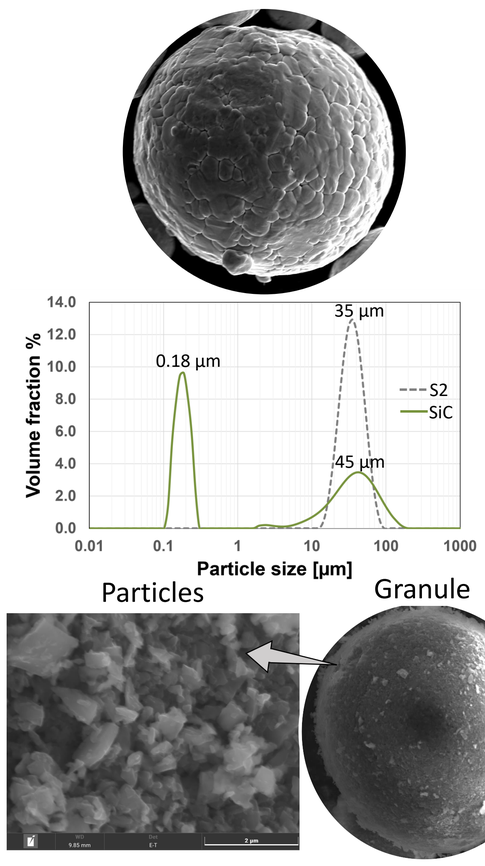
Preparation of powders mixture of AISI S2 Tool Steel and Silicon Carbide for use in Laser Powder Bed Fusion

E. Saggionetto[1], A. H. Seidou[1], G. Roger Vila[1], O. Dedry[1], F. Boschini[2], J. T. Tchuindjang[1], A. Mertens[1]
[1]*Metallic Materials Science (MMS), Aerospace and Mechanical Engineering Dpt., University of Liège*
[2]*GREEnMat Laboratory, University of Liège*

