Thermal Transport across Graphite-Water Interfaces

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Motivation

•Need for thermal storage of large transient pulses of heat on USAF platforms

•Salt hydrates and graphitic foam composites offer high thermal energy storage capabilities and high thermal conductivities respectively

•Thermal resistance across graphite-hydrous salt interfaces is unknown

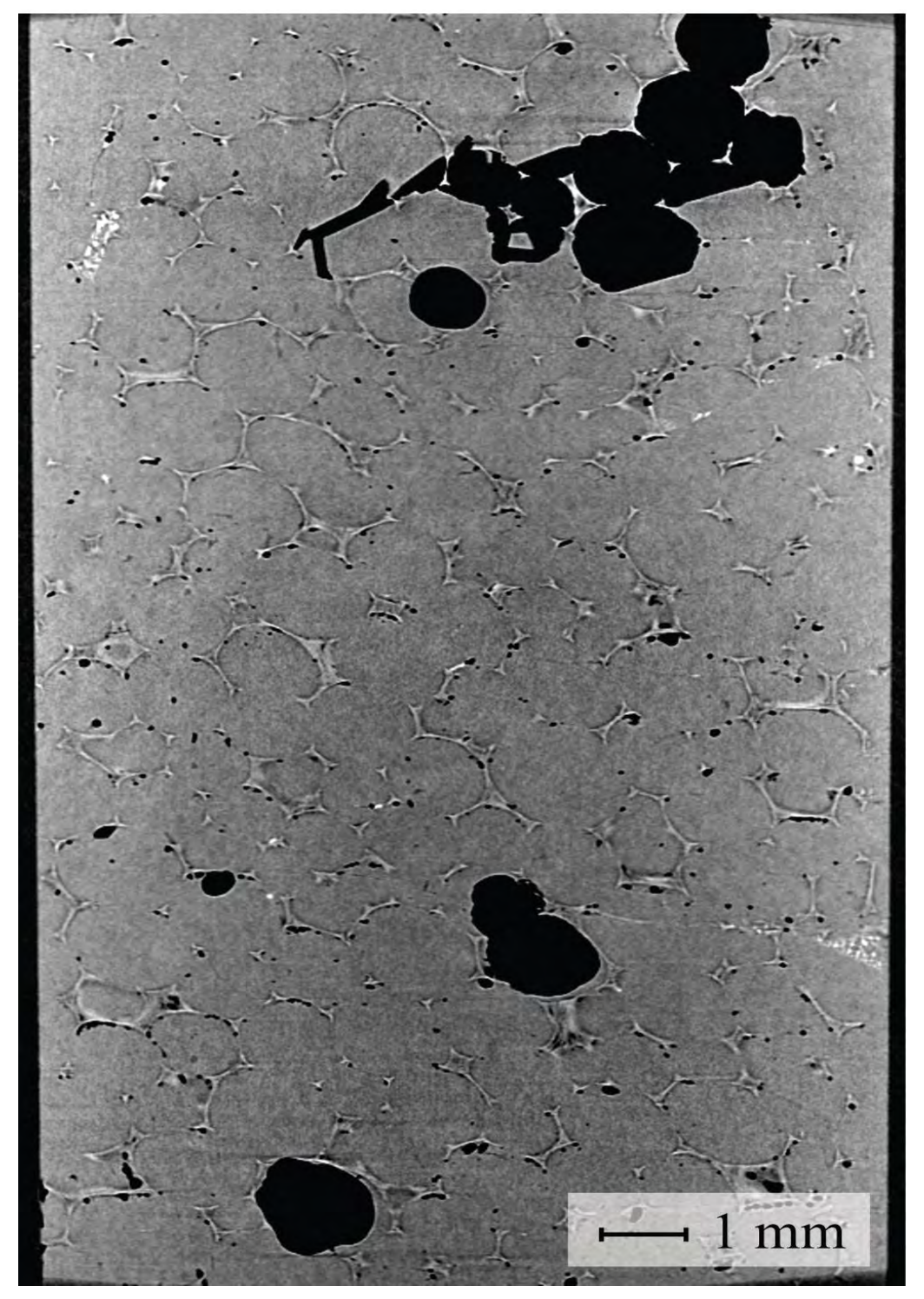


Fig.1 X-Ray Tomography Image of Graphitic foam wetting behavior

Objectives:

1. Analyze thermal transport across water graphite interfaces
2. Determine importance of thermal interfaces within composites

Graphite Wetting

•Graphite is naturally hydrophobic

•This is problematic when making a graphite/salt hydrate composite

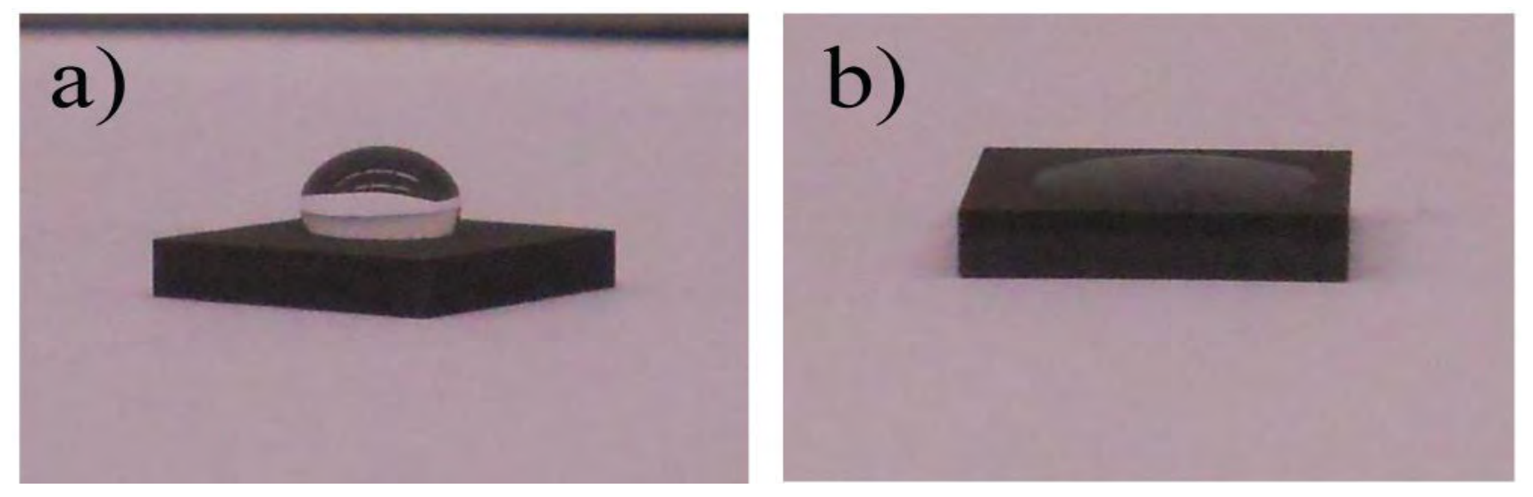
•Solutions Considered

  •UV-Ozone treatment

  •Thin SiO_x layer

  •DOW Corning Q2-5211 Super wetting Agent (Commercial non-ionic silicone surfactant)

•This study focused on using Dow Super wetting (SW) agent due to its ease of use



Pure H_2O

H_2O + 1 v.% DOW Superwetting Agent (Commercial non-ionic silicone surfactant)

