

# Evaluation under near-equilibrium conditions of the powders mixture AISI S2 Tool Steel and Silicon Carbide for Laser Powder Bed Fusion applications

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## Abstract

Ultra-fast cooling and heating rates typical of Laser Powder Bed Fusion (LPBF) lead to out-of-equilibrium conditions and to the formation of new metastable phases. Hence, comparison with a near equilibrium state is useful to help understanding the microstructures after LPBF.

In this work, Differential Thermal Analysis (DTA) has been used to evaluate the microstructure obtained by mixing AISI S2 tool steel and silicon carbide (SiC) in different amounts. By cross referencing microstructure observations with the exothermic peaks of the DTA cooling curve, it was possible to elucidate the solidification sequence and to gain insights on the effects of SiC additions in S2 under near-equilibrium conditions. These outcomes will be used as reference for the development of this new alloy by LPBF.

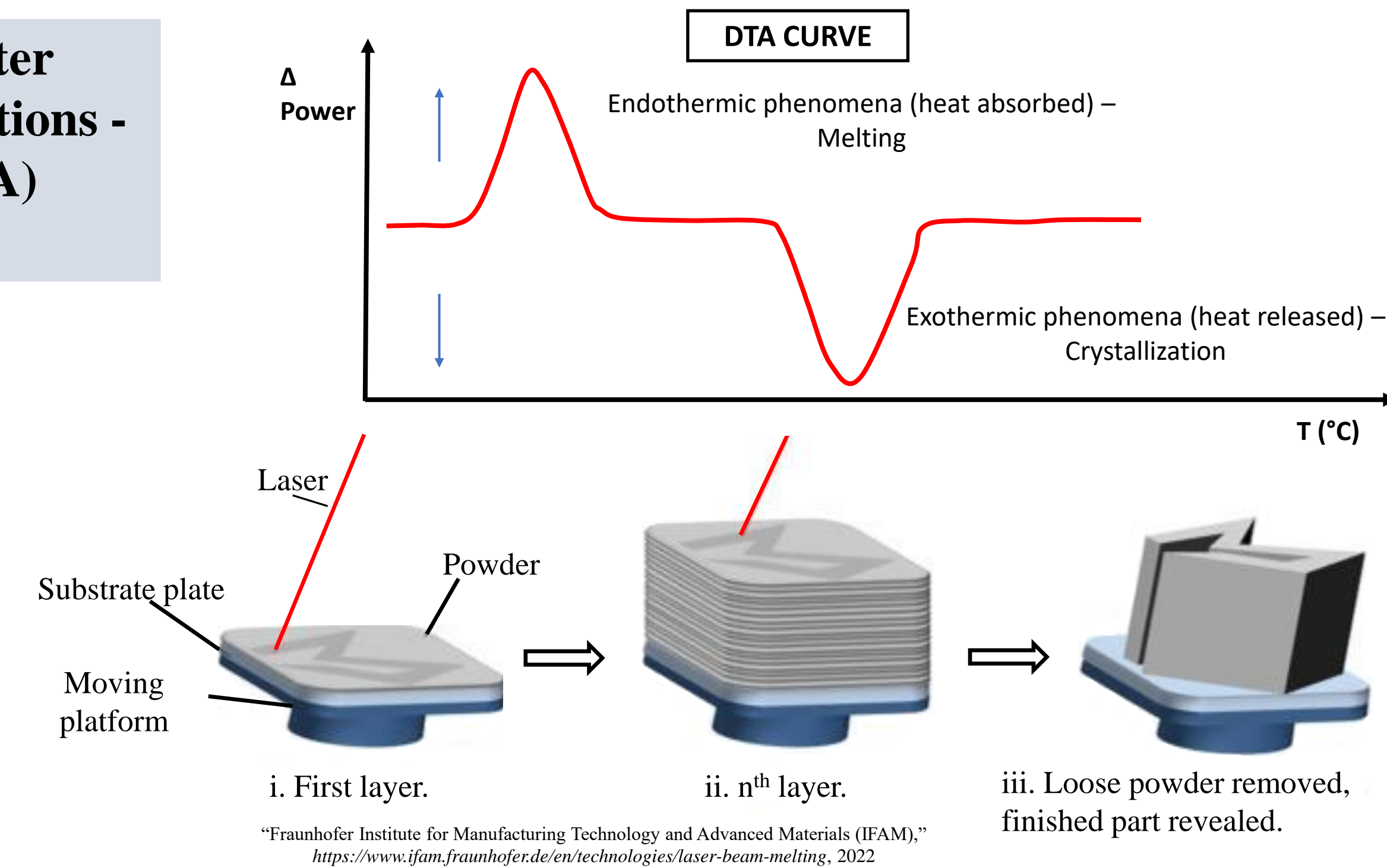
## Background

Microstructural characterization after solidification in near-equilibrium conditions - Differential Thermal Analyses (DTA) (Cooling rate: 5-20°C/min)

To understand

Microstructures after solidification in out-of-equilibrium conditions - Additive Manufacturing (Cooling rate: 10<sup>3</sup>-10<sup>6</sup> °C/min)

Endothermic and exothermic peaks associated to reactions during heating and cooling