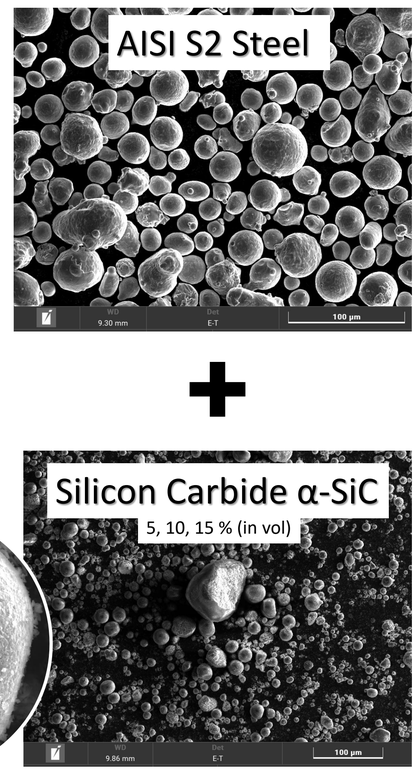
Abstract

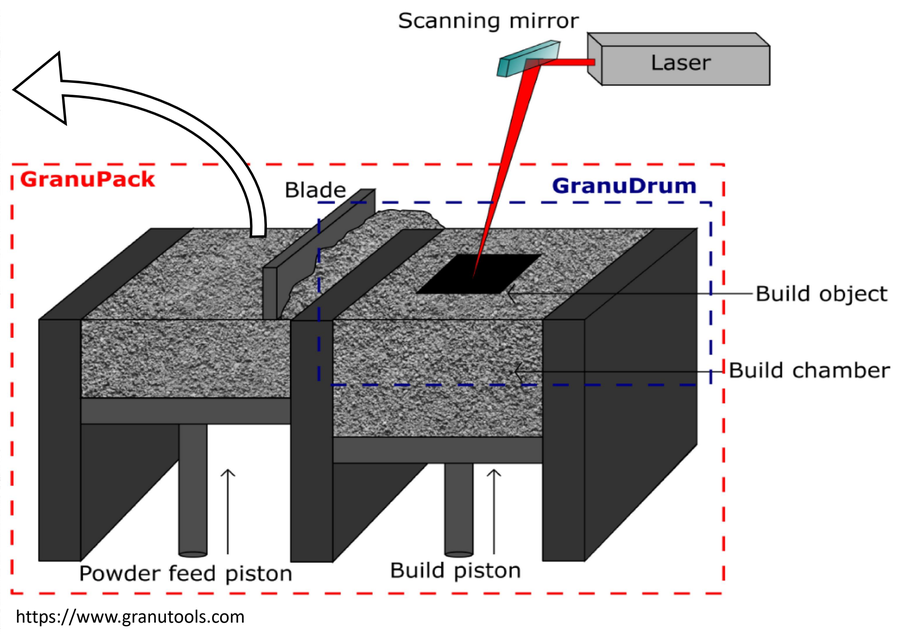
Mixing different powders is a promising way to broaden the choice of materials for Laser Powder Bed Fusion (LPBF). However, powders for LPBF must present appropriate rheological properties. Indeed, if the initial batch of powders is not homogeneous, both spreadability and laser - powder interaction suffer, affecting the final part quality.
This work thus focuses on the preparation of mixed AISI S2 tool steel and silicon carbide (SiC) powders for use in LPBF. To promote the complete dissolution of SiC in the melt pool, spray dried granules of SiC nanoparticles were selected. A combination of sieving, ball milling and thermal treatment was finally selected as it resulted in good rheological properties of the powders mixture and in a good quality of the final part.



