A survey of Radiative Coolers in the Literature

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Preface

This work is intended to be is a resource on prior radiative cooling designs in the literature, and will be periodically updated with new findings. The readers are requested to note that the resource reflects the literature as known by the authors. As such, it cannot be used to determine novelty of new designs, but may be useful for identifying precedents.

Some additional points to note:

- The emittances and reflectances quoted here are all measured using spectral data extracted from papers, rather than reported by authors. This is to ensure consistency in reported performances for the sake of comparison. Care has been taken to minimize errors during the data extraction process (which is estimated to be < 0.01, or 1%).
- Solar reflectance of the data presented here has been measured relative to the AM1 spectrum. Most papers use AM 1.5, but as Levinson et. al. (Solar Energy, 84(9), 1717-1744) demonstrated, AM 1 solar spectrum better represents solar irradiance during summer noon in most places, when reflectance plays the most important role.
- Emittances are calculated for a temperature of 30 °Celsius to represent warm summertime weather.
- Care should be taken to distinguish between directional (near-normal) and hemispherical emittance. Most papers claim the directional value as the "emittance", but that overestimates the true hemispherical emittance and thus the radiative cooling performance under open skies.
- Some of the data from the author's own works are improved versions of previously published works.
- Some of the data from older works (e.g. Polyvinylidene Chloride by Trombe and Grenier) correspond to reproductions by the author.

