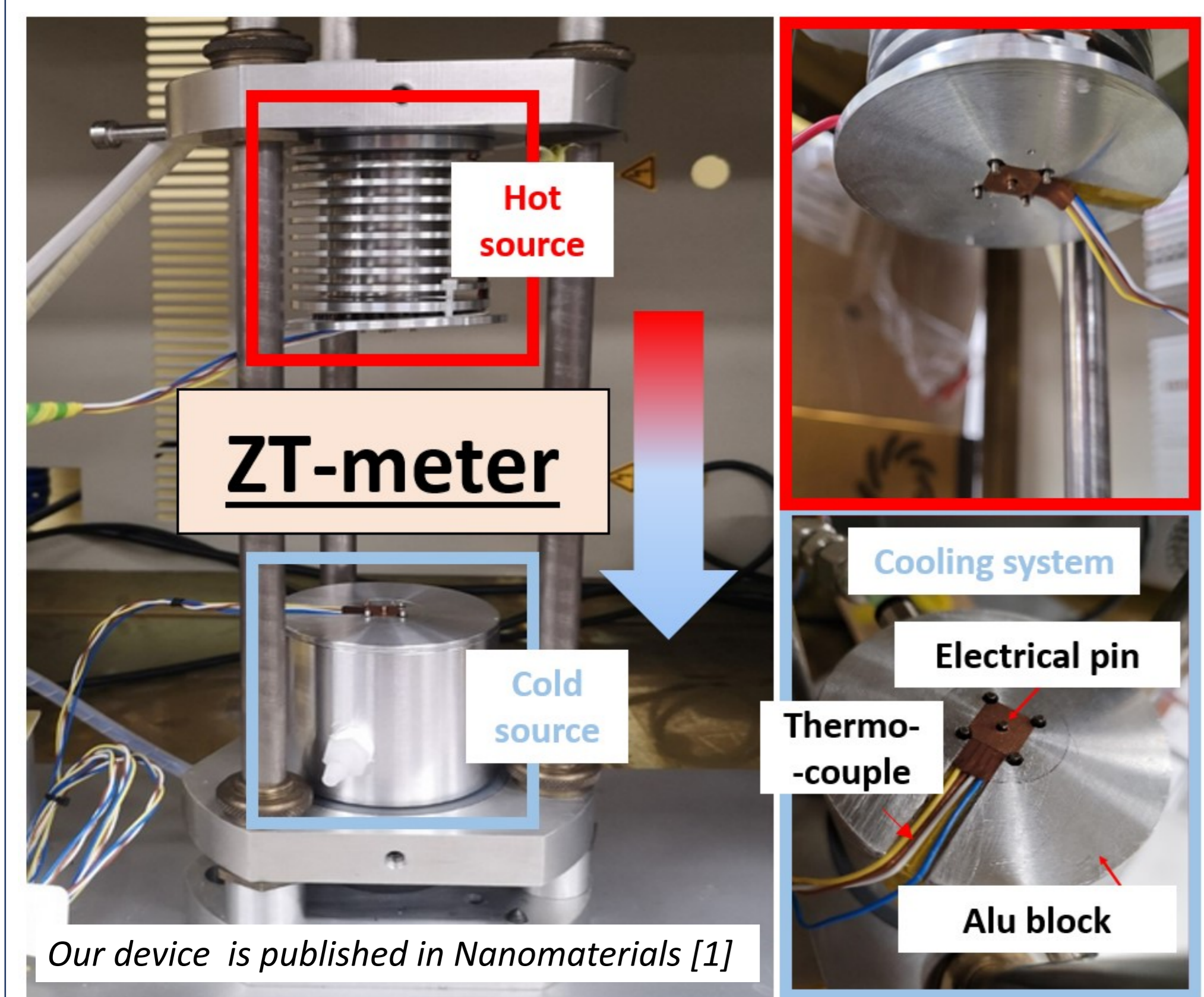
Nanographene-coated mesoporous silicon have recently been evaluated and have shown particular interest thanks to a controllable and simple to implement synthesis thus making it possible to correlate their physical properties with their morphological structure. In this study, the impact of nanographene incorporation is studied on the power factor ( $\sigma S^2$ ) depending on Seebeck coefficient and electrical conductivity.

