Thermal emissivity of silver nanowire networks : a characterization tool for instability studies

LIÈGE université Physique SPIN

CSL CENTRE SPATIAL DE LIÈGE

A. Baret[1], F. Balty[1,2], C. Gobron[1], A. Daloze[1], M. Georges[3], N. D. Nguyen[1]

[1] Université de Liège, Département de Physique, SPIN, B-4000 Liège, Belgium

[2] Université de Liège, Département de Physique, EPNM, B-4000 Liège, Belgium

[3]Centre Spatial de Liège, STAR Institute, Université de Liège, Liège, Belgium

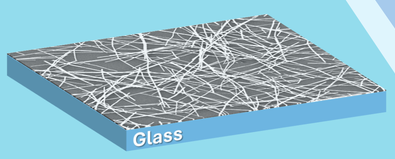
Learn more !

abaret@uliege.be

Introduction

Silver nanowire (AgNW) networks offer excellent optoelectronic performance with low material consumption and production costs. However, AgNWs are thermally unstable near 300 °C, where nanowire spheroidization leads to the loss of network connectivity[1], hindering their integration in complex devices[2]. In large-area devices, even localized degradation can compromise overall performance, highlighting the need for efficient techniques to identify and characterize locally damaged regions. Current assessments typically depend on time-consuming characterization by electron microscopy.

AgNW Networks

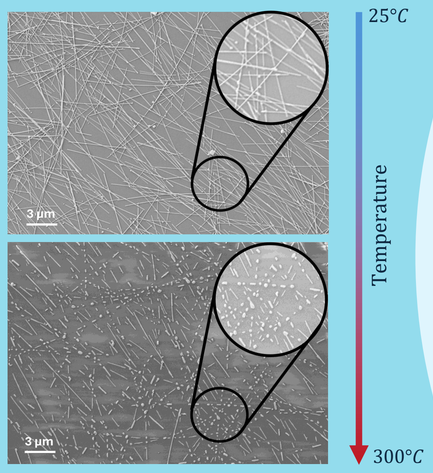


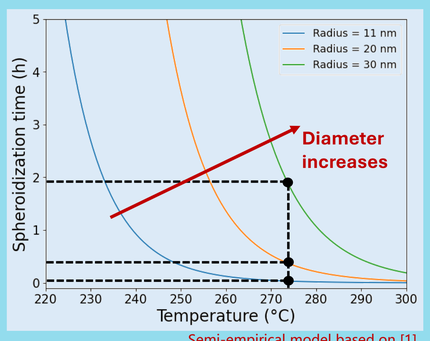
Highly transparent

Excellent conductors

Cheap fabrication processes

Spheroidization

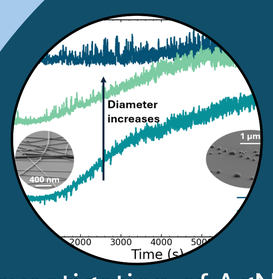




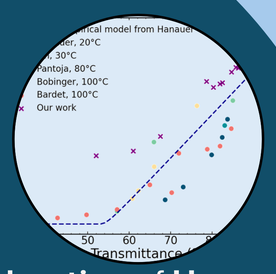
Semi-empirical model based on [1]

- Performance **degradation**
- No **apparent visual** changes

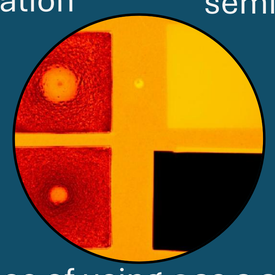
Key concepts



Investigation of AgNW networks degradation dynamics



Exploration of **Hanauer**'s semi-empirical model[3]

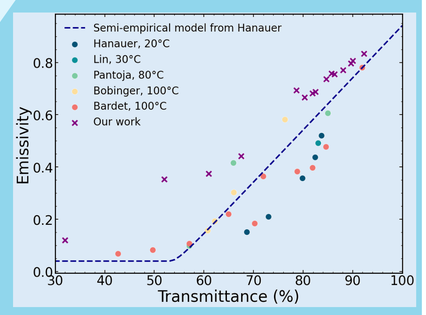


Relevance of using ϵ as a **spatially-resolved**, **non-invasive** & cheap integrity **metric** correlated with electrical properties