Fig.2 Superwetting agent effects on graphite wetting

Experimental Approach

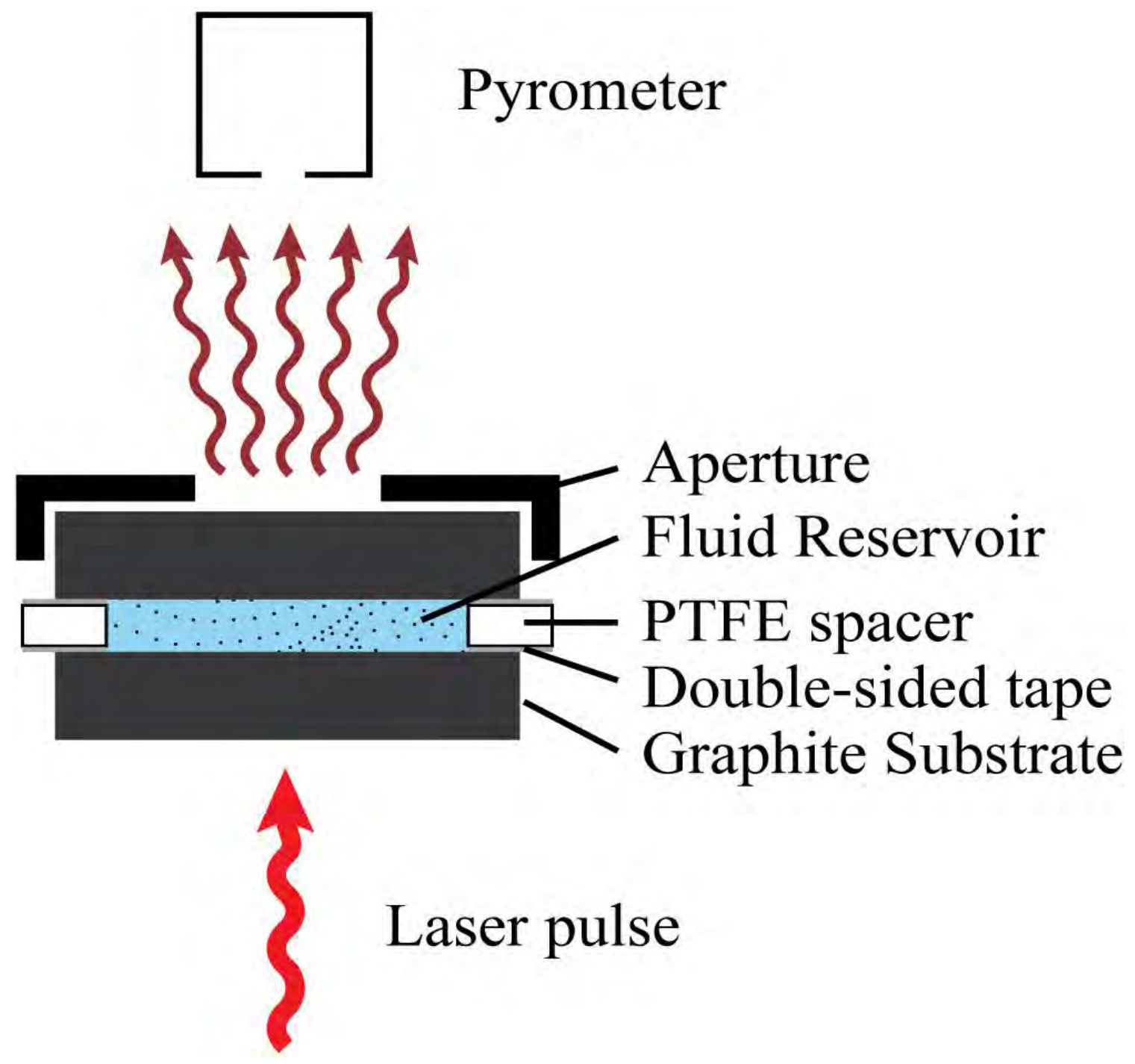


Fig. 3 Graphite-Water-Graphite stack set up.

- Thin water (36 μl) layer sandwiched between two graphite substrates
- Water enclosed by Teflon/vacuum grease or Teflon/double-sided tape.
- Used Netzsch LFA 457 to conduct transient measurements
- Independently measured values were used for substrate properties

- Model fit resulted in correlation coefficients of .995 and higher.
- Data was best fit by using a model accounting for heat loss.