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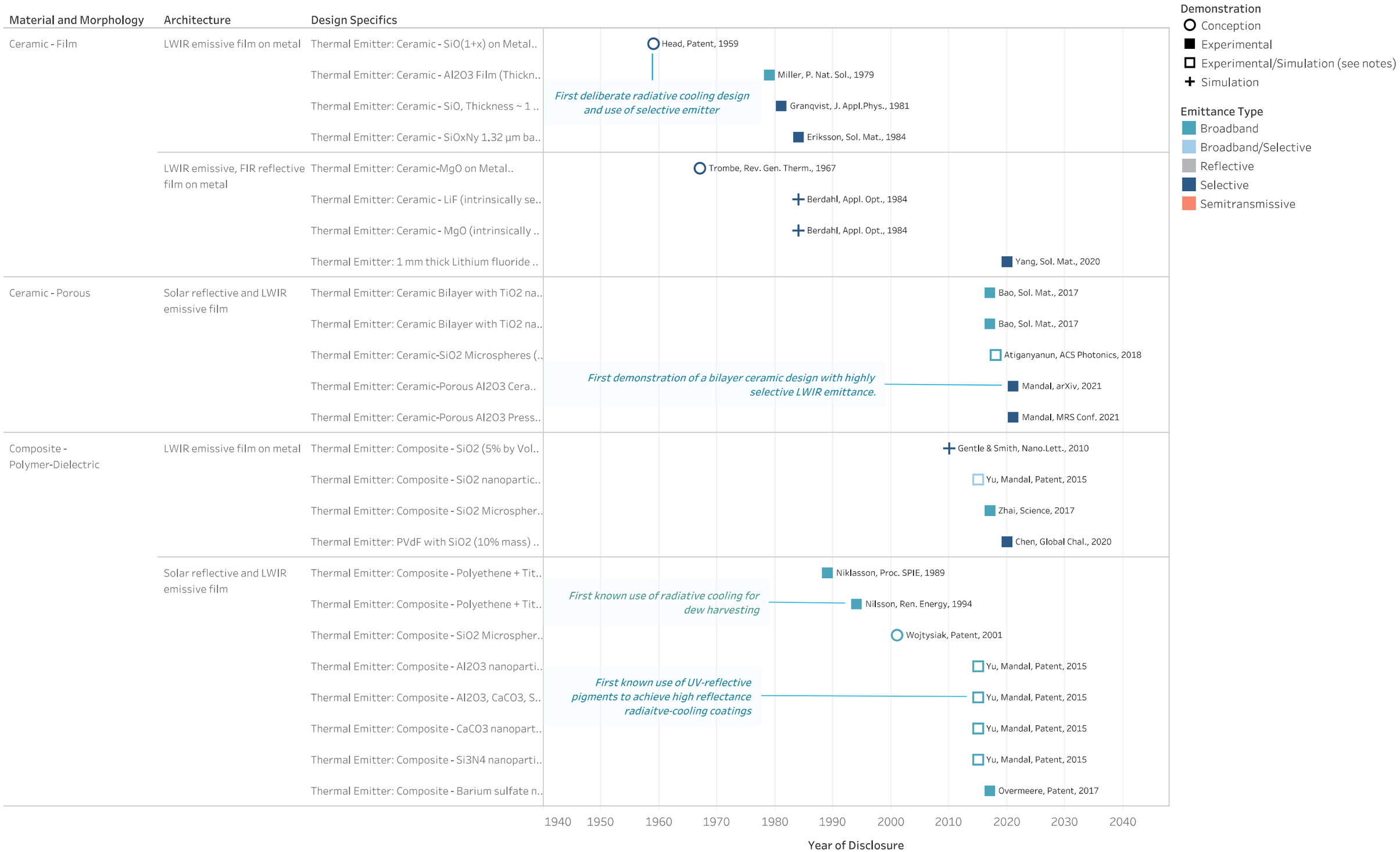
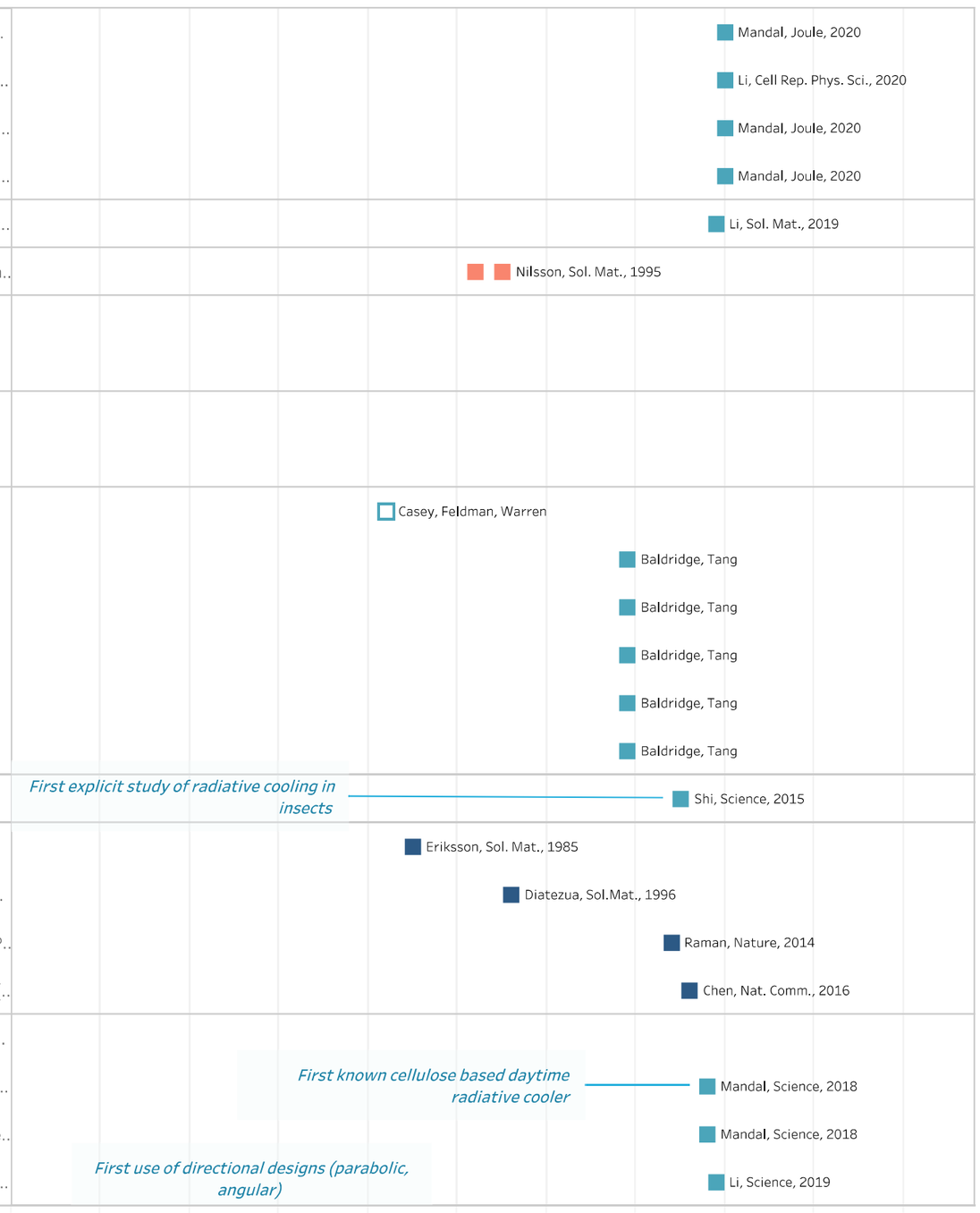
History of different radiative cooling designs