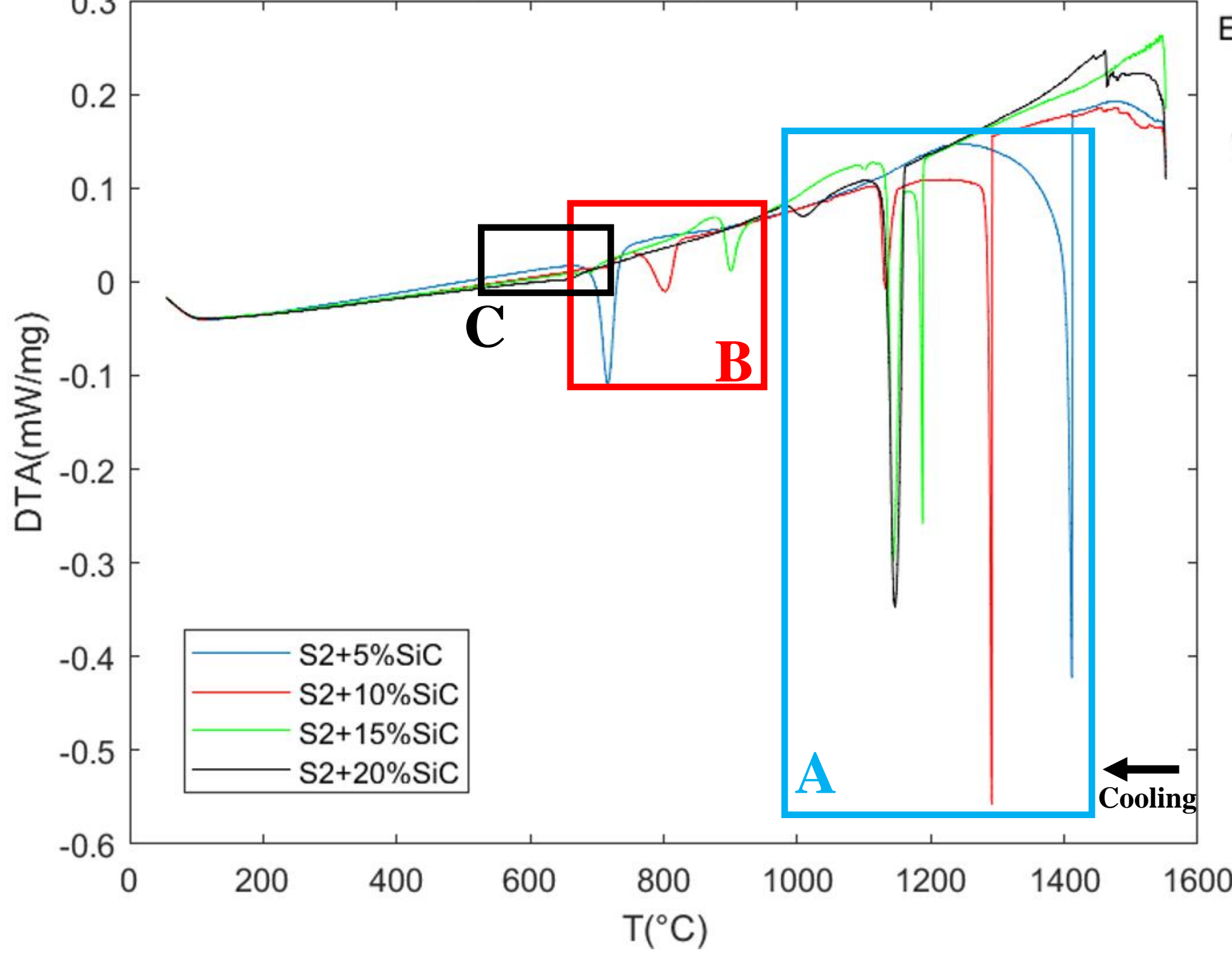


## Results

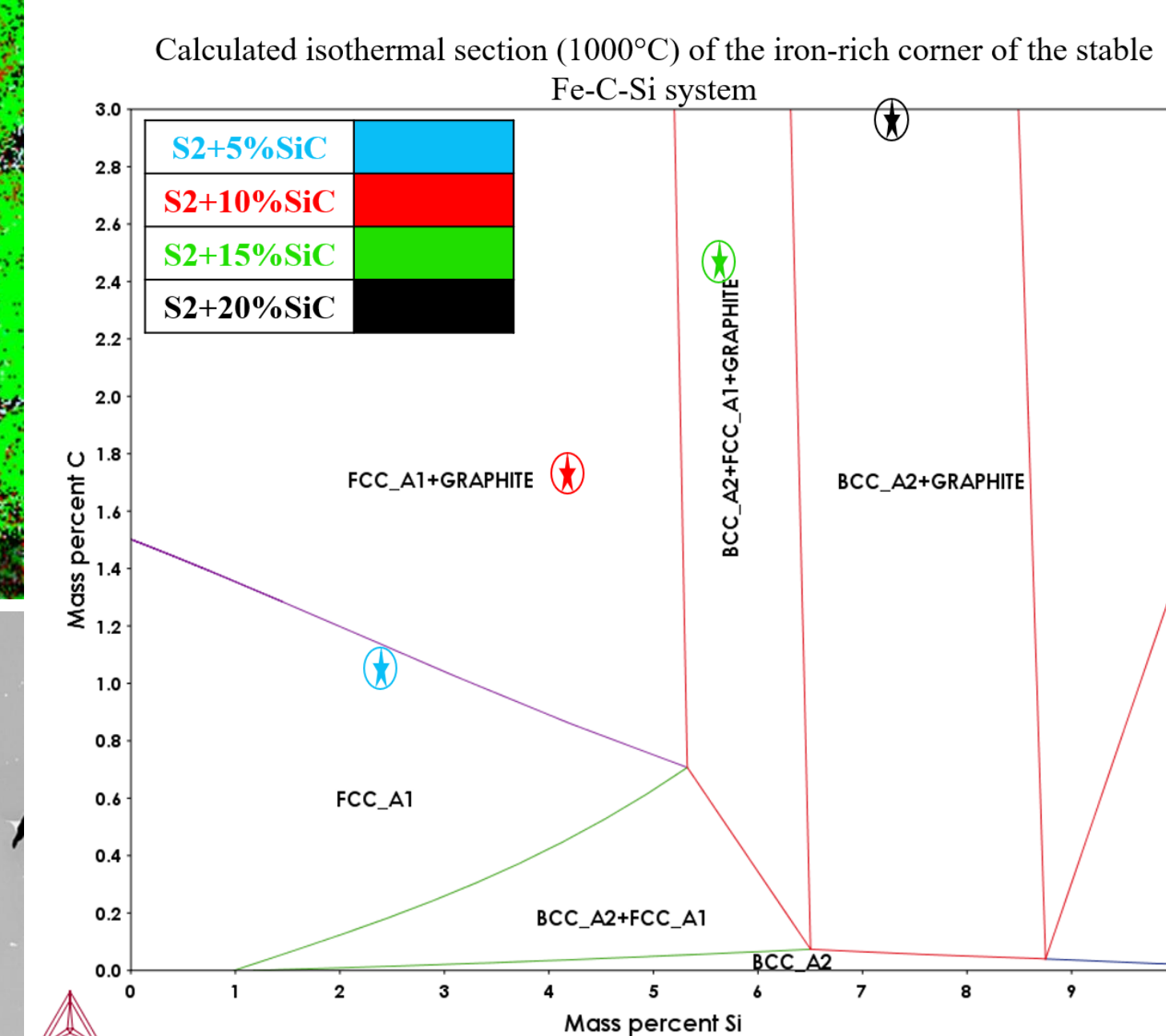
