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# Bubbles and drops dynamics on micro-and-nano enhanced interfaces: microscale approach for (macro) industrial applications

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Microscopic phenomena occurring at liquid-solid interfaces govern fluid flow and heat transfer mechanisms in different micro and macro industrial applications, such as in cooling systems. For instance, surfaces with customized micro/nano modified wetting patterns (reversible depending on the ambient conditions) can play a relevant role in controlling pool and flow boiling heat transfer. However, the efficient development of such systems depends on the accurate understanding and control of the governing mechanisms.

This lecture introduces a micro-to-macro scale approach for the development of cooling systems for industrial applications, with particular focus on microscale applications to sustainable energy conversion systems. Case studies focus on recent developments of heat sinks based on microgeometries for pool and flow boiling cooling of concentrated solar panels, combined with microenhanced surfaces. In this context, an entire methodology comprising a custom-made optimization tool based on a genetic algorithm, to define the geometries to test, and an advanced experimental procedure combining advanced high-speed imaging, post-processing based on machine learning and time and space resolved thermography are put together. As an example, flow in microchannels combined with micro-structured surfaces is visualized, as shown in Figure 1, and images are post-processed to obtain a full quantitative characterization of the fluid dynamics and heat transfer processes, following the work early presented in [1].

Detailed characterization of drops and bubble dynamics play a paramount role in this analysis.

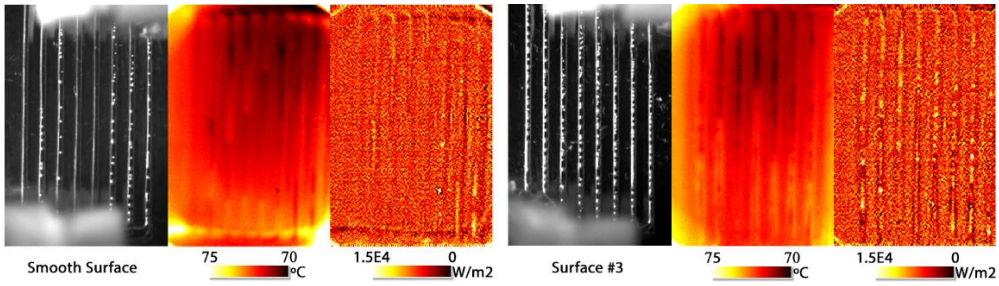


Figure 1. High-Speed vs Temperature Map vs Heat Flux Map, obtained for a two-phase flow in a microchannels based heat sink.

**Keywords:** Microfluidics, micro-and-nano enhanced interfaces, time resolved thermography.

**References**:

[1] Marseglia, G., De Giorgi, M.G., Carvalho, D.S., Pontes, P., Souza, R.R., Moreira, A.L.N., Moita, A.S.,2024, Experimental investigation on the effects of the geometry of microchannels based heat sinks on the flow boiling of HFE-7100. *Applied Thermal Engineering*, 236:121479.

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