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Investigation of Critical Heat Flux and Heat Transfer Coefficients of metallic surfaces with micro/nanostructures produced through femtosecond laser surface processing

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Authors

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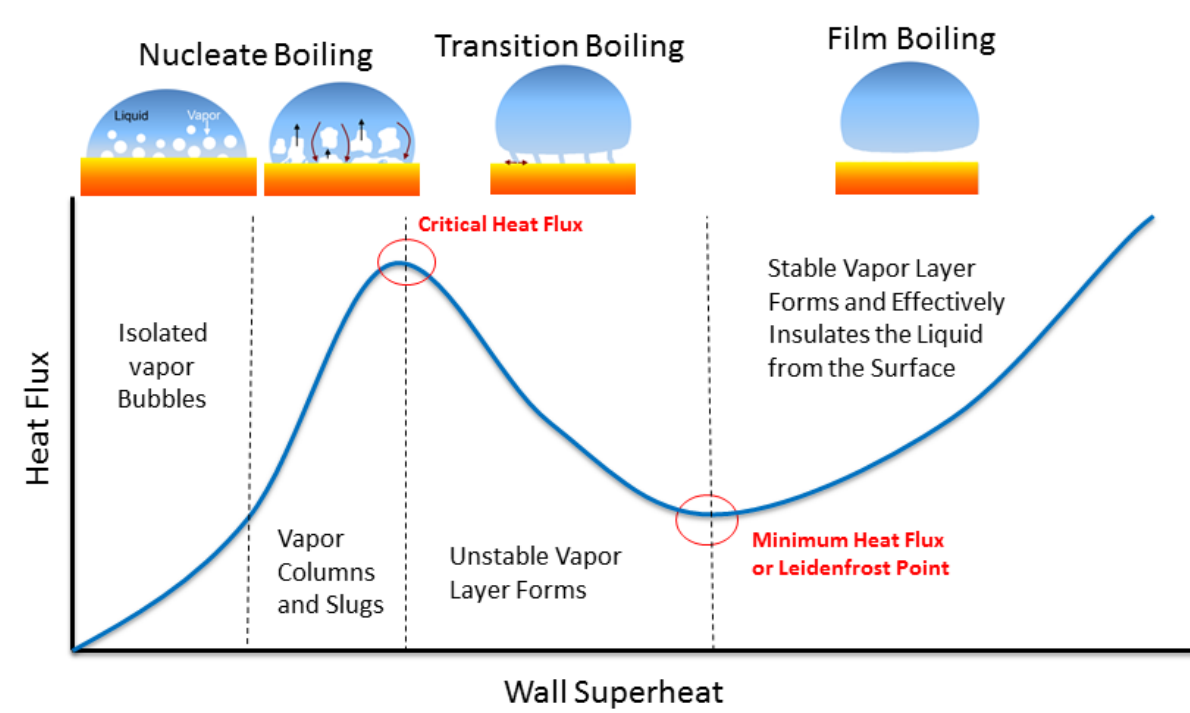
Investigation of Critical Heat Flux and Heat Transfer Coefficients of metallic surfaces with micro/nanostructures produced through femtosecond laser surface processing

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Motivation

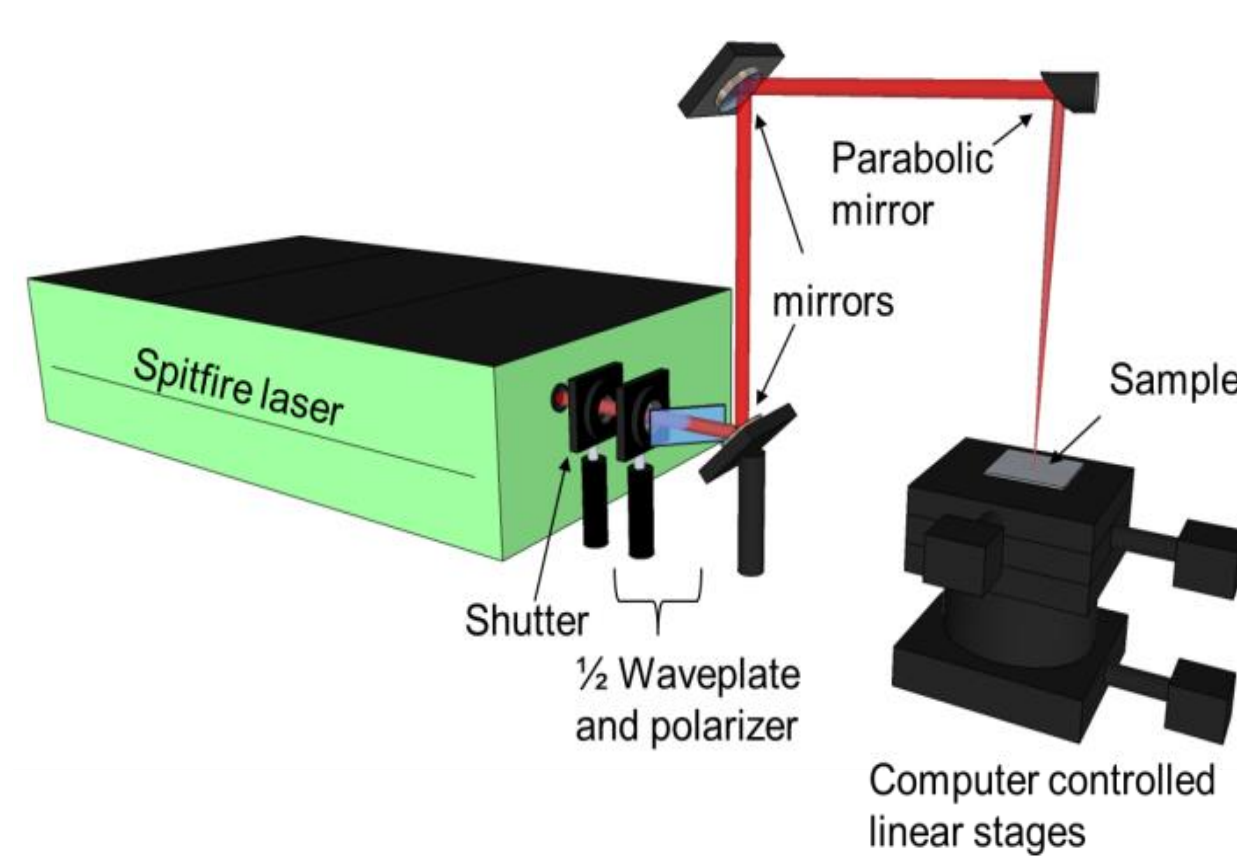
Effects of surface Geometry on Critical Heat Flux (CHF)