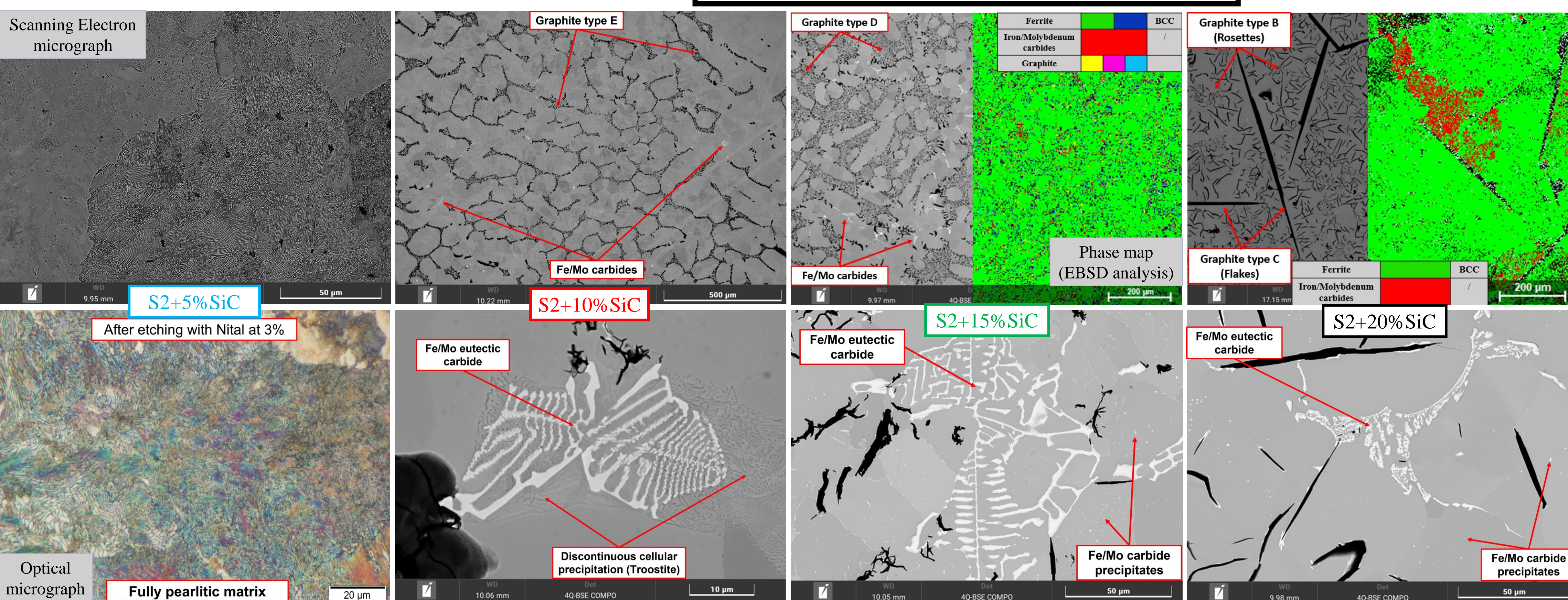
The solidification path during cooling is determined by combining DTA, Thermo-calc and microscopy observations

