

# Measurements of the effective thermal conductivity of composite metal powders for additive manufacturing

Hyunjong Lee<sup>1\*</sup>, Apostolos Koutsoukis<sup>2</sup>, Rocco Lupoi<sup>2</sup>, Davoud Jafari<sup>1</sup>, Valeria Nicolosi<sup>2</sup>, Bernard J. Geurts<sup>1</sup>, Wessel W. Wits<sup>1</sup>

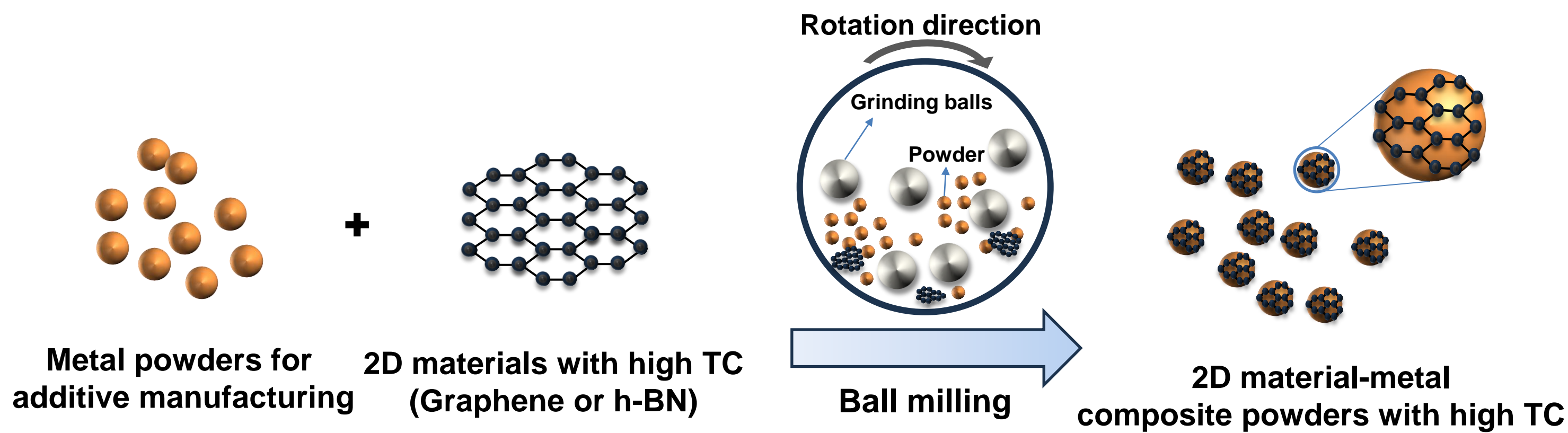
<sup>1</sup> University of Twente, Enschede, The Netherlands