Wettability effect on treated surfaces influencing CHF

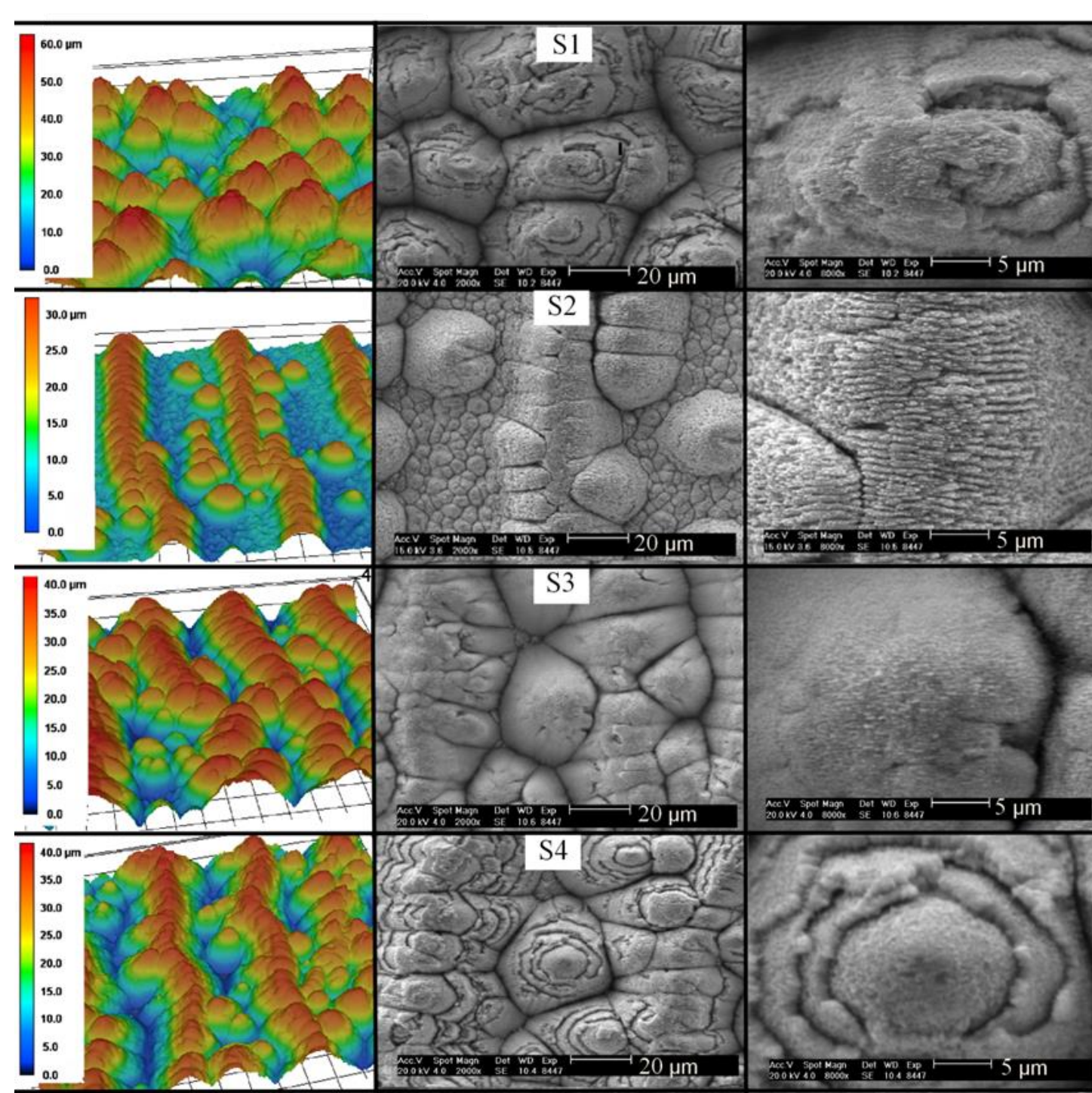
FLSP Procedure

Femtosecond Laser Surface Processing



- Surfaces are processed with Spectra-Physics Spitfire Laser
- Different settings produce unique surfaces