- Synthesis of mesoporous silicon by electrochemical etching (PSi) & nanographene insertion (G-PSi) by Chemical Vapor Deposition (CVD)
- Seebeck coefficient determination by two methods : ZT-meter (in-depth) & UPS Spectroscopy (in-plane)
- Impact of nanographene insertion on power factor

## Synthesis and characterization of PSi & G-PSi



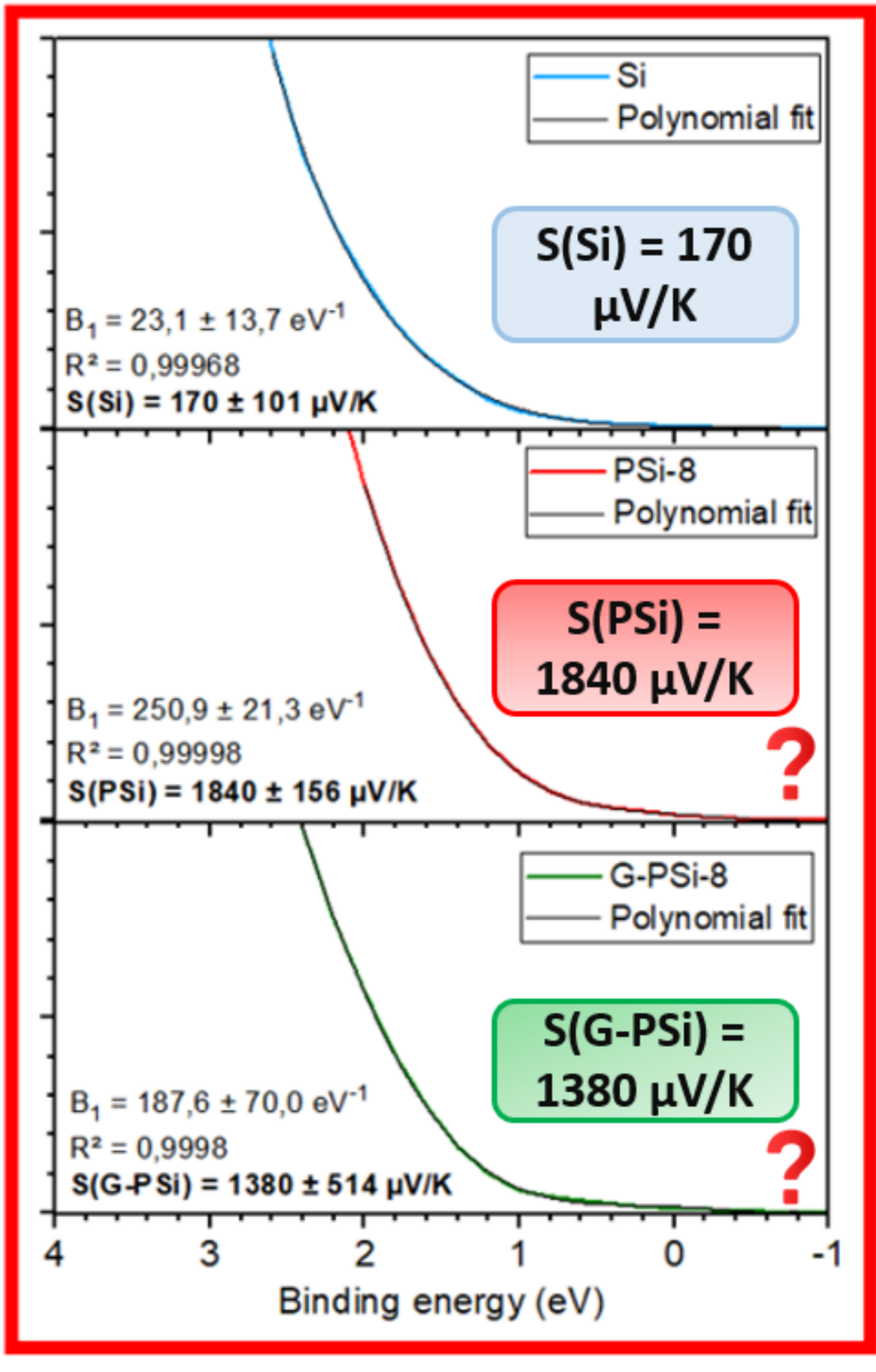
