On the thermal emissivity of highly efficient VO_2-based thermochromic stacks coated with silver nanowires networks

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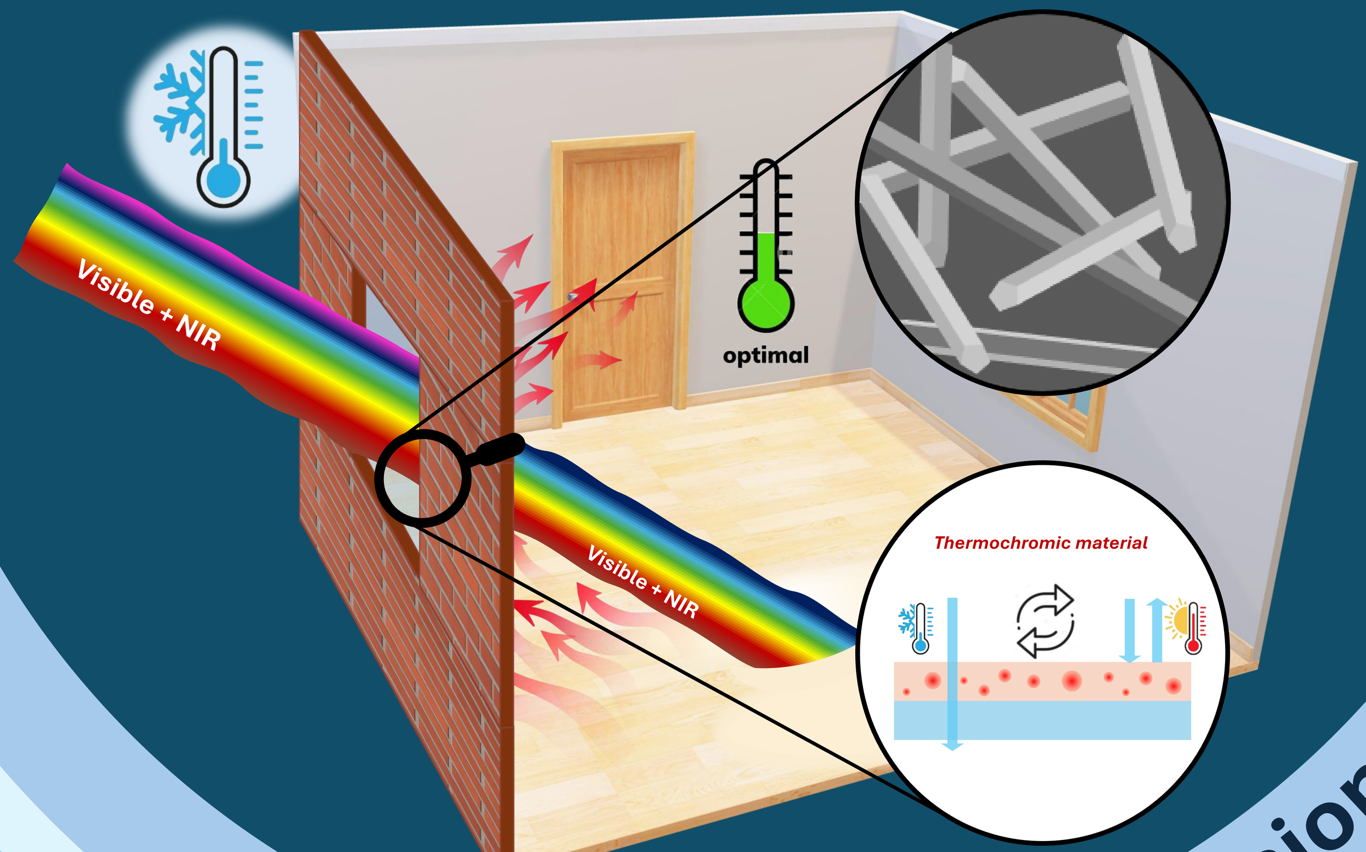
Abstract

In response to the urgent need for environmentally sustainable alternatives to combat climate change, considerable attention has been directed towards the development of functional materials for energy management. Among these, thermochromic-based smart windows have emerged as a significant area of interest due to their ability to dynamically and passively regulate the amount of sunlight entering a building while maintaining consistently high visible transmittance. Additionally, low thermal emissivity is crucial for energy efficiency in cold climates.

