3Dプリント金属多孔質構造を用いたプール沸騰熱伝達の向上
Enhancement of pool boiling heat transfer using 3D-printed metal porous structure

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Introduction

Decrease size & improved performance of electronics (i.e. CPUs) → **Effective cooling solutions**

Increasing driving range of electric vehicles (EVs) → **Recover and use of heat produced by batteries and motors.**

→ **Enhanced and improved critical heat flux (CHF) and heat transfer coefficients (HTC) in pool boiling**

→
- **Efficient thermal management in compact electronic devices,**
- **Sustainability and performance of modern electronic systems and electric vehicles.**

Background : Enhanced pool boiling heat transfer studies

Studies have shown significant improvements in CHF in heat exchangers through innovative design modifications.

To evaluate heat transfer performance, several research has focused on the impact of:-

- Surface wettability
- Porous coating/structures
- Metal 3D printing to manufacturing complex cavity structures

THIS RESEARCH: Explores 3D-printed metal porous structures, combining porous materials and advanced geometries to enhance and improve heat transfer performance.

AIM: Validate existing findings while contributing to advanced heat exchanger development for high-performance applications.

Test specimen

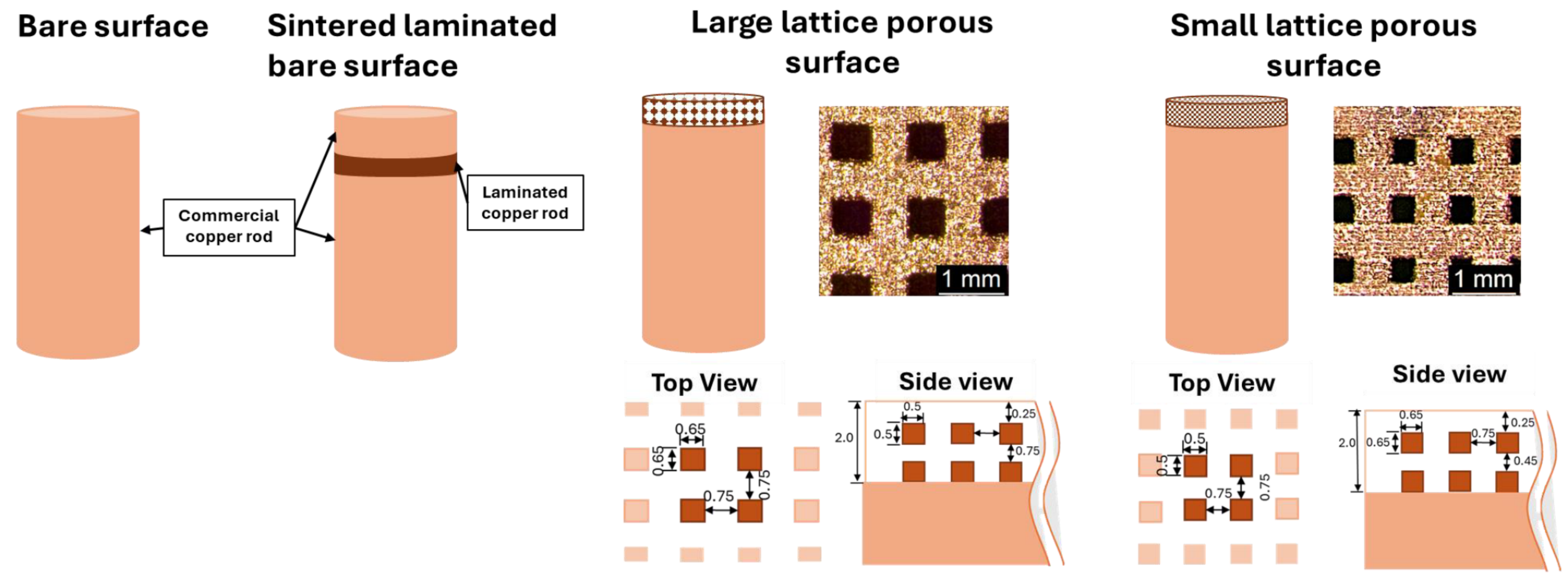

Figure 1: Test Pieces

Experimental setup

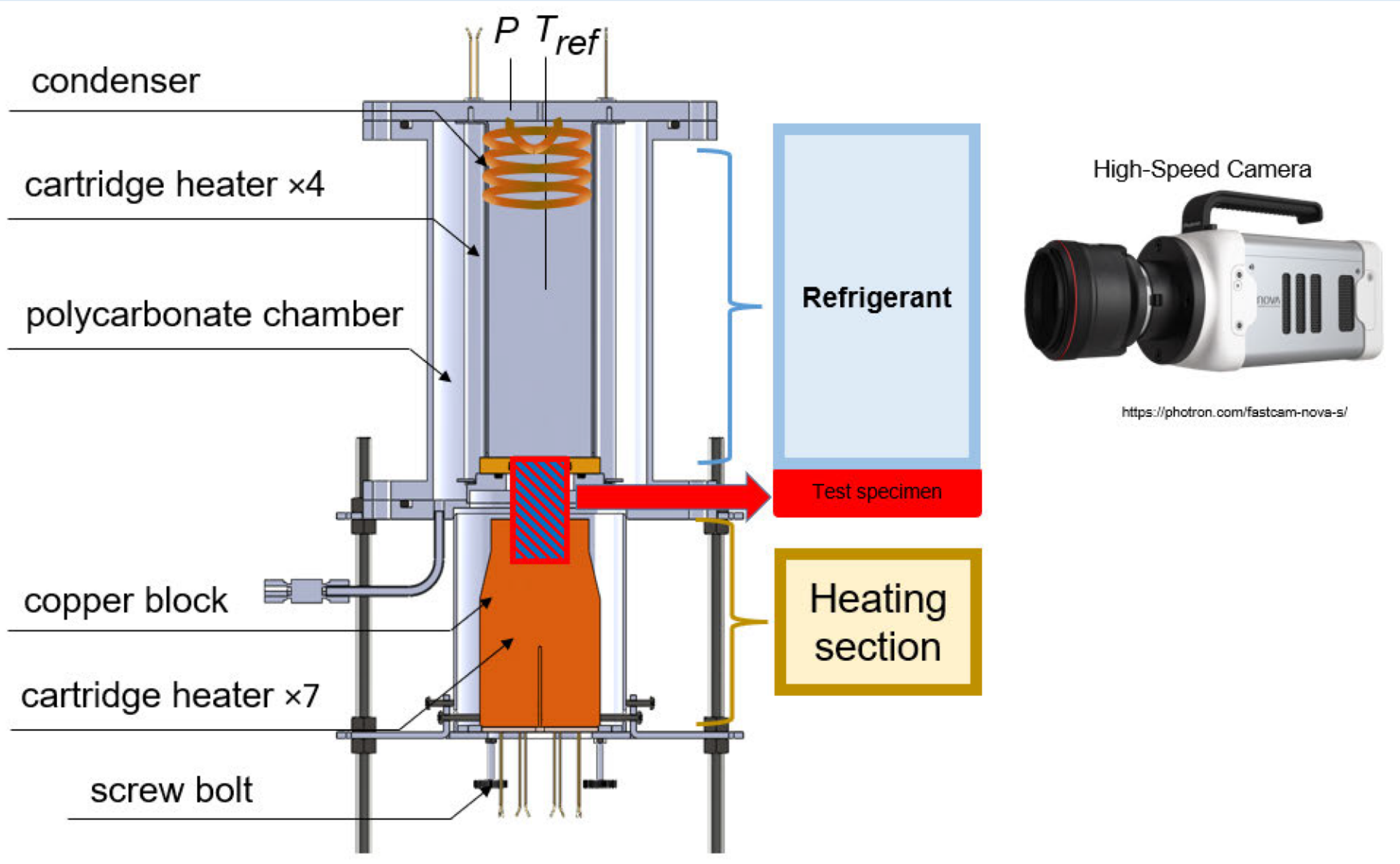

Figure 2: Experimental Setup

Reference

- Nam, et al. Int. Commun. Heat Mass Transfer, 2023, 146, 106887. doi: 10.1016/j.icheatmasstransfer.2023.106887.
- Jaikumar, A., & Kandlikar, S. G., Int. J. Heat Mass Transfer, 2015, 88, 652–661. doi: 10.1016/j.ijheatmasstransfer.2015.04.100.
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Validation of the equipment