Surface examples of Processed Stainless Steel

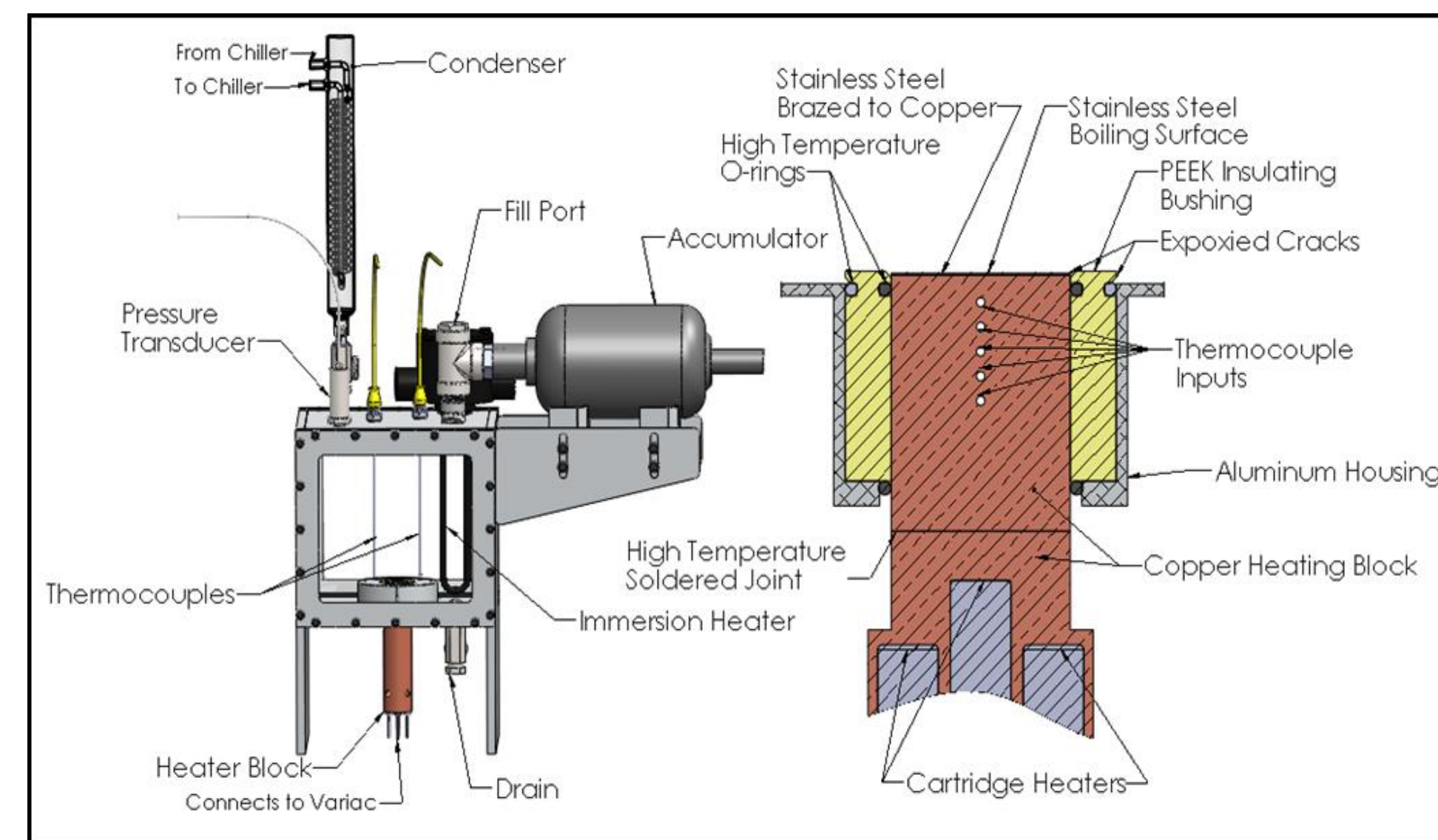


Creation of Microstructures and Nanostructures

- Increase surface area
- Increase in multiscale roughness
- Increase wettability
- Increase capillary wicking