Introduction

Key concepts

- Design of **efficient** thermochromic multilayer stacks
- Introduction of an **original figure of merit** tailored to reflect on experimental data
- Demonstration of the **relevance** of using **silver nanowire networks** as low-emissivity coatings for VO_2 **NPs-based** stacks



Stack optimization

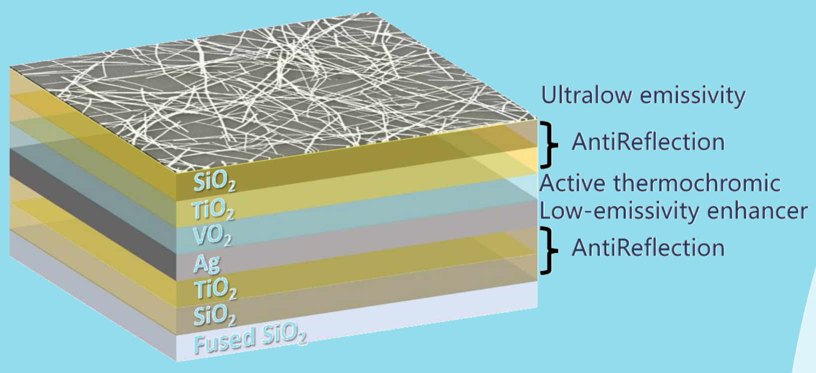
Thermochromic properties

Luminous transmittance T_{lum}

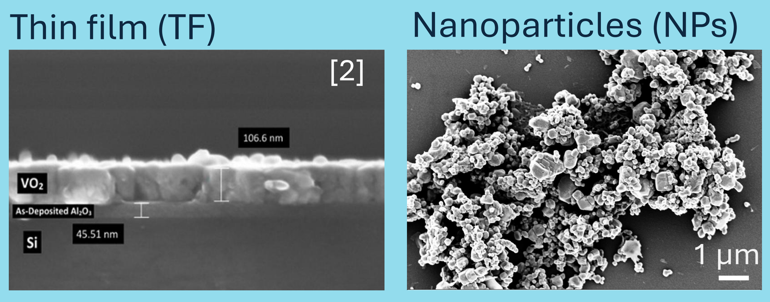
Solar modulation ΔT_{sol}

$FOM = \Delta T_{sol} \times T_{lum}^4$

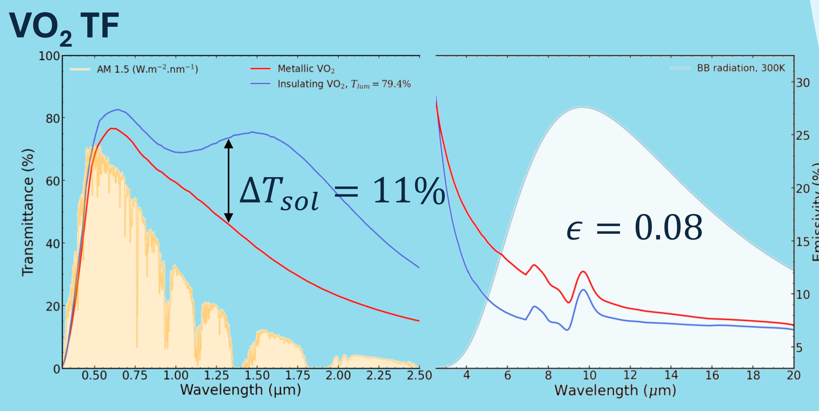
- Quantifiable optimization
- Application-oriented
- Comparability



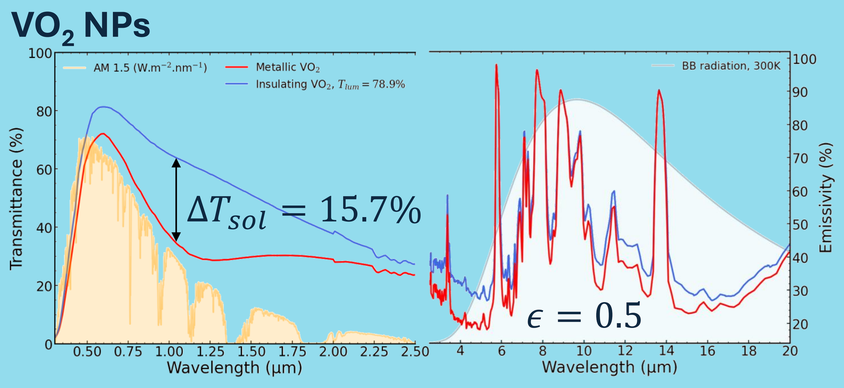
Thin film (TF) Nanoparticles (NPs)