Actual image

Figure 3: Plain surface (Surface roughness: 1μm)

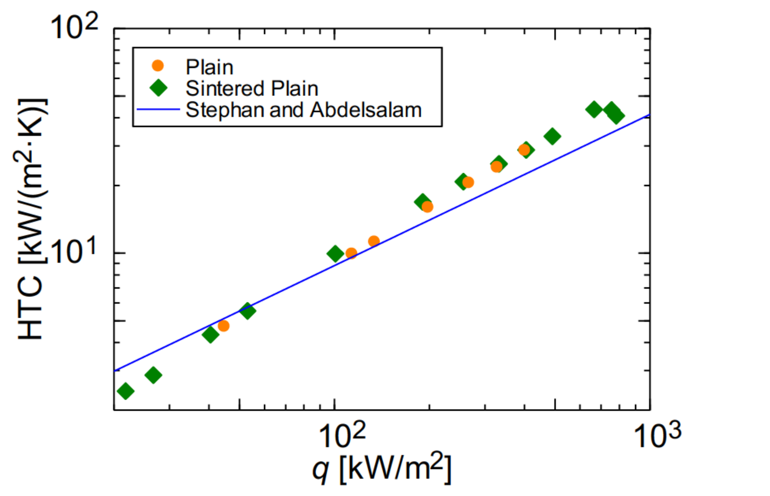

Figure 4: Pool boiling validation(Stephan's correlation)