Experimental Setup

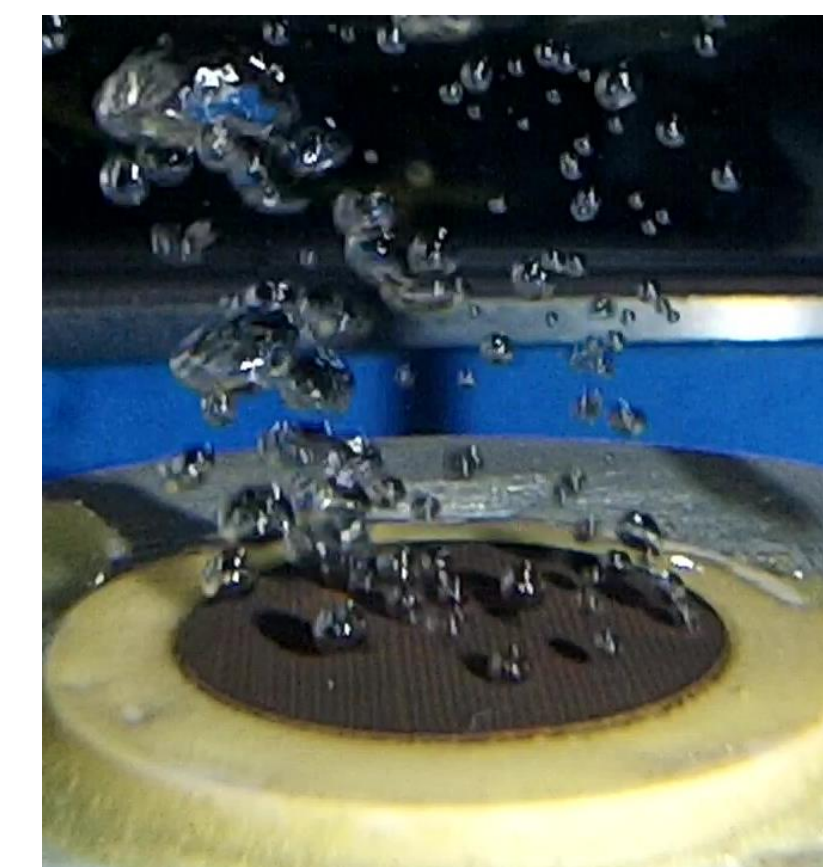
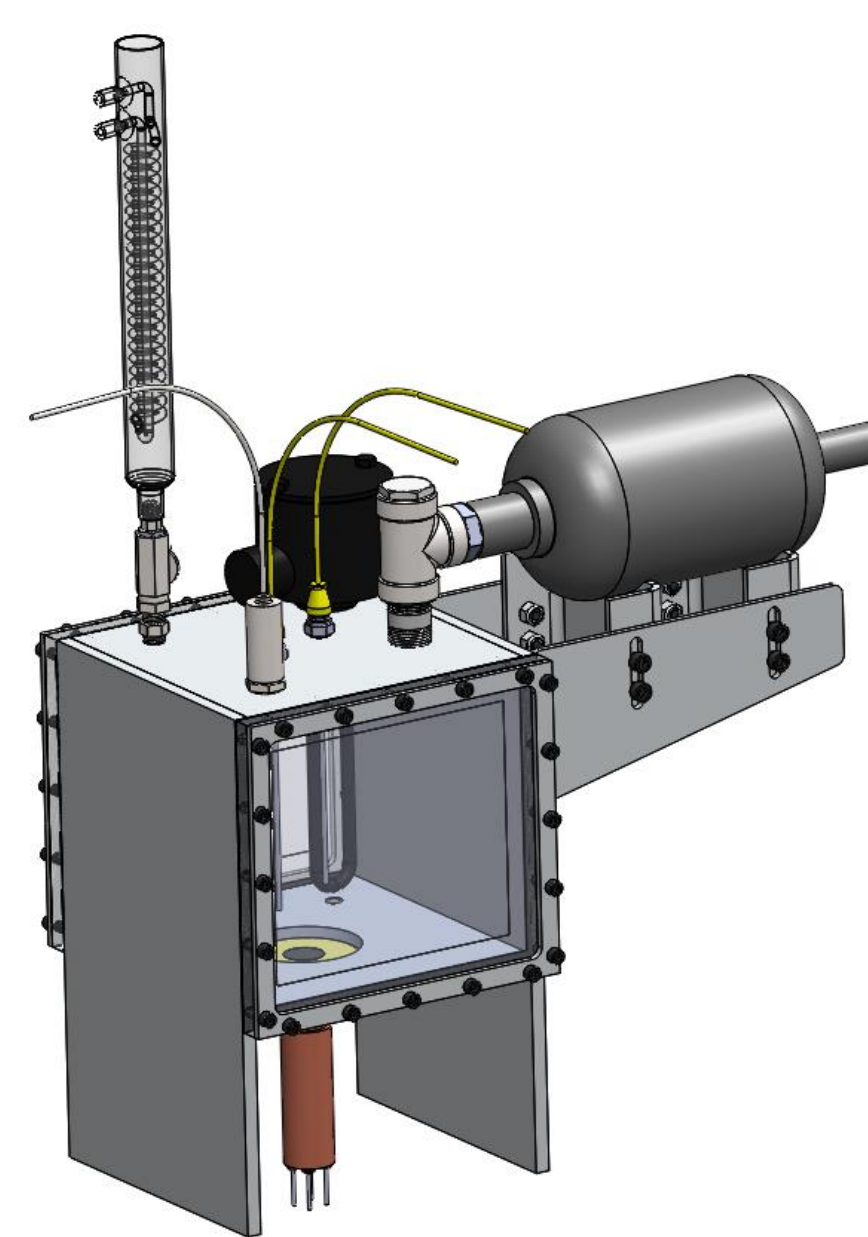
Pool Boiling Containment



