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SiO_2 COATINGS FOR BETTER COOLING AND CORROSION PROTECTION

Nairamdakh Bold

University of Tokyo Department of Nuclear Engineering and Management, Tokyo, Japan

naira@g.ecc.u-tokyo.ac.jp

Abstract

Efficient thermal energy removal is critical for the safety of heat transfer systems, where surface degradation and corrosion pose serious challenges during prolonged high heat flux conditions. This study aims to enhance critical heat flux (CHF) and provide corrosion resistance by applying SiO_2-based ceramic spray coatings on copper boiling surfaces. The experiments were conducted using a custom-built flow boiling facility with a transparent acrylic channel and a copper heating surface under saturated pool boiling at atmospheric pressure. SiO_2 aerosol spray coatings were applied for 1–5 seconds to investigate the relationship between coating thickness, surface characteristics, and CHF behavior.

Results show that coated surfaces exhibited improved CHF compared to bare copper, attributed to increased surface roughness and slightly enhanced wettability (contact angle ≈ 80°). The highest CHF enhancement was achieved with the thinnest coating (1 s spray), where partial coverage preserved copper nucleation sites, promoting vigorous nucleate boiling. Thicker coatings increased surface temperature due to added thermal resistance, reducing CHF enhancement. Prolonged boiling tests over multiple cycles confirmed the coating's stability and maintained CHF performance, indicating its potential for long-term application.

These findings highlight the promise of SiO_2 coatings for nuclear reactor components, heat exchangers and data center cooling scenarios. Future work will examine high-temperature corrosion resistance, and the optimization of non-uniform coating patterns to further improve CHF and durability in realistic environments.

Keywords:
Critical Heat Flux, Surface Modification, Water Cooling