Timeline of radiative cooling innovations, showing "Year of Disclosure" for each "Design Specifics", broken down by "Material and Morphology" and "Architecture". Color shows details about "Emittance Type". Shape shows details about "Demonstration". Note: this list is not exhaustive, so it can only be used to say that a design has similar predecents, and NOT for claims of novelty.

History of different radiative cooling designs

Material and Morphology	Architecture	Design Specifics
Composite - Polymer-Dielectric	Solar reflective and LWIR emissive film	Thermal Emitter: Paint - BaSO4 in P(VdF-HFP)..
		Thermal Emitter: Paint - CaCO3 Pigment in Acr..
		Thermal Emitter: TiO2-based Cool Roof Paint - ..
		Thermal Emitter: TiO2-based Cool Roof Paint - ..
	Solar reflective and therma..	Thermal Emitter: Layer of Aluminum Phosphat..
	Solar reflective and therma..	Thermal Emitter: Composite - Polyethene + Zin..
Ideal (blackbody)	Ideal (blackbody)	Ideal Broadband Emitter at 30°C
		Ideal Selective Emitter at 30°C
Metal	Metal Reflector	Aluminium
		Silver
Natural - Geological	Solar reflective and LWIR emissive film	Thermal Emitter: Snow..
		Thermal Emitter: Rock..
		Thermal Emitter: Snow/Ice..
		Thermal Emitter: Soil..
		Thermal Emitter: Vegetation..
		Thermal Emitter: Water..
Natural-Biological	Solar reflective and therma..	Thermal Emitter: Silver Ant Hairy Cuticle..
Photonic - Multilayer Design	LWIR emissive film on metal	Thermal Emitter: Ceramic - SiO2 0.7 µm|SiOx..
		Thermal Emitter: SiO2|SiOxNy|SiOx'Ny' Perio..
		Thermal Emitter: Photonic Stack - SiO2/HfO2 P..
		Thermal Emitter: Ceramic - Si3N4 (70 nm) / Si (..
Polymer - Bio - Porous	Solar reflective and LWIR emissive film	Thermal Emitter: Porous Biopolymer - Paper - ..
		Thermal Emitter: Porous Biopolymer - Cellulos..
		Thermal Emitter: Porous Biopolymer - Ethyl Ce..
		Thermal Emitter: Porous Biopolymer - Delignif..



Demonstration
- Conception
- Experimental
- Experimental/Simulation (see notes)
- Simulation

Emittance Type
- Broadband
- Broadband/Selective
- Reflective
- Selective
- Semitransmissive