Materials and Methods

Manufacturing technology 3D printing LPBF





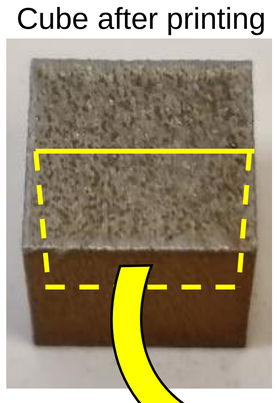
https://www.granutools.com

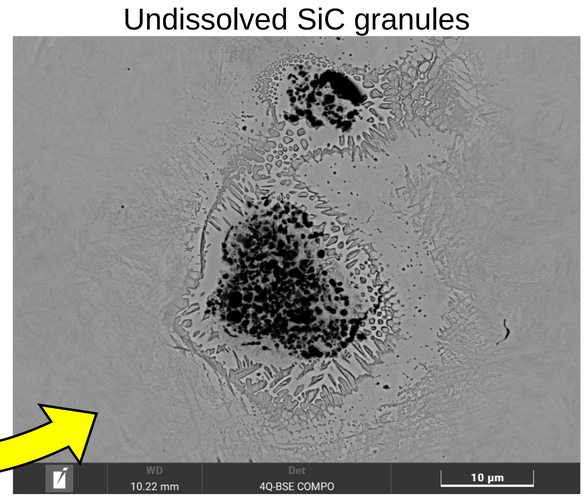
GOAL

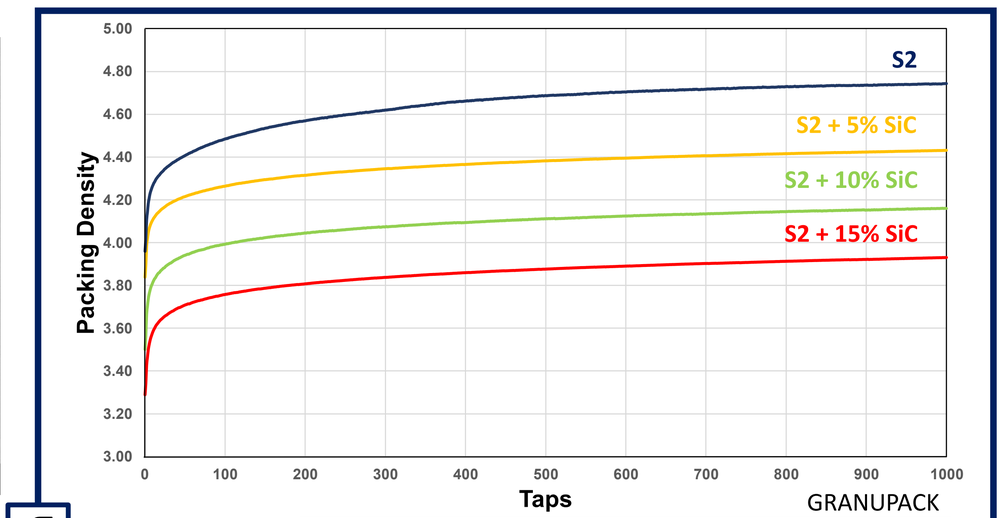
Achieve a fully dense, defect-free sample with a homogenous microstructure

Preliminary investigations

S2 + 5%SiC was manually mixed and processed by LPBF.
After printing, undissolved SiC were detected within the microstructure, leading to inhomogeneity





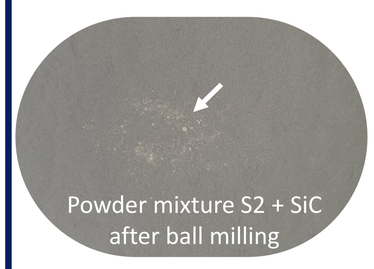


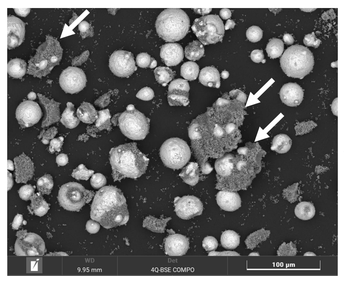
GRANUPACK

	ρ[0] [g/cm3]	ρ[n] [g/cm3]	Hausner ratio (ρ[0] / ρ[n])	Carr Index % (ρ[n] - ρ[0] / ρ[n])
S2	3.96	4.74	1.20	16.5
S2 + 5% SiC	3.84	4.44	1.16	13.5
S2 + 10% SiC	3.50	4.16	1.19	15.8
S2 + 15% SiC	3.24	3.93	1.20	16.3

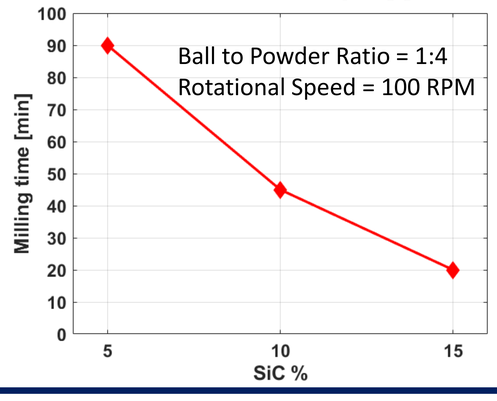
Optimal preparation

Agglomeration of SiC at excessive milling time, undesirable due to inhomogeneity of the mixture





Adaptation of milling time depending on SiC amount due to easy agglomeration



Ball Milling

Sieving SiC < 50 µm
To exclude big granules (difficult to dissolve)

Accurate manual mixing S2 + SiC
To avoid pre-segregation in ball milling

Ball Milling S2 + SiC
To decorate S2 surface with SiC nanoparticles and to break SiC granules