- 8 liters of deionized water
- Heated to saturation temperature by immersion heater
- Pressure and Temperature data is recorded inside container

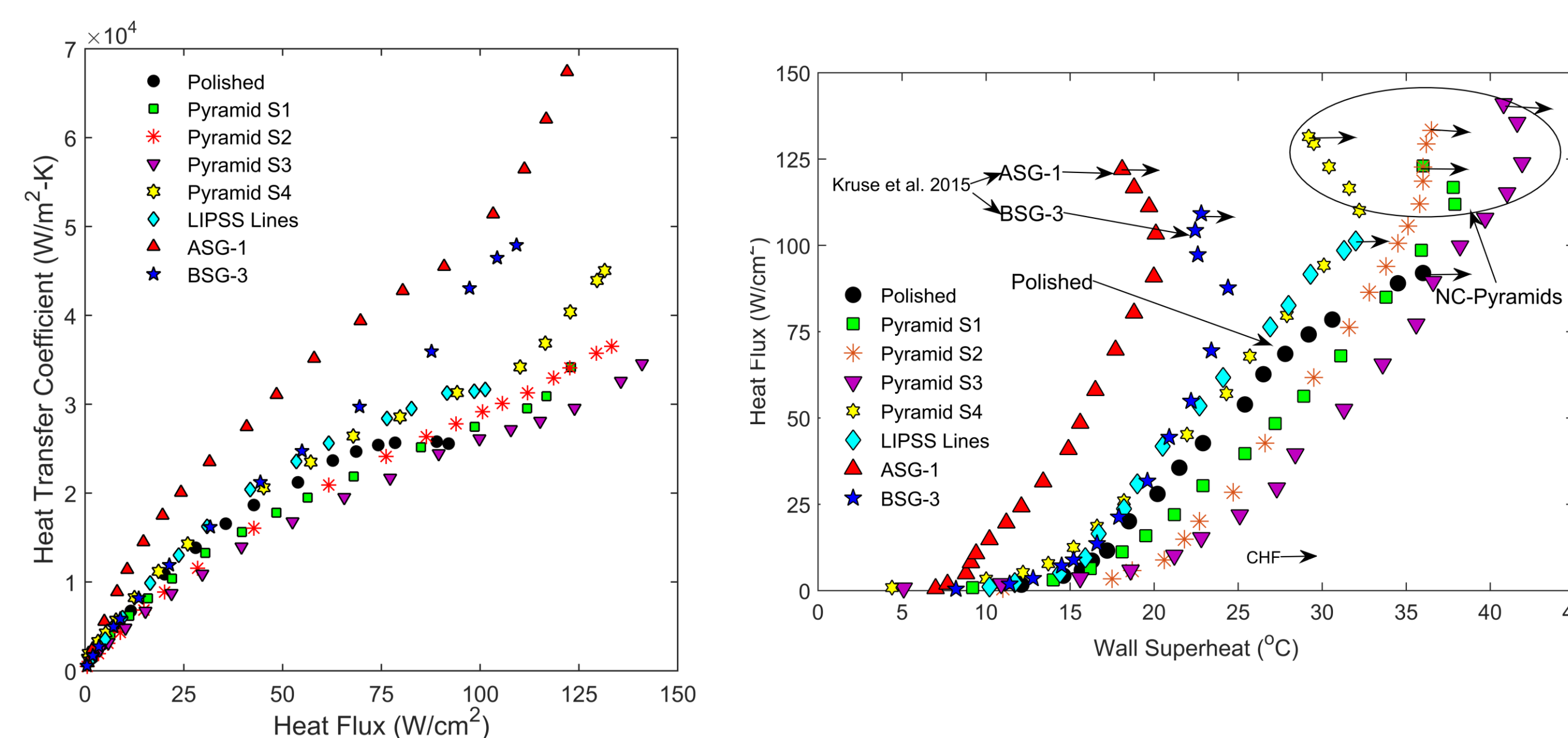
Test Surface Parameters

- Processed surface (25.4 mm diameter) heated by copper heating block
- Two-phase heat transfer occurs at the interface between the test surface and liquid
- Thermocouples in copper block gather temperature data
- Heat flux is calculated based on the temperature gradient
- Surface temperature is calculated from the heat flux
- Heat flux is plotted with respect to surface superheat



