

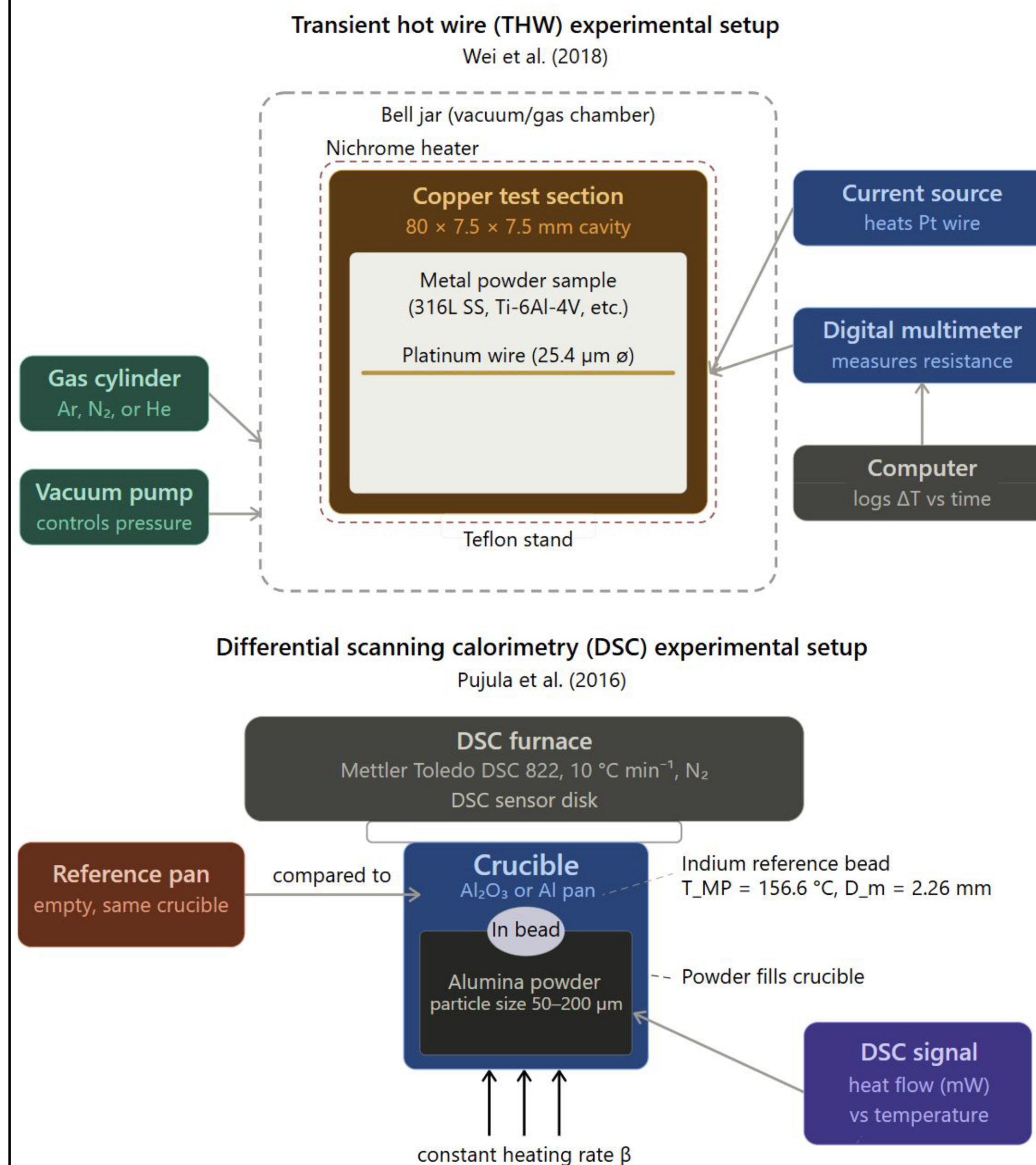
Optimization of Powder Bed Fusion of Pure Copper

Kai Castillo, Aerospace Engineering
Dr. Ladani, PhD. MechE.
Arizona State University



Objective and Research Question: How can powder bed fusion (PBF) process parameters be optimized to reduce impurities and improve the thermal and electrical conductivity of pure copper components for high-performance applications, including aerospace, semiconductor, and electronic systems?

Research Methodology: Two methods for measuring effective thermal conductivity and thermal diffusivity in loose metal powder beds were reviewed to better understand how heat behaves in powder bed fusion (PBF). The transient hot wire (THW) method embeds a thin platinum wire within the powder and heats it with an applied current. Thermal conductivity is extracted from the linear relationship between the wire's temperature rise and the natural logarithm of time [1]. The differential scanning calorimetry (DSC) method places a small Indium reference bead inside a powder-filled crucible and records heat flow during a controlled heating ramp. Once the bead begins melting, the slope of the DSC peak becomes proportional to the total thermal resistance of the surrounding powder, from which effective thermal conductivity is calculated [2].



Results and Discussion: Effective thermal conductivity values were found to range from approximately 6–15 W/m·K, depending on powder material and structure [1]. The surrounding gas environment also strongly influences heat transfer behavior. At low pressures, gas has little effect, but at higher pressures, gas conduction enhances heat transfer between particles [1]. Both experimental methods show consistent trends: lower thermal conductivity leads to slower heat dissipation, while higher conductivity improves heat spreading. Since thermal diffusivity is directly related to conductivity, increases in conductivity correspond to faster thermal response within the powder bed [1][2]. These results are critical for powder bed fusion of copper, where insufficient heat dissipation can cause melt pool instability and defects. Improving thermal transport within the powder enables more uniform heat distribution, leading to better process stability and improved thermal and electrical performance in the final component.

References: [1] “Transient Hot Wire Method for Measuring Thermal Transport in Metal Powders”, Lien Chin Wei et al. 2018
[2] “Measuring thermal conductivity of powders with differential scanning calorimetry: A simplified method”, Miguel Pujula et al.