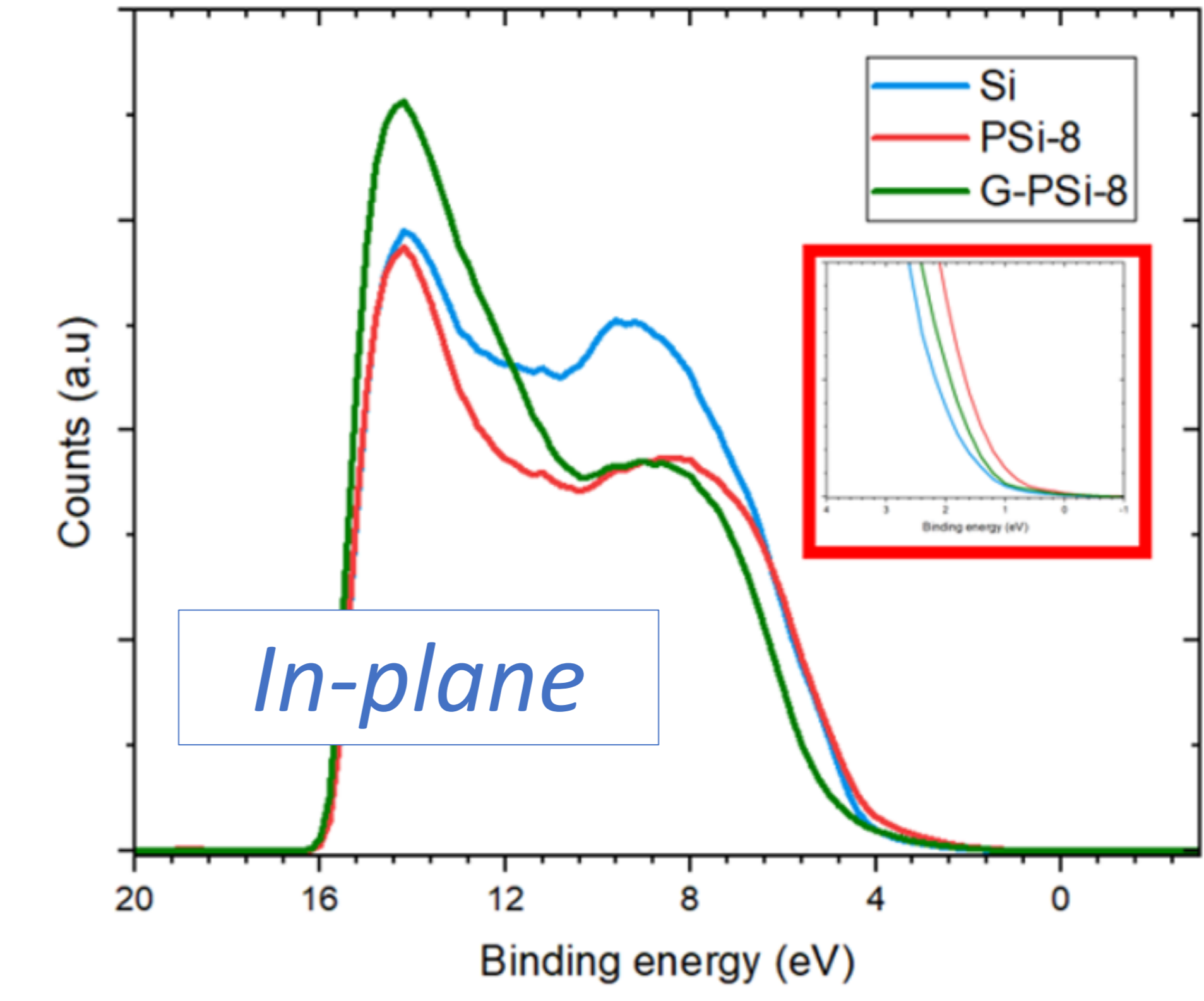
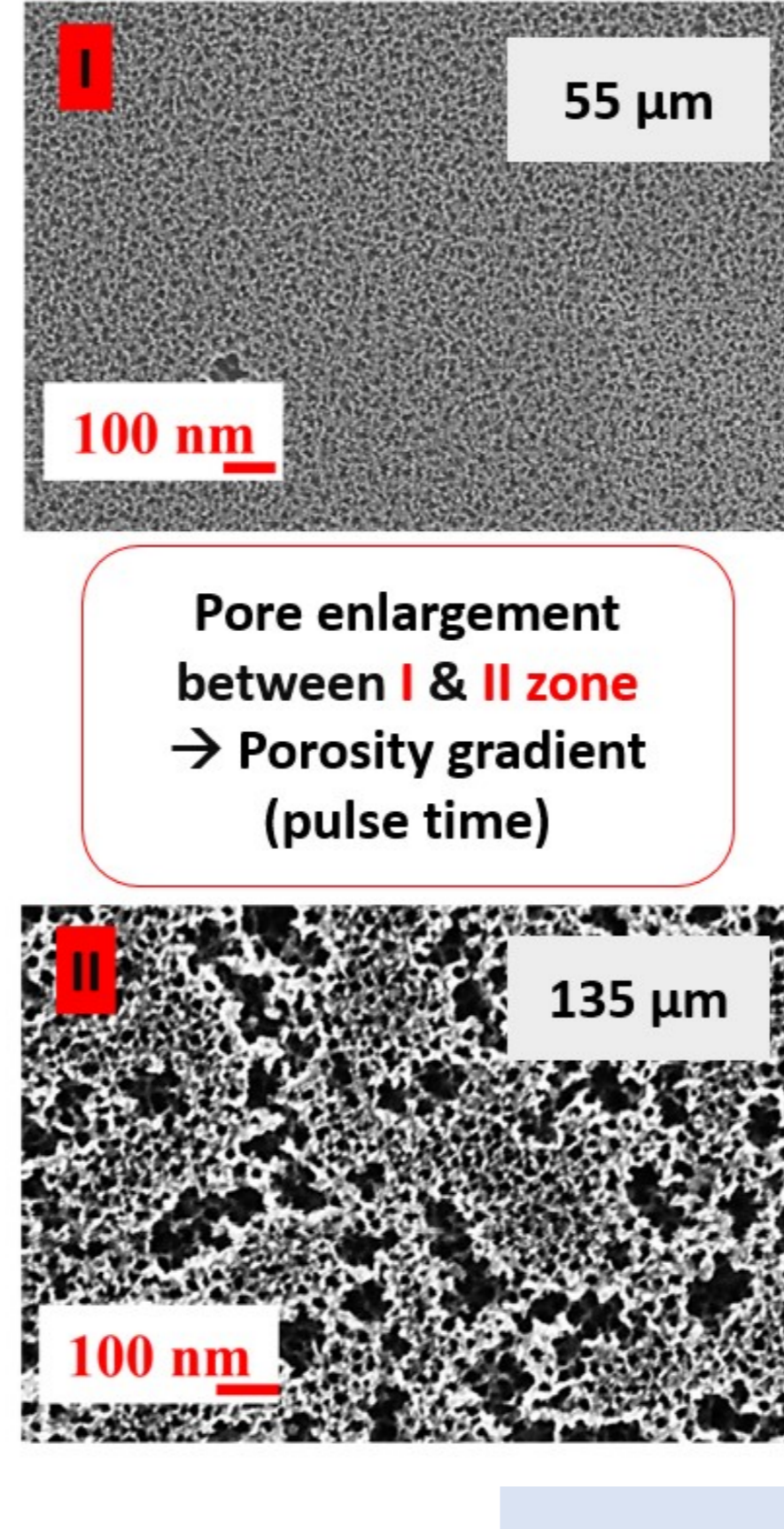
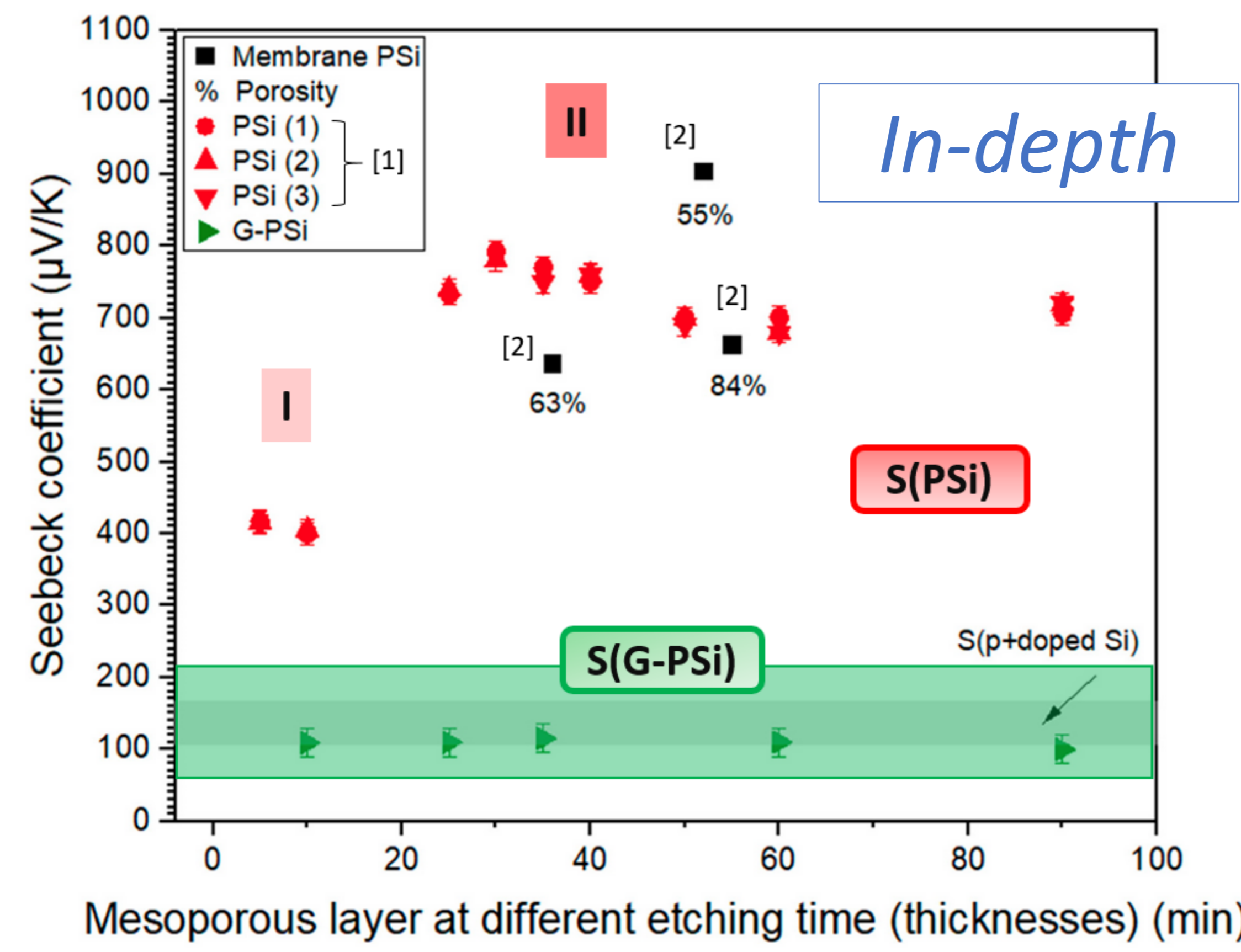
## Determination of Seebeck Coefficient (S)