Temperature profile

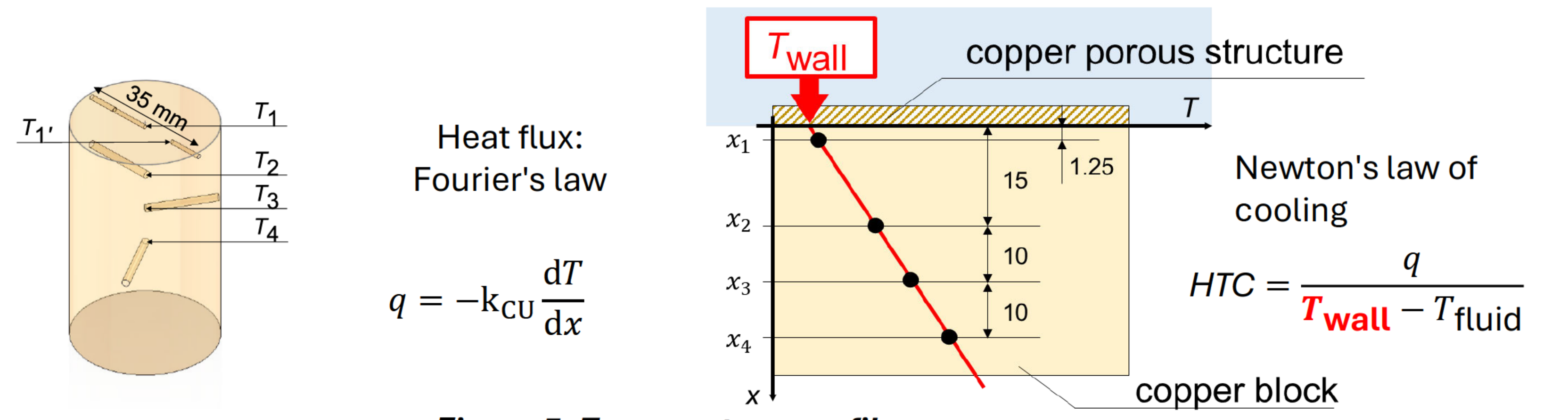

Figure 5: Temperature profile

Results

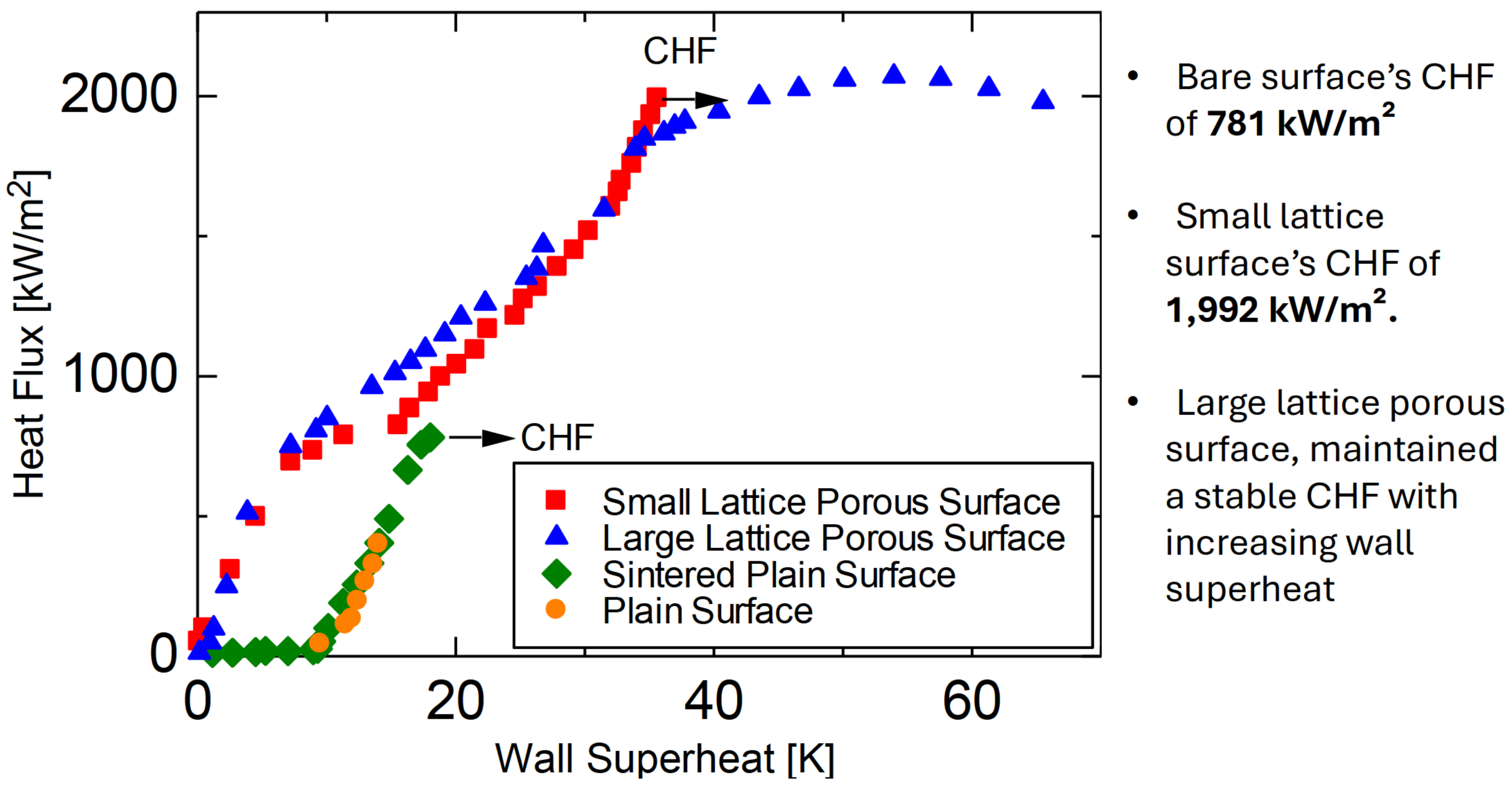

Figure 6: Boiling curve

- Bare surface's CHF of **781 kW/m²**
- Small lattice surface's CHF of **1,992 kW/m²**.
- Large lattice porous surface, maintained a stable CHF with increasing wall superheat

Figure 7: Near CHF boiling for small lattice: 1,992 kW/m²

Figure 8: Near CHF boiling for large lattice : 2000 kW/m²

Conclusion and future work

- Lattice porous surfaces **significantly enhance the CHF** performance compared to bare surfaces and demonstrate superior ability to manage heat transfer.
- These findings highlight the potential **of lattice porous designs to improve thermal management** in high-heat flux applications.

Future work

- **New geometries** of lattice porous surfaces represent potential future developments of great interest.
- Uses of different **working fluids** such as refrigerant **R1233zd(E)** instead of water for working fluid.

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