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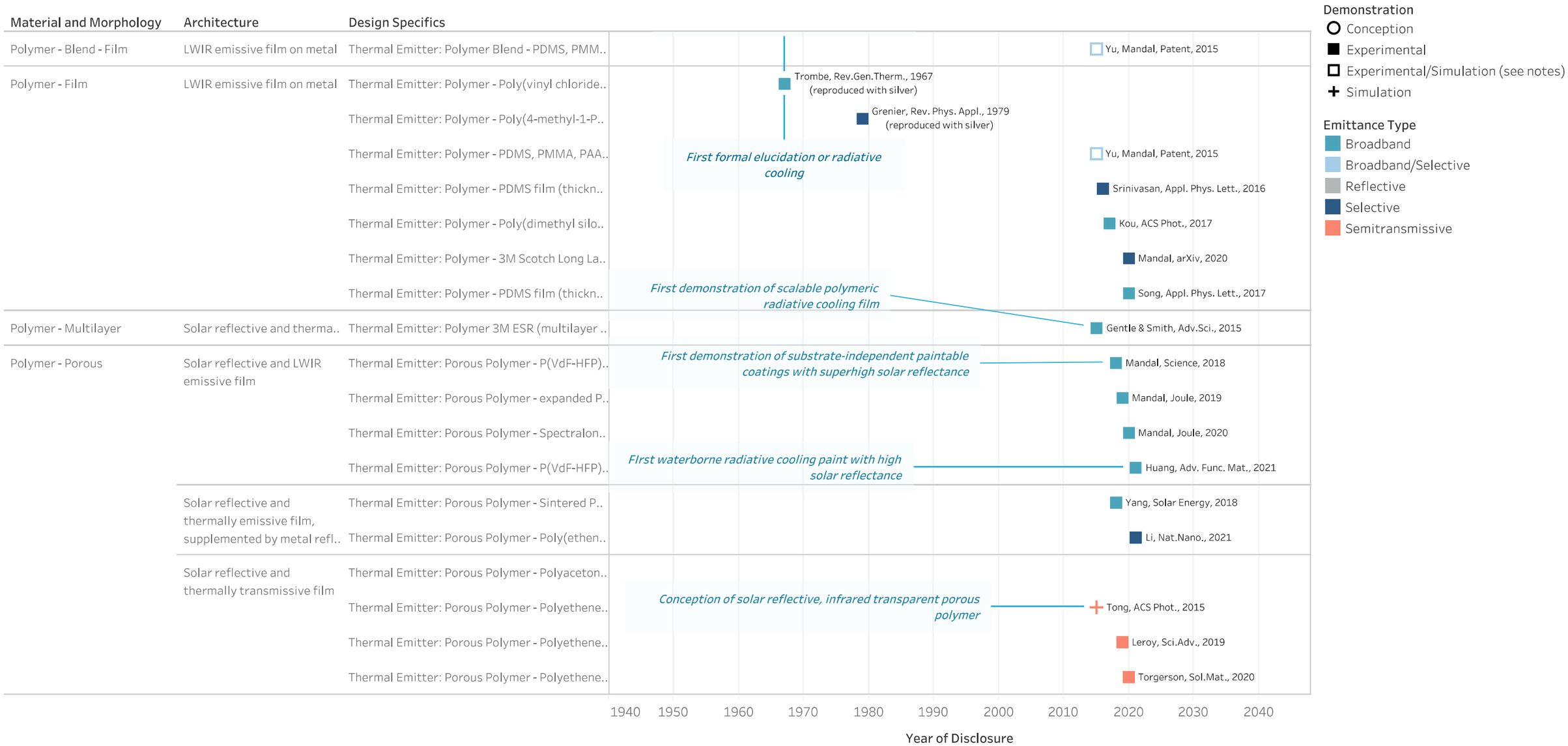
History of different radiative cooling designs