**Mott's Formula**  
 Estimation of S by study of UPS spectrum analysis (Fermi level)  

$$S(E, T) = \frac{\pi^2}{3} \cdot \frac{k_B^2 T}{q} \left( \frac{\partial \ln(\sigma(E))}{\partial E} \right)_{E = E_F}^*$$
  
 Derivative of the polynomial function to obtain \* at x=0  

$$y = A + B_1 x + B_2 x^2 + B_3 x^3 + B_4 x^4 + B_5 x^5$$



## Conclusion

We successfully measured the Seebeck coefficient of PSi, which is  $750 \pm 40 \mu\text{V/K}$ , uncorrelated with the mesoporous thickness and the Si sublayer. The oxide layer on the surface would explain the higher S values in the case of PSi and G-PSi. A decrease of Seebeck coefficient with the insertion of nanographene can be linked to the electrical conduction of the nanographene, which is higher than that of the mesoporous structure permitting to have a better power factor, to be increased to  $281 \pm 153 \mu\text{W/m.K}^2$ , i.e. 4 times higher than the PF of PSi.

[1] Nar, S.; Stolz, A.; Machon, D.; Bourhis, E.; Andrezza, P.; Boucherif, A.; Semmar, N. Effect of Nanographene Coating on the Seebeck Coefficient of Mesoporous Silicon. *Nanomaterials* **2023**, *13*, 1254. <https://doi.org/10.3390/nano13071254>.  
 [2] Valalaki, K.; Benech, P.; Nassiopolou, A.G. High Seebeck Coefficient of Porous Silicon: Study of the Porosity Dependence. *Nanoscale Res Lett* **2016**, *11*, 201. doi:10.1186/s11671-016-1411-z.