<sup>2</sup> Trinity College Dublin, The University of Dublin, Dublin, Ireland

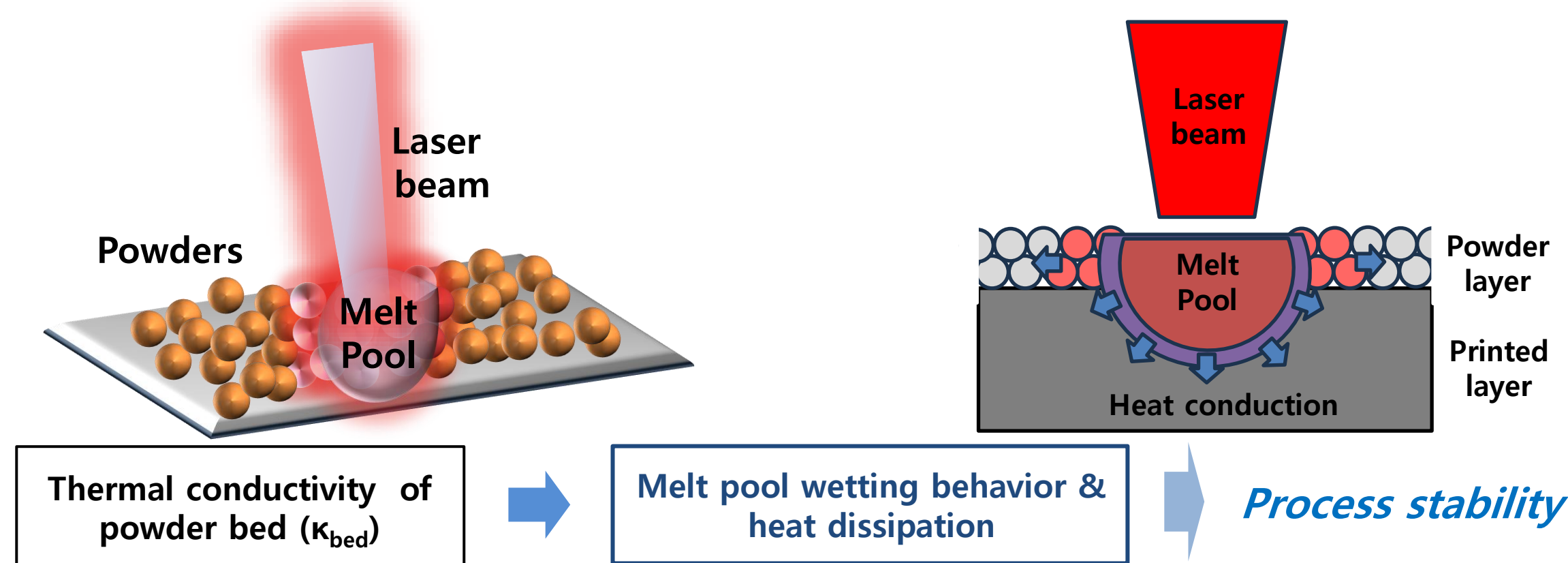
\* Presenter: H.Lee@utwente.nl

## Introduction

**Motivation 1: Selection of high thermal conductivity (TC) composite powders**



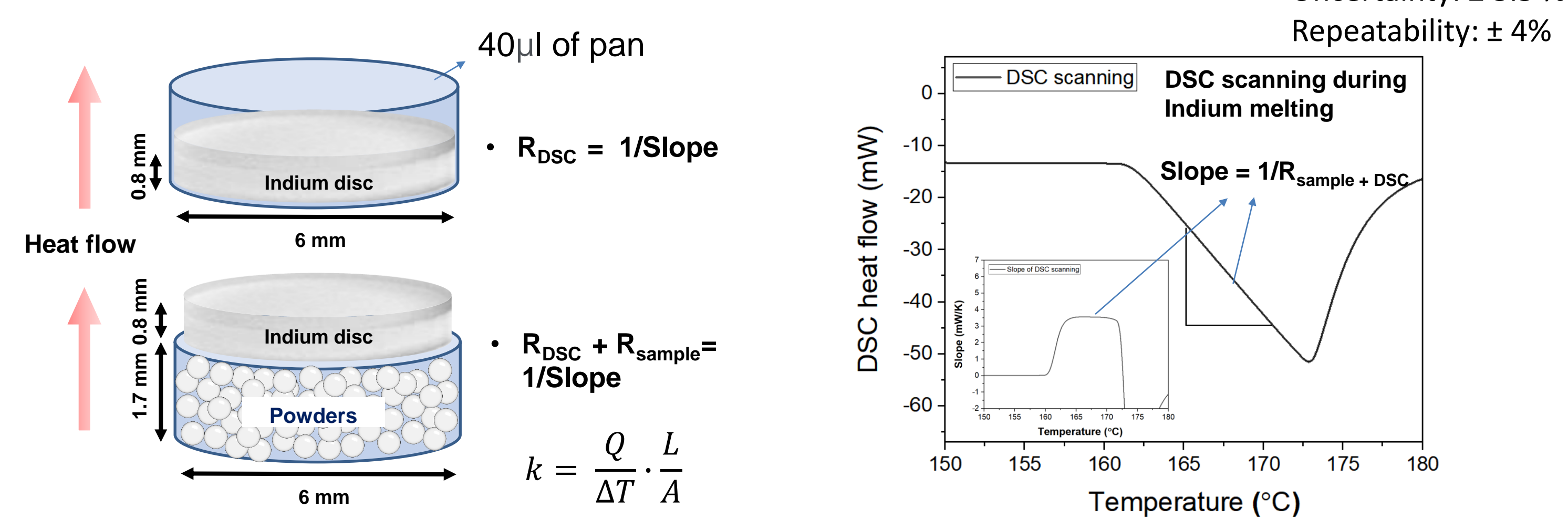
**Motivation 2: Process optimization by measuring effective TC of powder bed**