DTA graphs of AISI S2 Tool steel + X% (in volume) of Silicon carbide

Cooling combined plots at 5°C/min

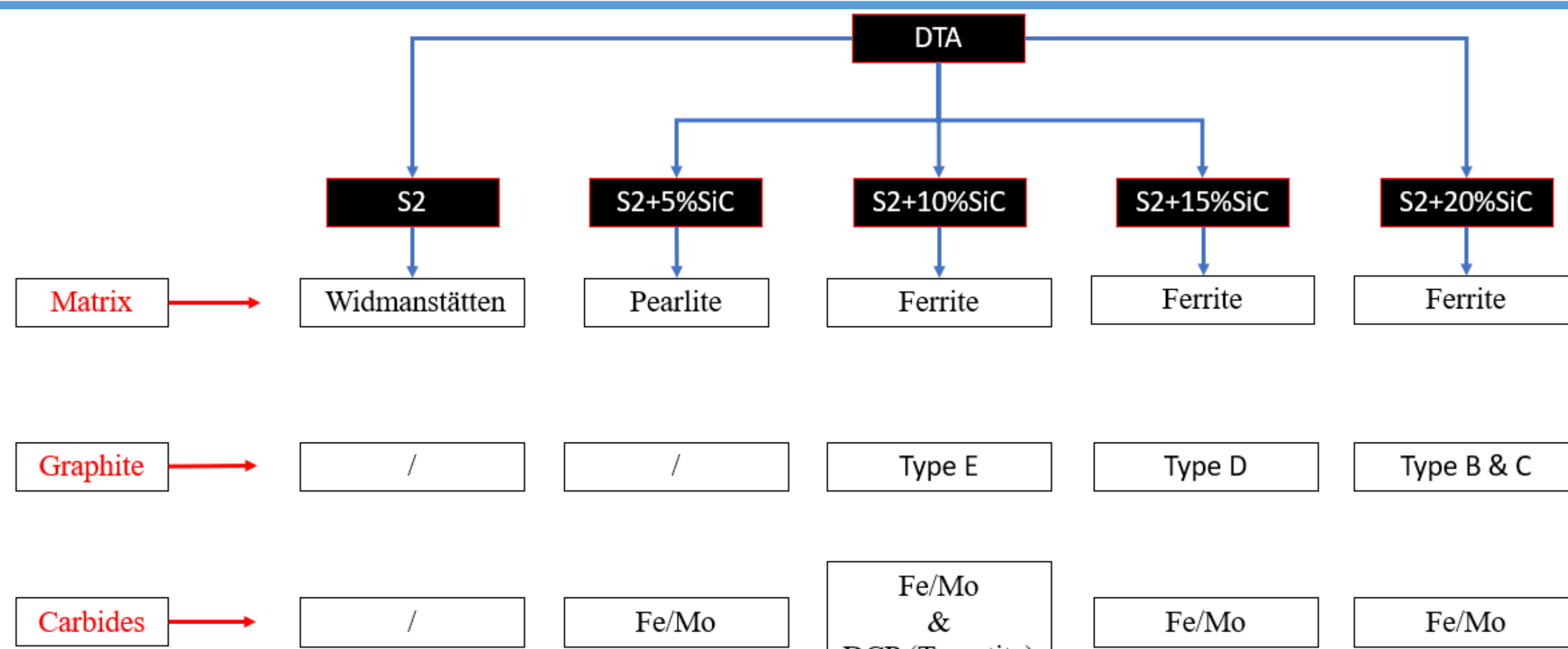


## Microstructures



Observed microstructures in agreement with the Fe-C-Si system at 1000°C, as predicted by Thermo-calc®.

## Conclusions



- Formation of graphite is promoted when increasing the amount of SiC.
- Si content higher than 7 wt.% allows ferrite to form as first phase from the liquid, instead of austenite.
- Mo and C contents allow the formation of Fe/Mo eutectic carbide under near-equilibrium conditions.

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