Results and Conclusions

Heat Transfer Data



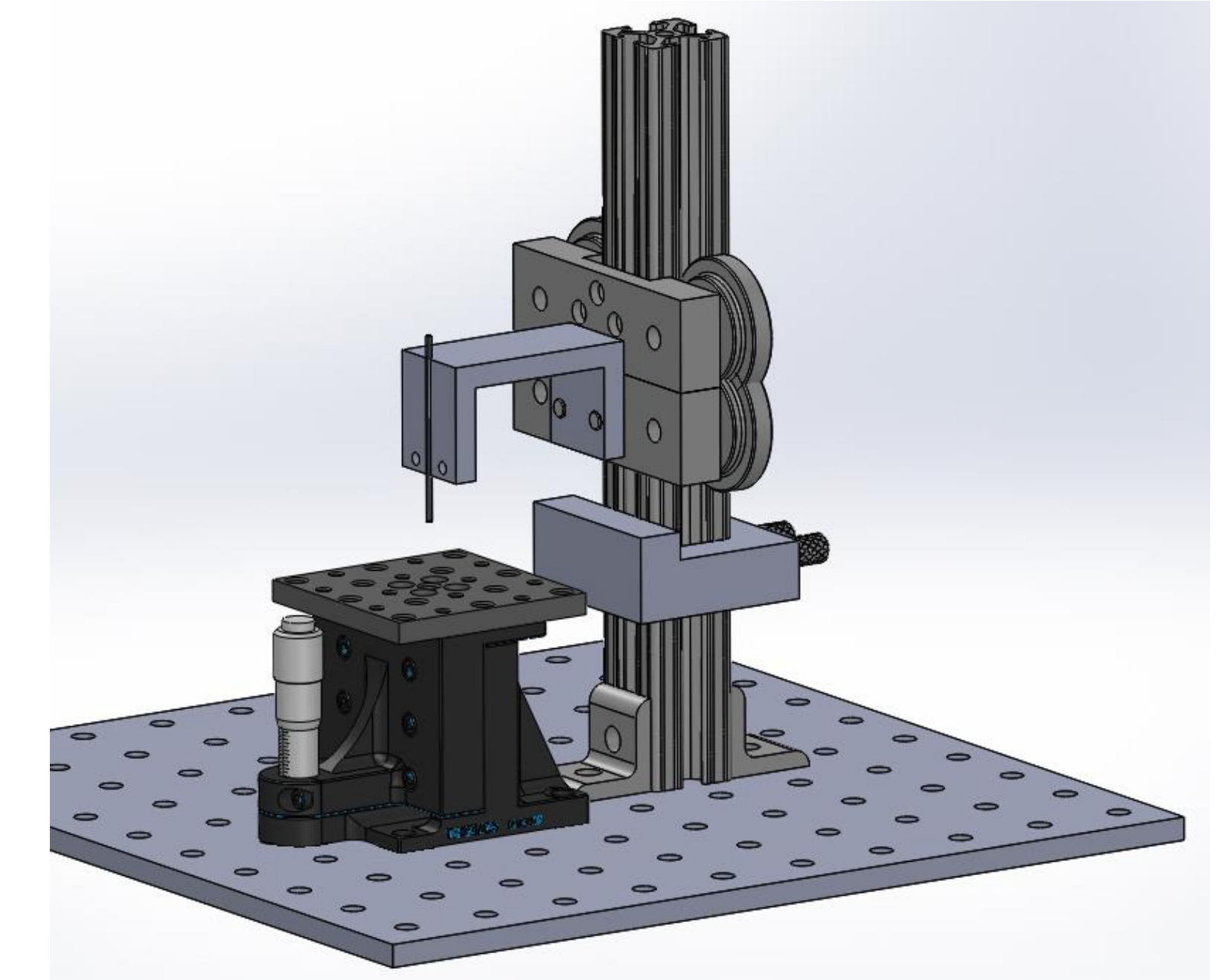
- Processed data is compared to a polished reference curve
- Critical heat flux is maximum attainable heat flux and is signaled by a very fast jump in surface temperature due to the transition to film boiling
- All processed surfaces resulted in an enhancement of the critical heat flux
- Heat transfer coefficient is plotted with respect to the heat flux.
- HTCs increase with increasing heat flux
- Heat transfer enhancement is a result of a combination of increased wettability, roughness, surface area, and capillary wicking

Future Study

- Efforts to link other factors to increased critical heat fluxes and heat transfer coefficients
 - Wettability (See right Column)
 - Surface Area
 - Surface Roughness
 - Capillary Wicking