- Challenge** ✓ Difficult to obtain reliable TC data due to the various factors of powder bed that affects heat transfer
- Research gap**
  - Lack of TC data for composite powders
  - Effect of powder composition on the  $k_{bed}$

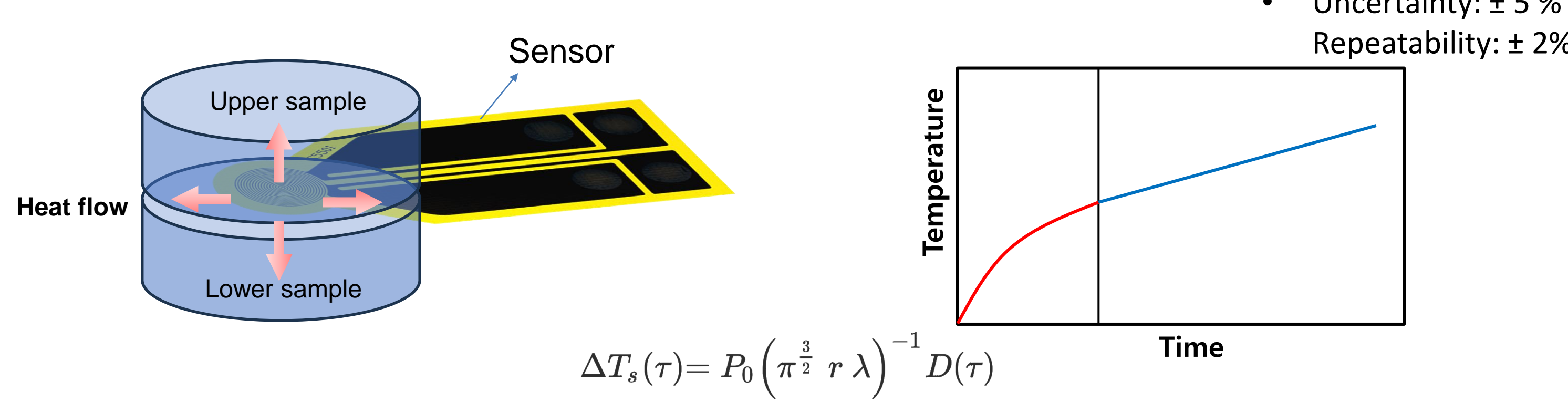
## Methodologies

**1. Differential scanning calorimetry (DSC)**



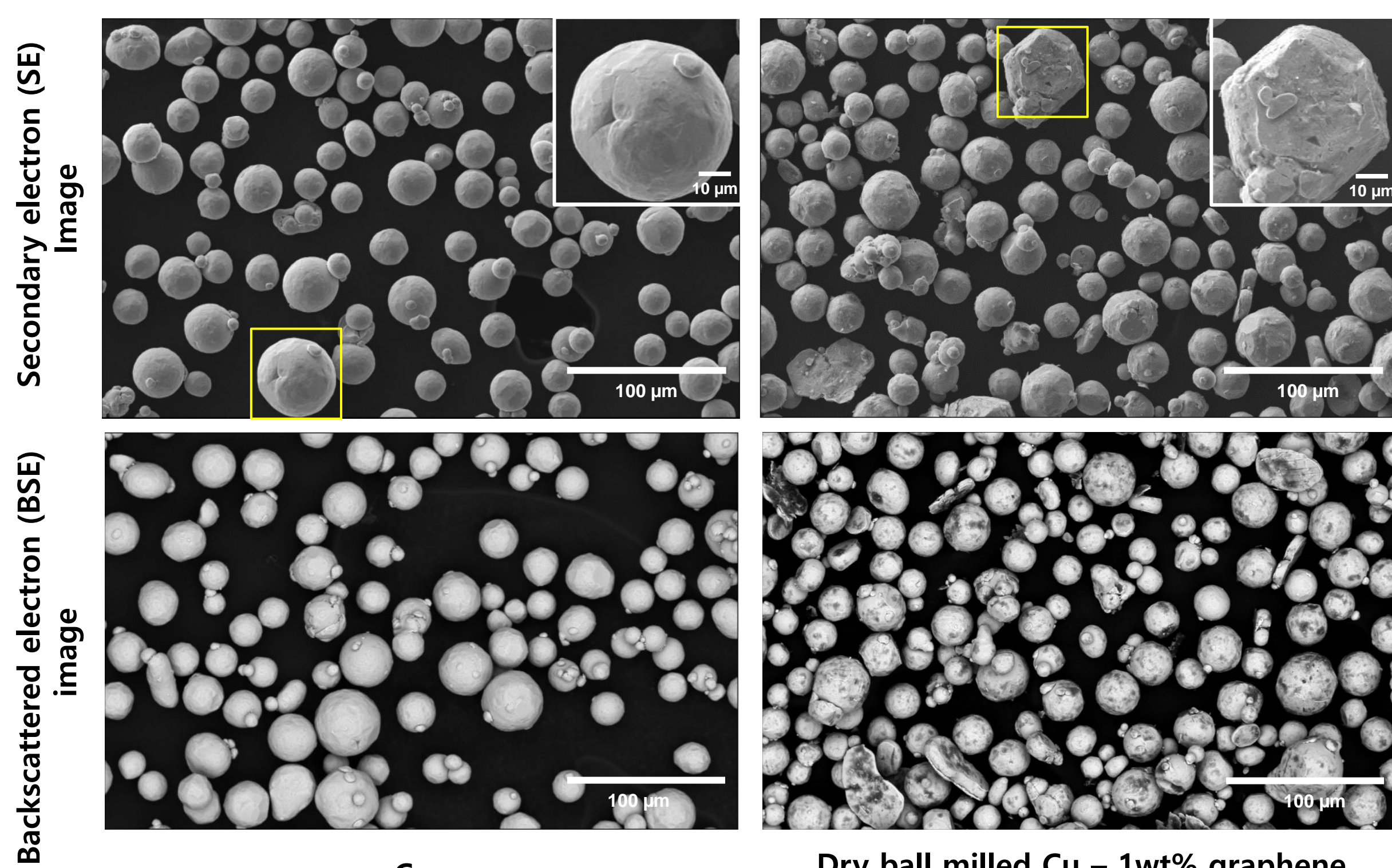
Indirect measurements of TC through measuring thermal resistance of powder bed

**2. Transient plane source (TPS)**



Direct measurements of TC by calculating temperature vs. time profile of powder bed