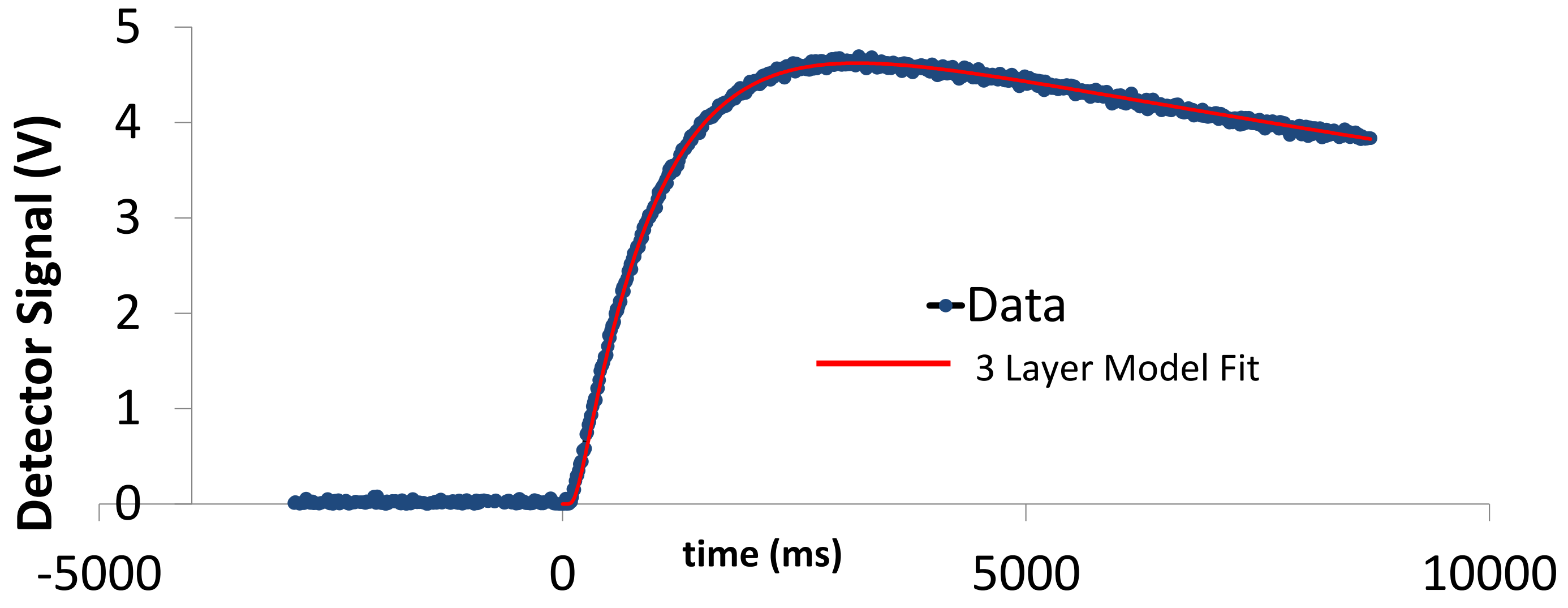


Fig. 4 Netzsch LFA 457 Data fit

Results

Effect of Thickness

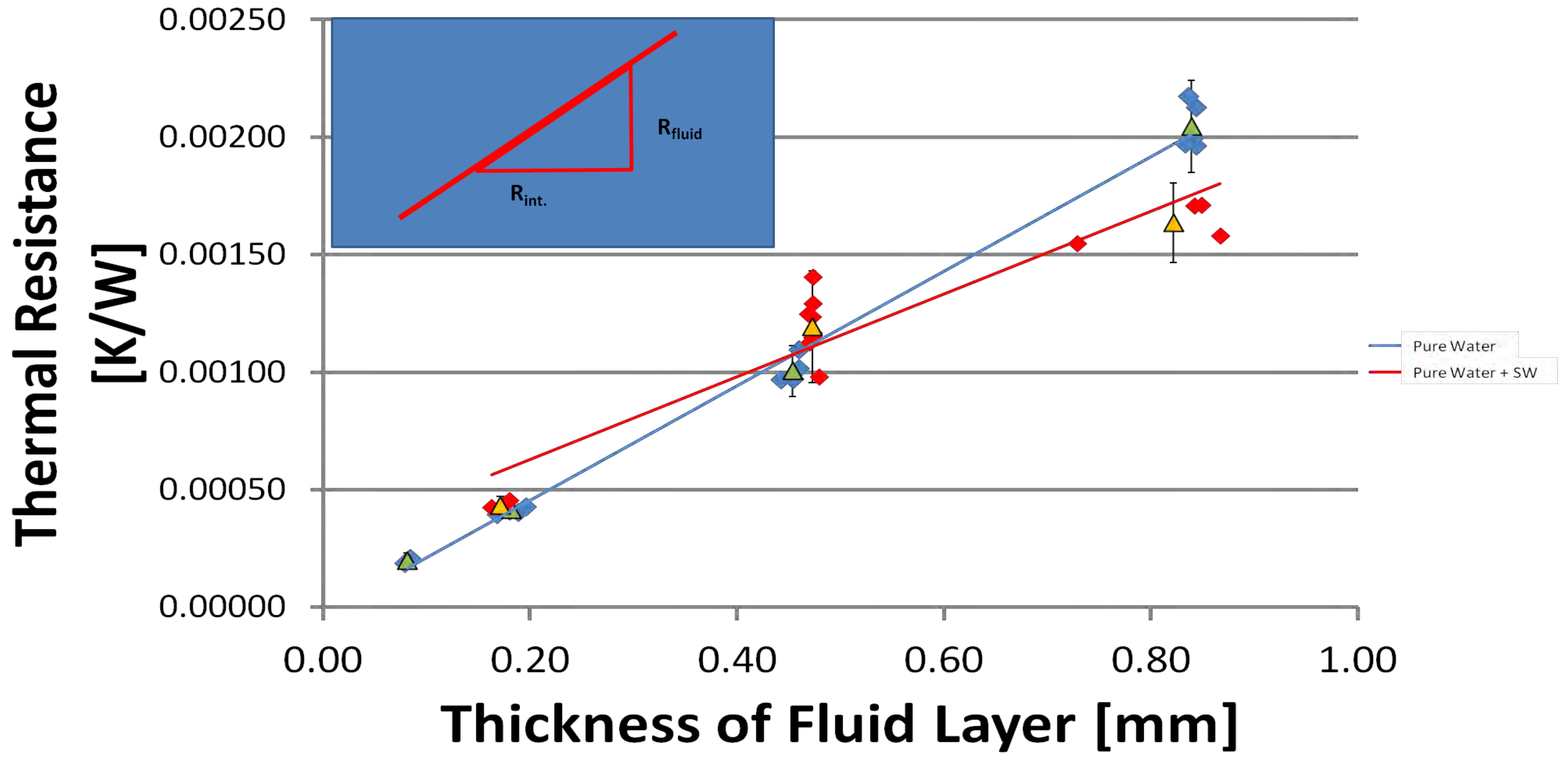


Fig.7 Thermal Resistance vs. Thickness of Fluid Layer

- $R_{\text{interface}} < 0.14$ K·cm²/W (at 95 % CI)
- $R_{\text{interface}} << R_{\text{fluid}}$ (~10 K·cm²/W)
- Previous measurements:[1]

  $R_{\text{H2O interface}} = 0.03$ to 0.2 K·cm²/W

Effect of SW Concentration

•Concentration dependence on diffusivity was analyzed

•In all cases effective diffusivity values were lower than accepted literature values for bulk water

  •Difference from NIST value may be due to:

    1.Interpreting data with complex 3-Layer model

    2.Complexity of sample geometry

    3.Convection in fluid layer

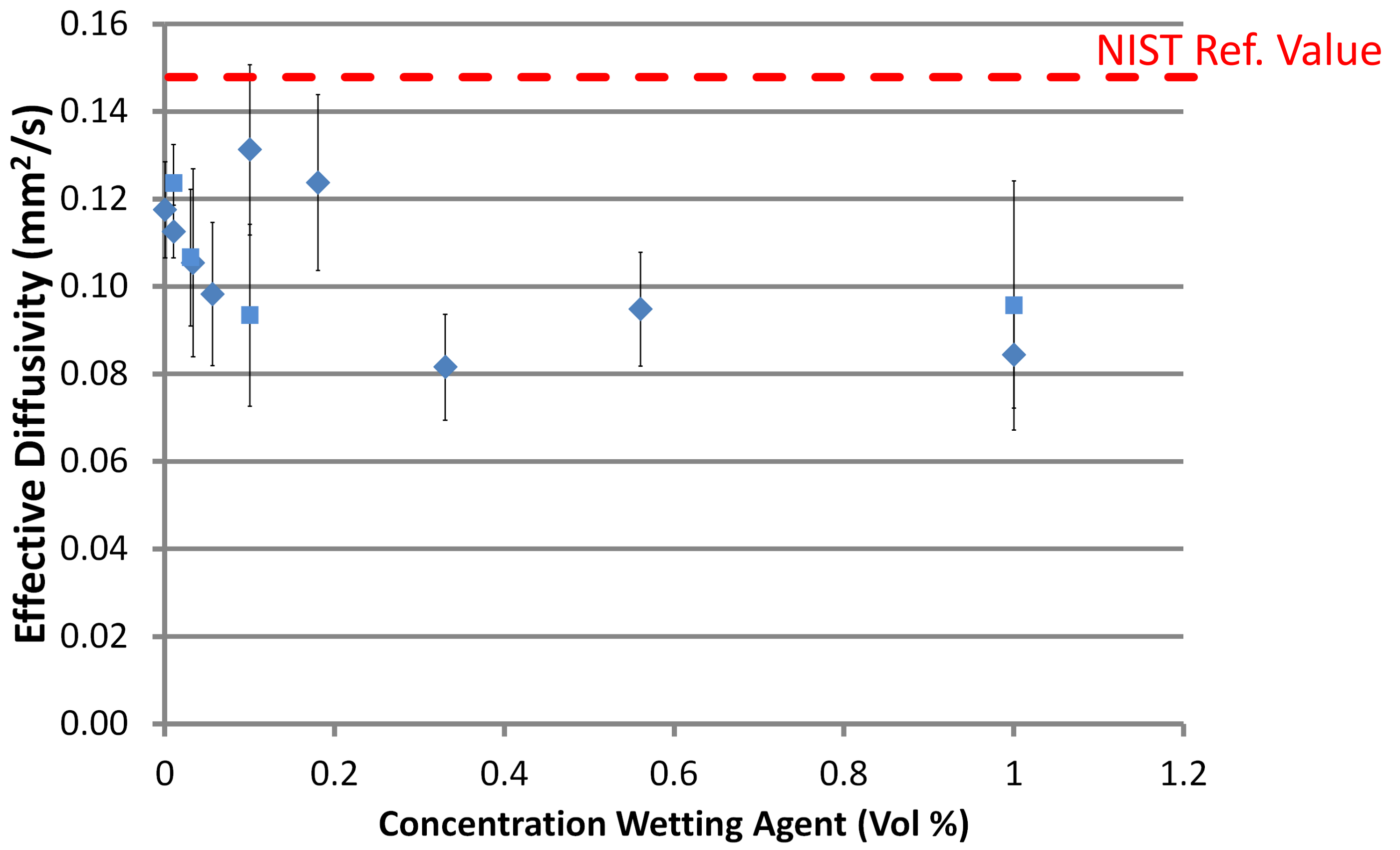


Fig.6 Effective Diffusivity vs. Concentration %

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[1] Ge, Z., Cahill, D.G., Braun, P.V., (2006), Thermal Conductance of Hydrophilic and Hydrophobic Interfaces, *Phys. Rev. Lett.* **96**, 186101.