Volume Flux Test

Experimental Setup

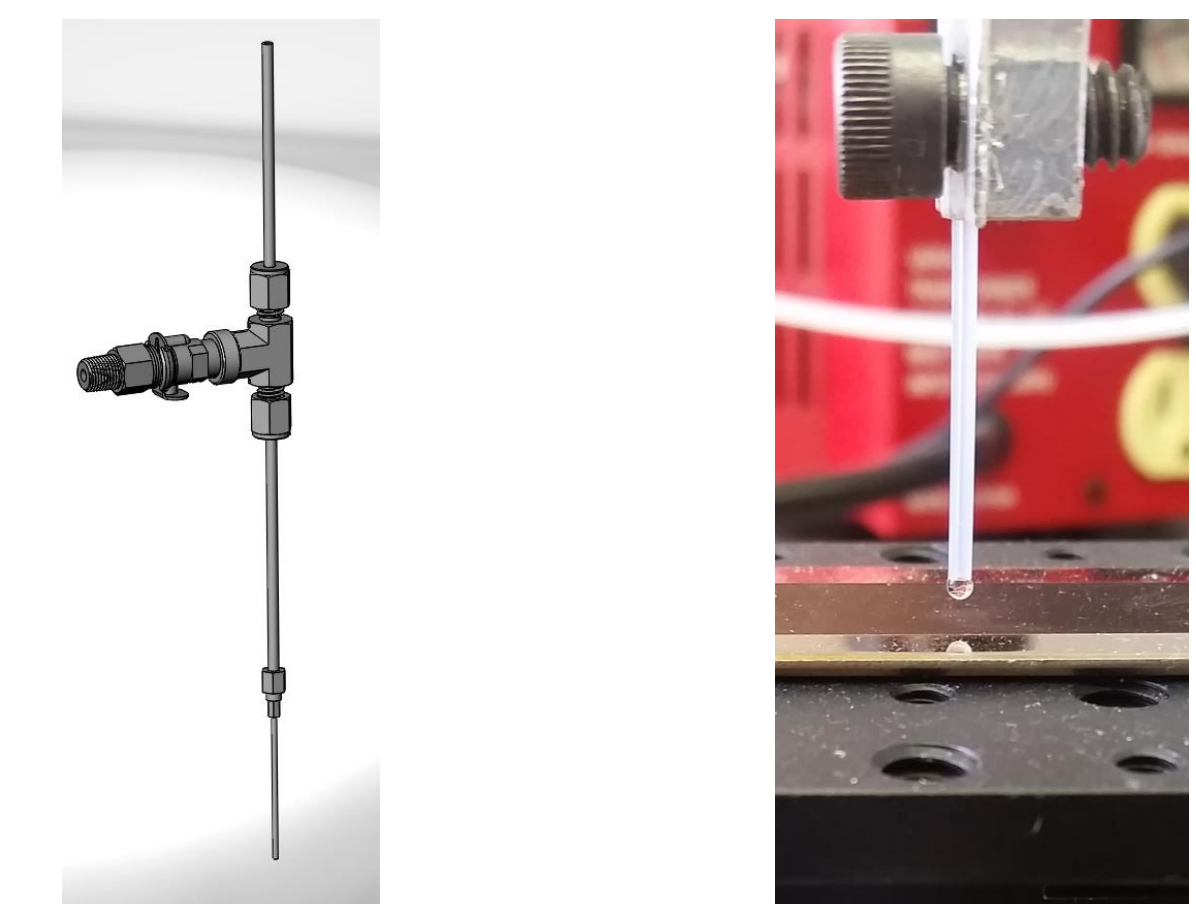


Purpose

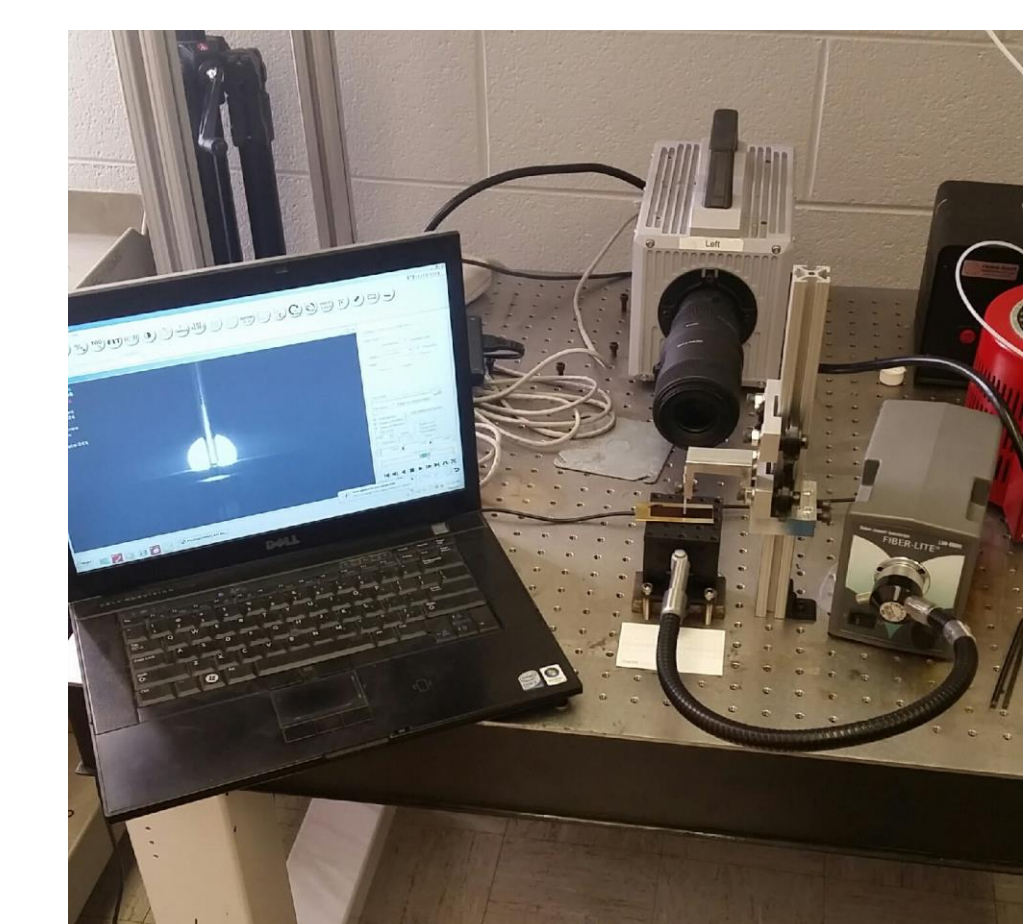
- Measure wettability of surfaces
- Establish a link between surface wettability and CHF