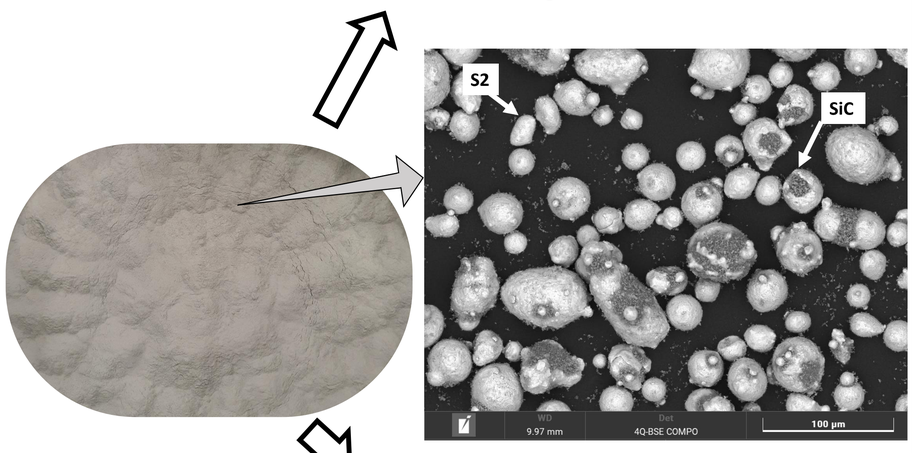
Sieving S2 + SiC < 63 µm
To exclude any agglomerates that may have formed

Choice of the appropriate LPBF parameters

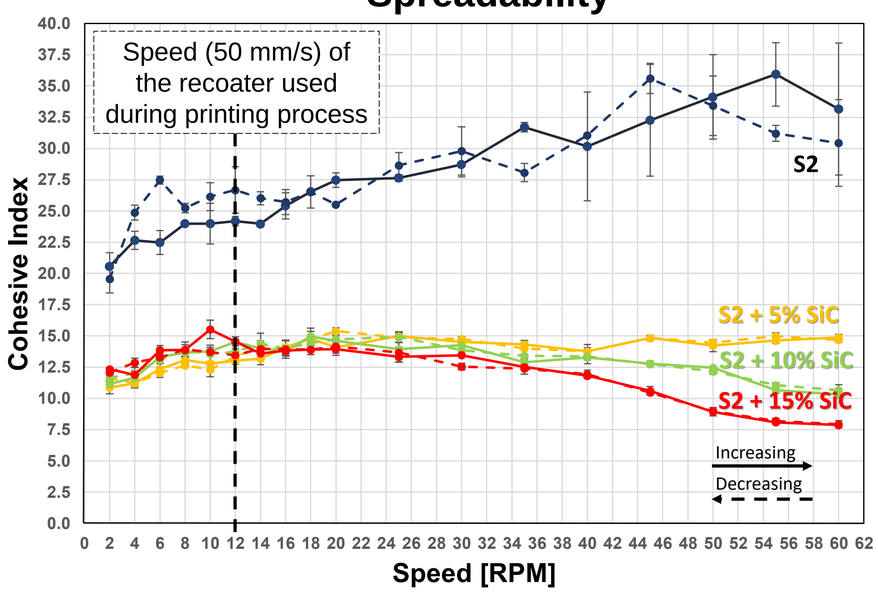
LPBF of samples with final density > 99% and defect-free

Powders after optimal preparation

Packability



Spreadability



Conclusions

- Manual mixing of S2 + SiC resulted in undissolved SiC granules and inhomogeneous microstructure after LPBF.
- An increase in SiC content implies a decrease of the milling time due to the tendency of SiC to agglomerate.
- Adding SiC also leads to a decrease of both packability and cohesive index, while positively affecting the spreadability of the powders mixture.
- The optimal preparation allows to achieve homogeneous layers during the recoating step of LPBF.
- Samples obtained with the appropriate LPBF parameters exhibit a density > 99% and a homogeneous defect-free microstructure.

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Enrico SAGGIONETTO
Materials Engineer / PhD Candidate
Metallic Materials Science Unit (MMS)
University of Liège, Belgium
enrico.saggionetto@uliege.be