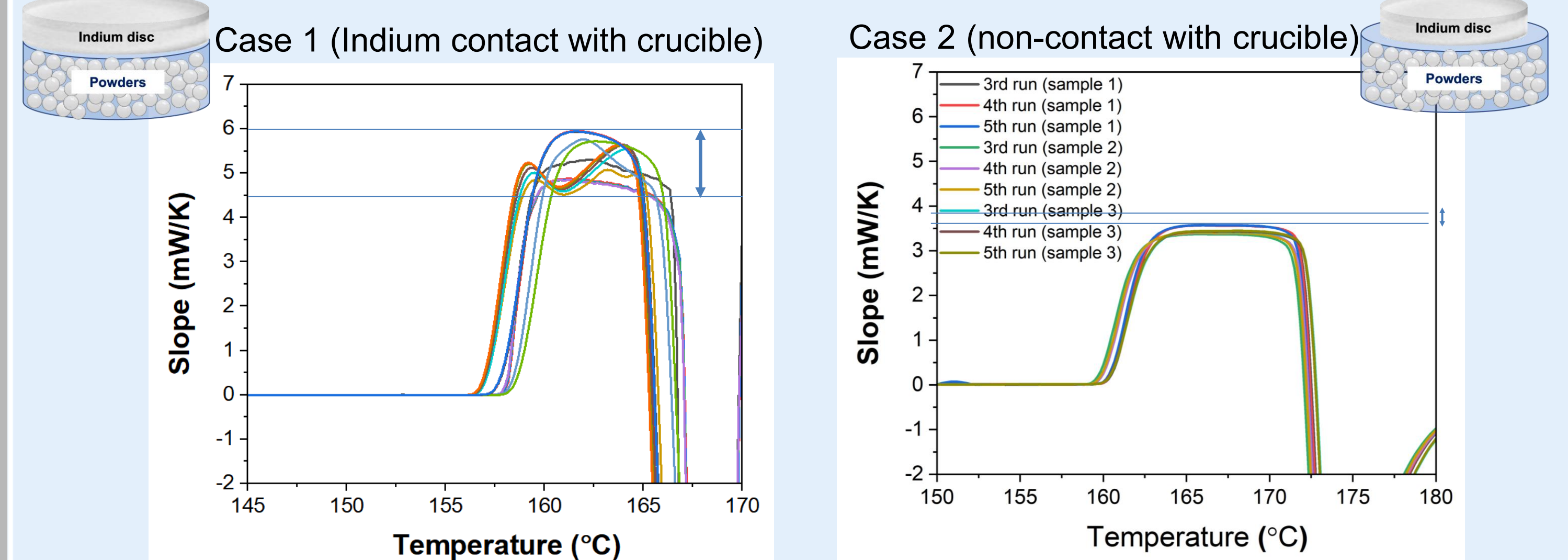
## Powder materials



Morphology change of composite powders during ball milling (spherical → polyhedron)