VO_2 TF



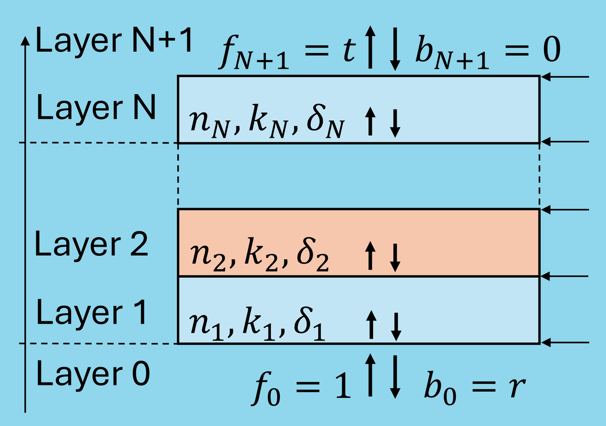
VO_2 NPs



- Excellent thermochromic properties
- Low ϵ for TF
- High ϵ for NPs

Methods

Transfer-matrix approach

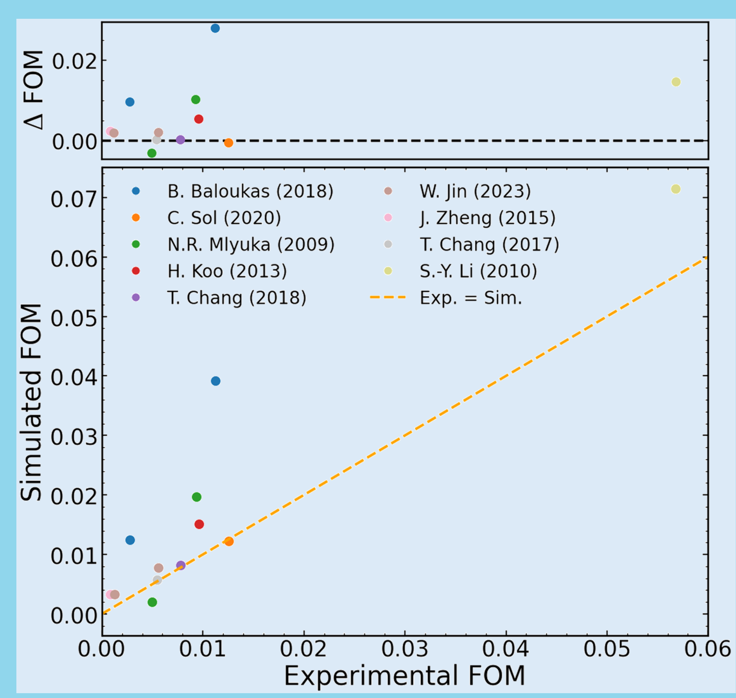


$(T(\lambda), R(\lambda), A(\lambda))$

Matrix version of the Fresnels and Beer-Lambert equations [1]