Conclusions

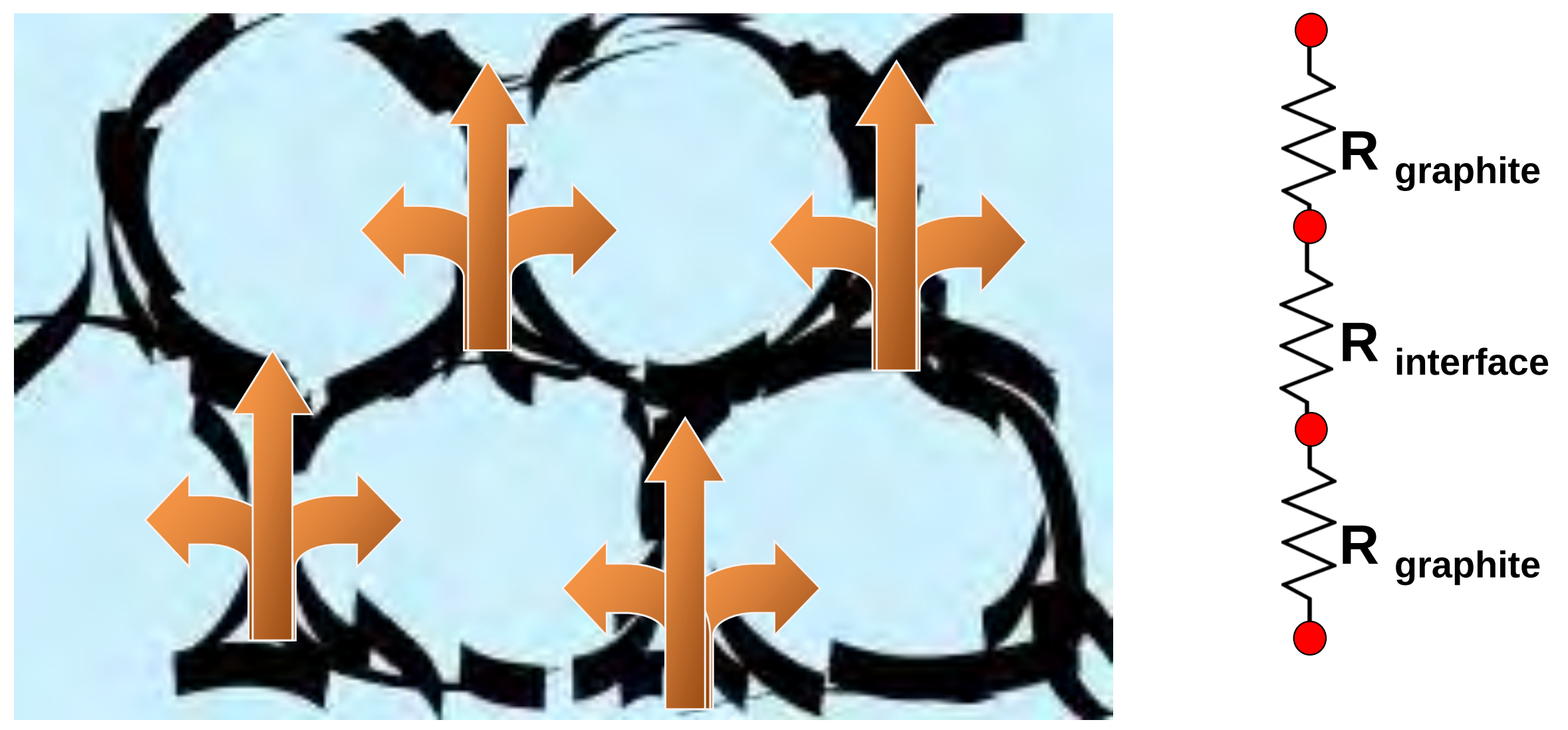

Fig.7 Heat transfer in graphitic foam

•In this case, $R_{\text{interface}}$ (~.10 K·cm²/W) < < R_{fluid} (~10 K·cm²/W)

• $R_{\text{interface (Pure Water)}} \sim R_{\text{interface (Pure Water + SW)}}$

•Therefore interfaces are negligible when dealing with heat transfer within composites

•Use of surfactants proved successful in increasing wetting ability of graphite