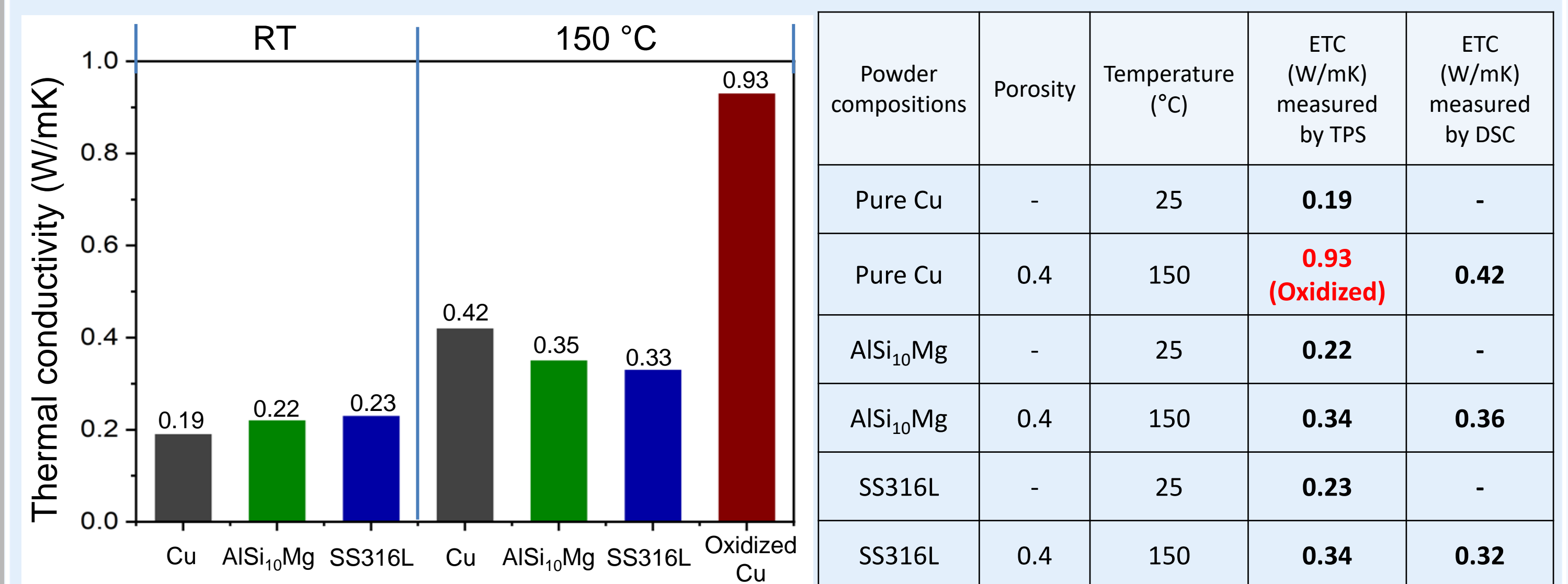
## Results and Discussion

**Optimization of effective thermal conductivity (ETC) measurements of powder bed using DSC**



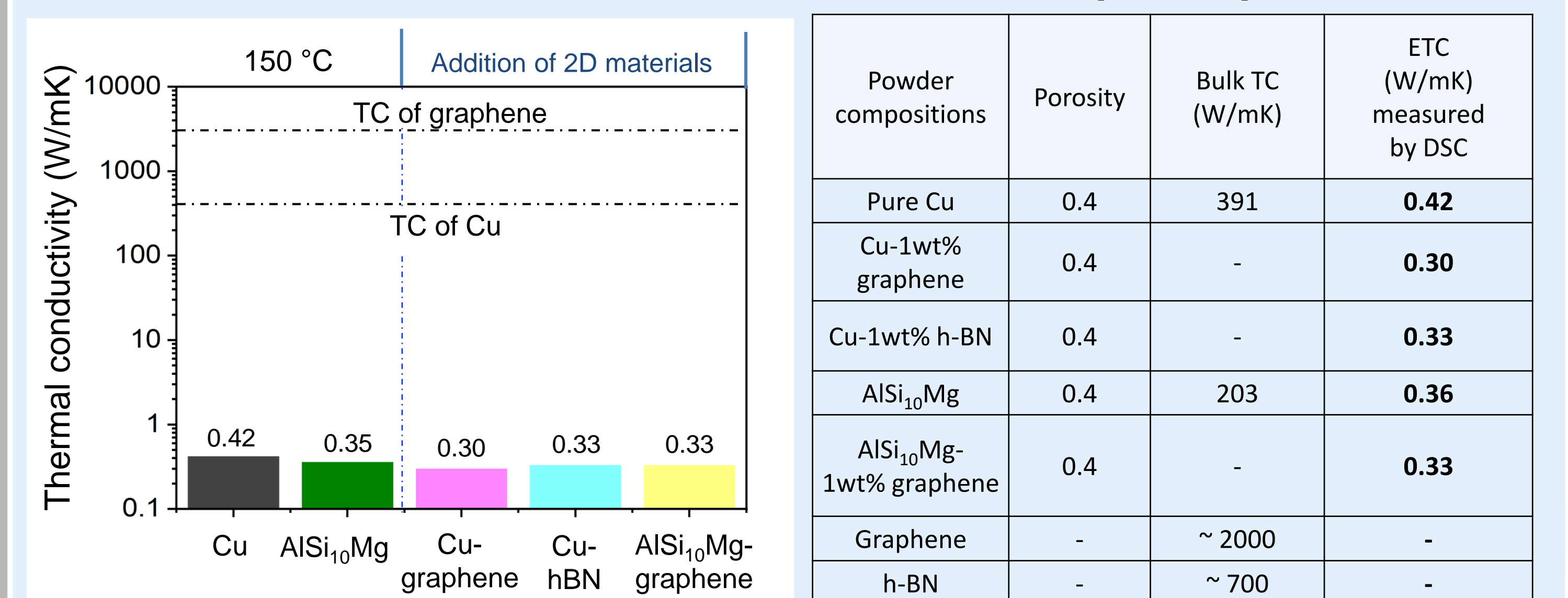
DSC heat flow slope is stabilized by avoiding contact between indium and crucible

**Effect of powder compositions on ETC of metal powder beds**



The powder compositions has little influence on the ETC of powder beds  
Raise of temperature and presence of oxidation increases the ETC of powder beds

**Effect of 2D materials addition on ETC of composite powder bed**



Addition of 2D materials does not directly lead to high ETC of composite powder beds  
Reduction of ETC of composite powder beds likely originate from morphology change

## Conclusions and future work

### ETC of powders

- ETC of all powders (metals + composites) reveals large discrepancy compared to bulk TC of materials (~ 1000 times lower)
- Selection of high TC materials based on ETC value of powder is not viable

### Parameters that affect ETC

- Composition
- Temperature
- Morphology
- Oxidation
- The most dominant factors are temperature and oxidation among all parameters

### Future work

- Systematic study on heat transfer mechanism between powder particles within a powder bed system