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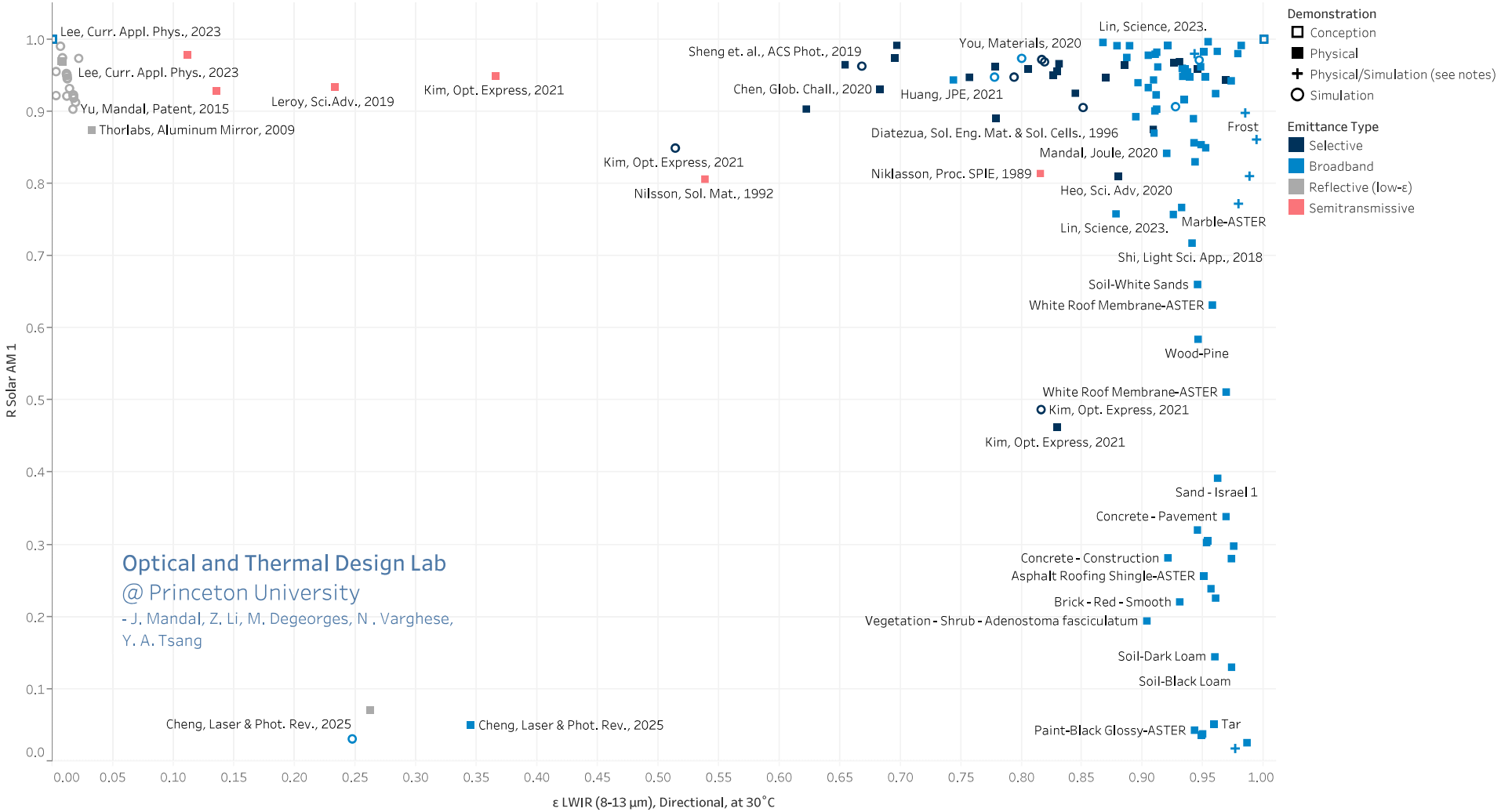