$\epsilon(\lambda) = A(\lambda) = 100 - R(\lambda) - T(\lambda)$

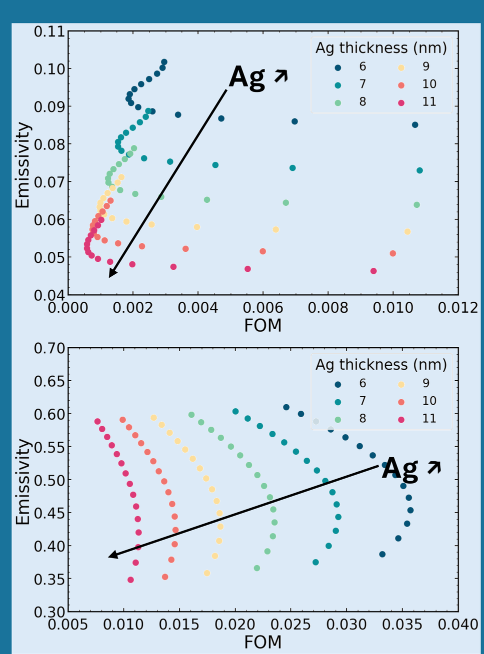
Method validation

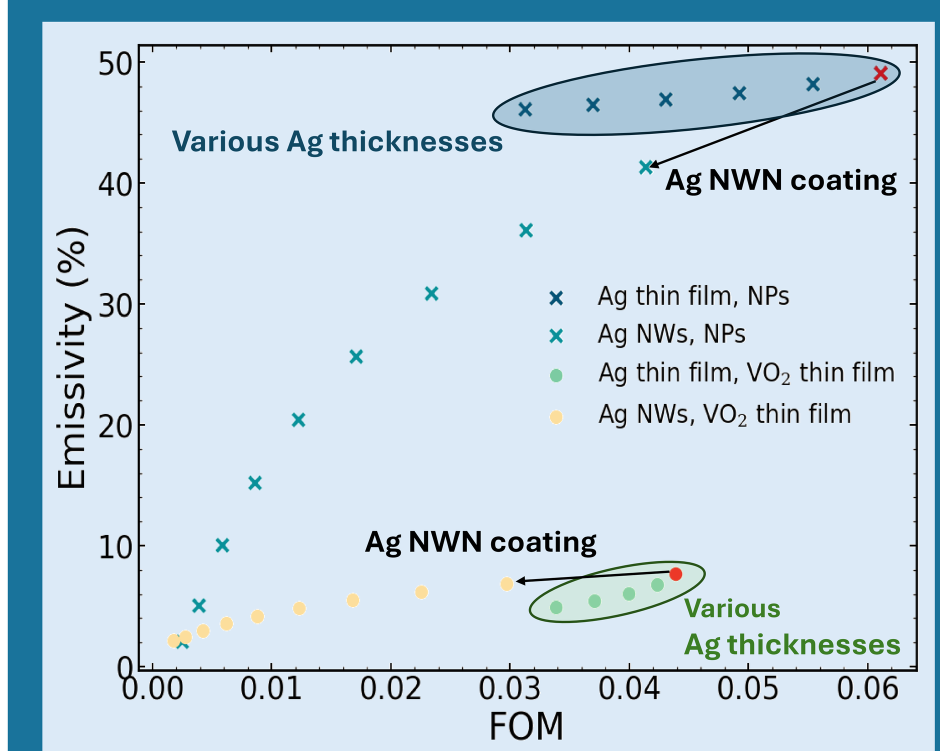


Excellent matching

Emissivity

Key results

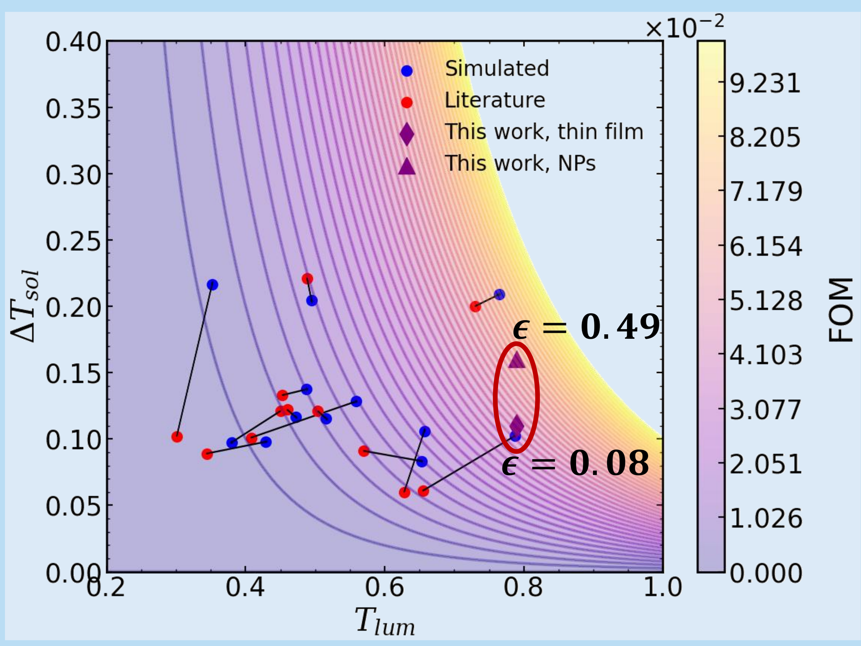




- AgNWs show enhanced emissivity-lowering compared with the use of a thicker Ag **thin film** layer for the NPs-based stack
- The **opposite** behavior is observed for the VO_2 thin film stack
- This difference is attributed to the presence (or not for the NPs) of beneficial interference effects

Conclusions

In summary



$FOM = \Delta T_{sol} \times T_{lum}^4$

- Relevant **FOM** introduction [3]
  - Quantifiable optimization
  - Application-oriented
  - Comparibility
- **Highly efficient** thermochromic stacks
- **Low-emissivity**
- Ag NWs benefit NPs stacks, **not** TFs

Perspectives

- Experimental validation
- Numerical tool application to other thermochromic stacks
- Use of AgNW networks in electrochromic-based devices [4]

Want to learn more on AgNW networks ?

Sym. B, Session 4, 24th Jun. 25, 16h30

References

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Acknowledgments

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