Procedure

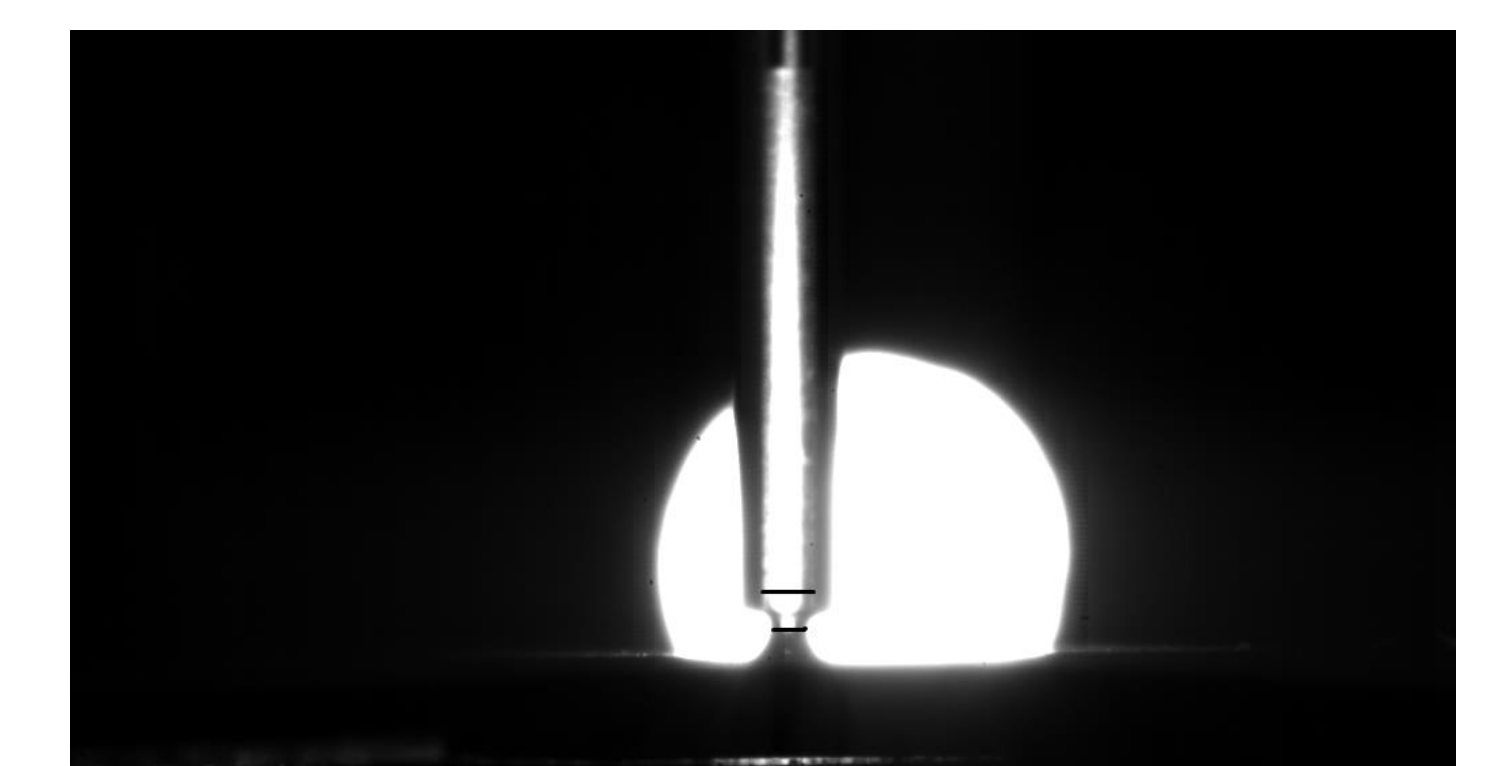
- Measure specific quantity of water through pump and tube setup



- Record volume flux with high speed camera



- Interpret images with Matlab code



Acknowledgements

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