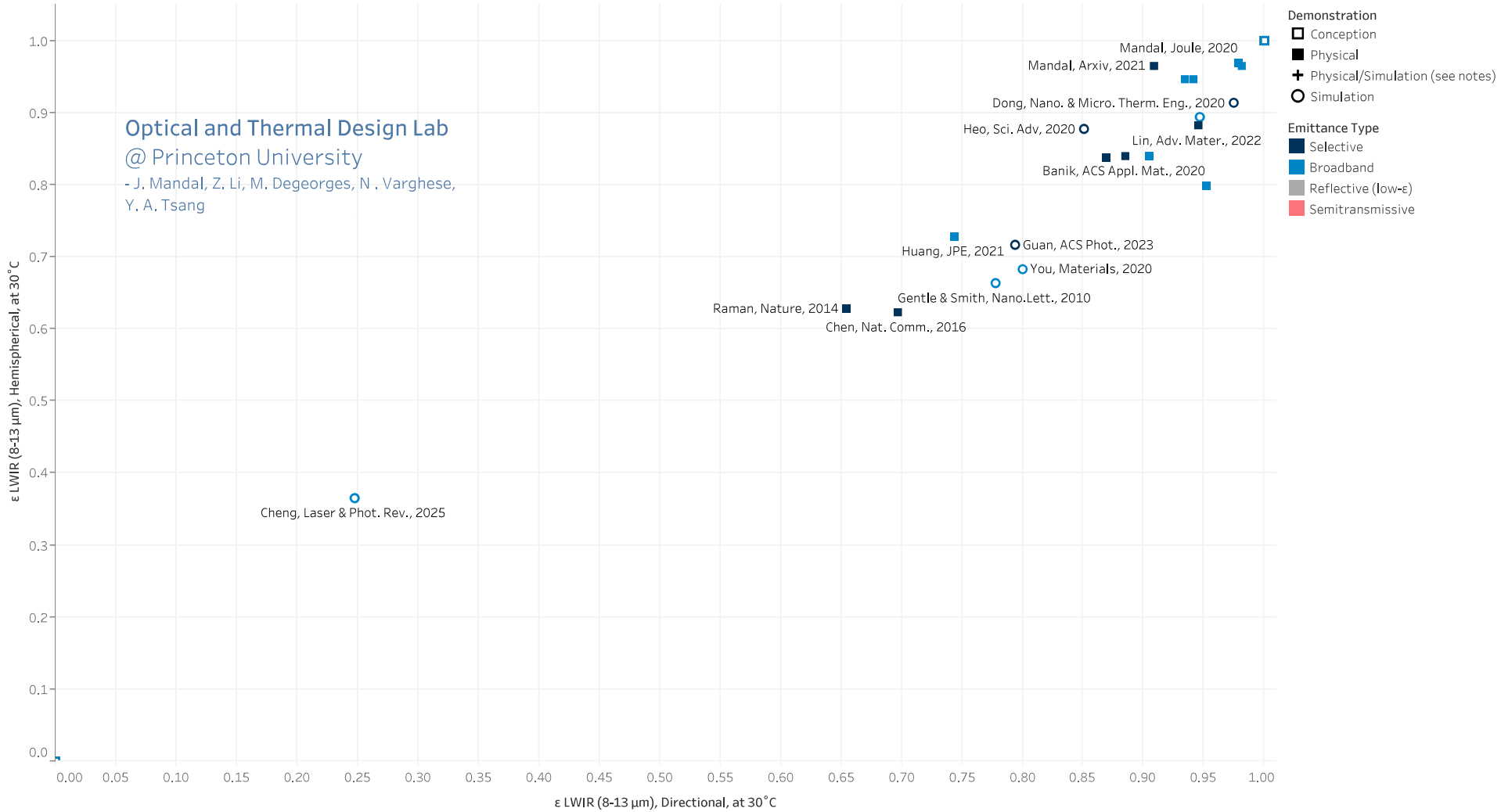
R Solar AM 1 vs ε LWIR (8-13 µm), Directional, at 30˚C