AgNW networks

Emissivity

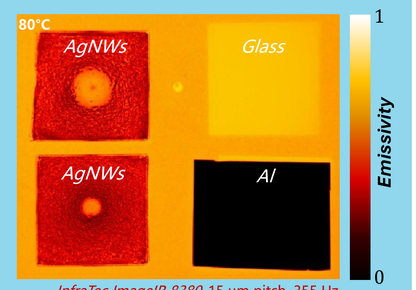
Hanauer's semi-empirical model



$$\epsilon(T) = \sqrt{\epsilon^{Ag^2} + \left(\epsilon^{Ag} + \epsilon^{sub}(1-\eta) + (\epsilon^{sub} - \epsilon^{Ag}).T\right)^2}$$

Weighted surface average

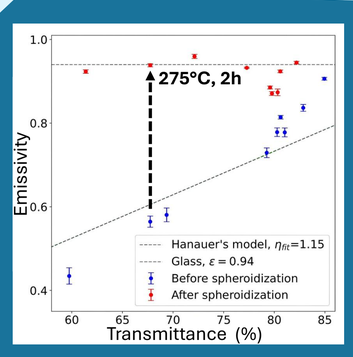
Measurement

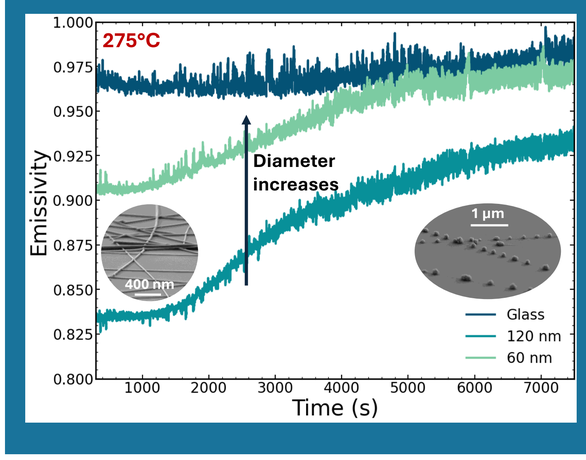


InfraTec ImageIR 8380, 15 µm pitch, 355 Hz

- **Spatially** resolved
- **Non-invasive**

Results





- **Spheroidization** is clearly associated with a **change** in **emissivity**
- **Emissivity** after spheroidization matches that of **glass**
- **No** significant **change** in the **transmittance** for a given sample
- **Quantifiable data** on the **kinetics** of the degradation (***in-situ*** measurement)

Conclusions

In summary

- **Experimental validation** of Hanauer's law
- **Emissivity** as a **proxy** for **local** networks **integrity**
- **Kinetics** depend on NWs **diameter**

Perspectives

- Systematic parameter investigation (NWs diameter, density, substrate)
- Correlation with local resistivity measurements
- Kelvin-probe microscopy

Want to learn more on AgNW networks ?

Room 2, O23, 21st Oct. 25, 18h30

References

[1] Balty *et al.*, JCIS, 673: 574-582 (2024).

[2] Hanauer *et al.*, ACS Appl. Mater. Interfaces, 13.18: 21971-21978 (2021).

[3] Baret *et al.*, Nanoscale 16.17: 8361-8368 (2024).

TCM-TOEO 2025

Rethymno, Greece

19th October 2025

Acknowledgments

M-ERA.NET program (INSTEAD project). Computational resources have been provided by the Consortium des Équipements de Calcul Intensif (CÉCI), funded by the Fonds de la Recherche Scientifique de Belgique (F.R.S.-FNRS) under Grant No. 2.5020.11 and by the Walloon Region. A. B. and N. D. N. acknowledge the financial support from F.R.S.-FNRS via the CDR project J.0124.19 and the PINT-MULTI project R.8012.20.