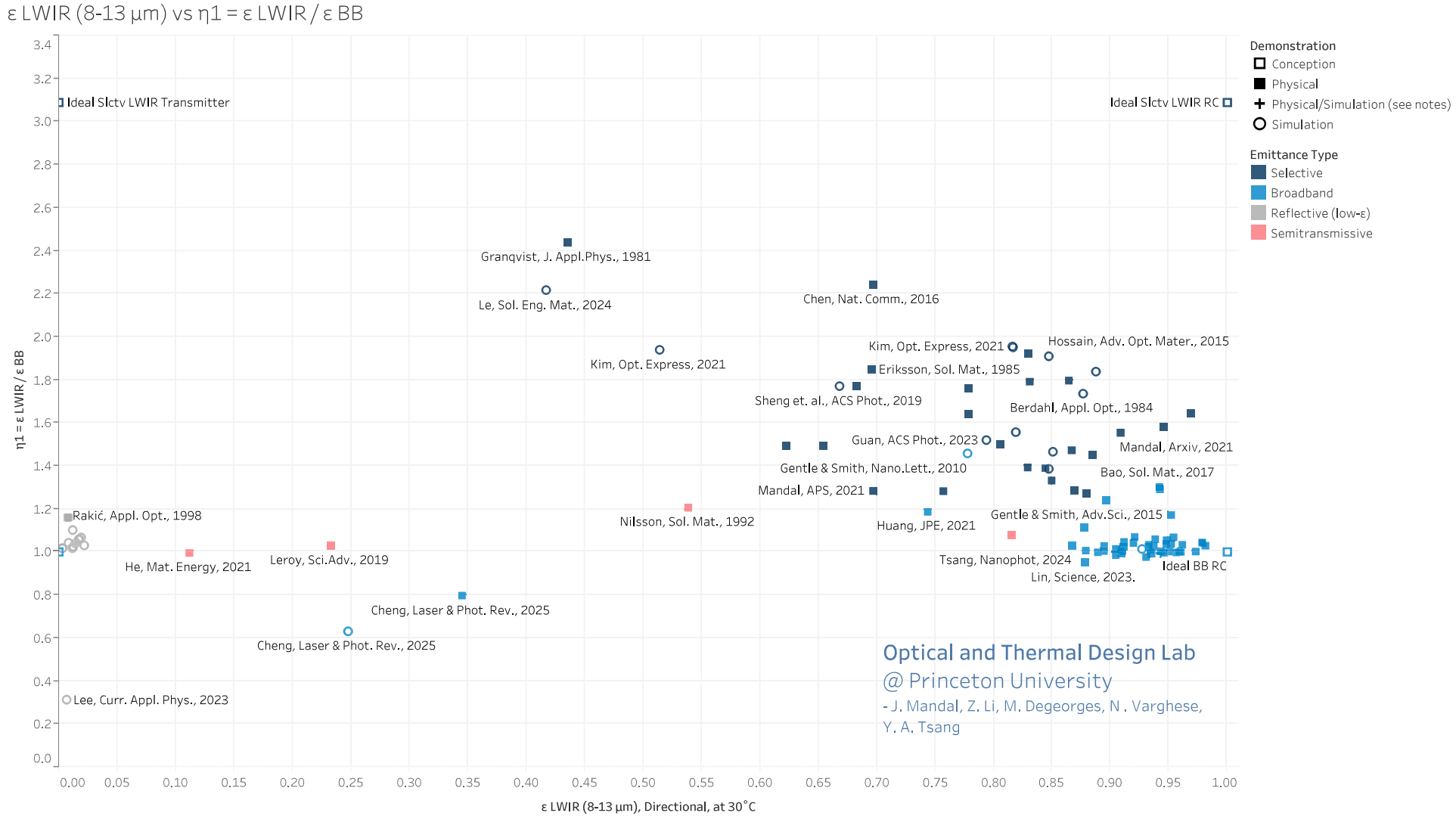


E LWIR (8-13 µm), Directional, at 30˚C vs. R Solar AM 1. Color shows details about Emittance Type. Shape shows details about Demonstration. The marks are labeled by Label. Details are shown for various dimensions. The view is filtered on Commercial, which keeps No and Yes.

ε LWIR (8-13 µm), Directional vs Hemispherical, at 30˚C

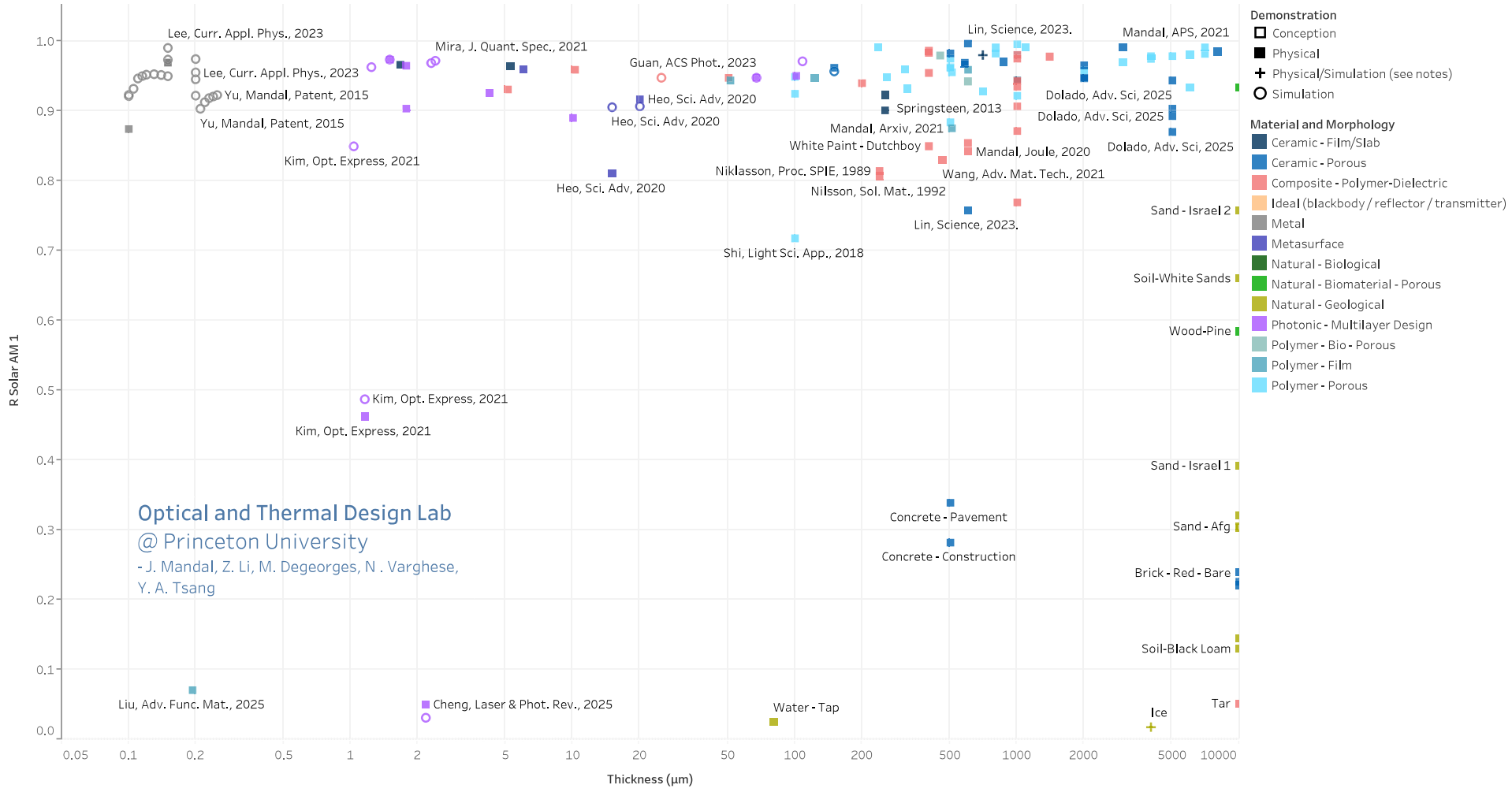


E LWIR (8-13 µm), Directional, at 30˚C vs. ε LWIR (8-13 µm), Hemispherical, at 30˚C. Color shows details about Emittance Type. Shape shows details about Demonstration. The marks are labeled by Label. Details are shown for various dimensions.



E LWIR (8-13 µm), Directional, at 30˚C vs. η1 = ε LWIR / ε BB. Color shows details about Emittance Type. Shape shows details about Demonstration. The marks are labeled by Label. Details are shown for various dimensions.

Thickness vs R Solar AM1



The plot of sum of R Solar AM 1 for Thickness (µm). Color shows details about Material and Morphology. Shape shows details about Demonstration. The marks are labeled by Label. Details are shown for various dimensions.