OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG
FACULTY OF MECHANICAL ENGINEERING
IWTM

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Powder Metallurgical Synthesis of Ternary Intermetallic Phases in the V–Si–B System

L. Thielemann[1]*, G. Hasemann[1], W. Yang[2], R. Schwaiger[2,3], B. Gorr[4] and M. Krüger[1]
[1]Otto-von-Guericke University Magdeburg, Institute of Materials, Technologies and Mechanics
[2]Forschungszentrum Jülich GmbH, Institute of Energy Materials and Devices, Structure and Function of Materials
[3]RWTH Aachen University, Chair of Energy Engineering Materials
[4]Karlsruhe Institute of Technology, Institute of Applied Materials – Applied Materials Physics

HT Materials

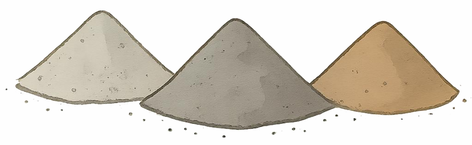
Introduction

High-temperature structural materials require high strength, creep and oxidation resistance. Vanadium-based alloys offer a low-density alternative to Mo- and Nb-based systems but suffer from poor oxidation resistance [1]. Intermetallic phases such as V_3Si, V_5Si_3, and V_5SiB_2 could contribut to meeting the necessary requirements, making the V–Si–B system a promising candidate [2,3]. Recently a new ternary phase was discovered which may play a key role in microstructure evolution and stability [4]. However, its thermodynamic behavior and mechanical properties are still unknown. The aim of this study is the synthesis and characterization of monolithic V_8SiB_4 and V_5SiB_2 via powder processing routes to gain more insights about their temperature and microstructure stability.

Experimental procedure

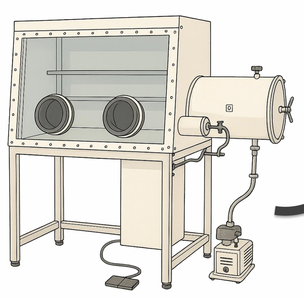
Mechanical Alloying

V (99.5%) Si (99.5%) B (98%)

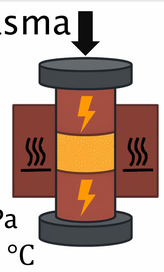


- 200 rpm
- 20 h duration
- every 15 min reverse rotation direction
- every 5 h loosening of powder

weighing in a glove box under protective argon atmosphere



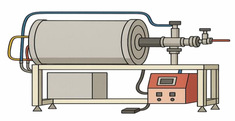
Spark Plasma Sintering



- p = 50 kPa
- T = 1600 °C
- β = 100 K/min
- t_{max} = 5 min

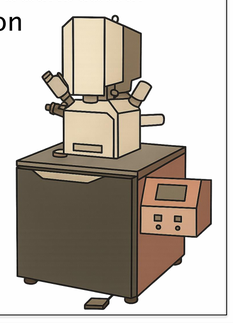
Heat Treatment

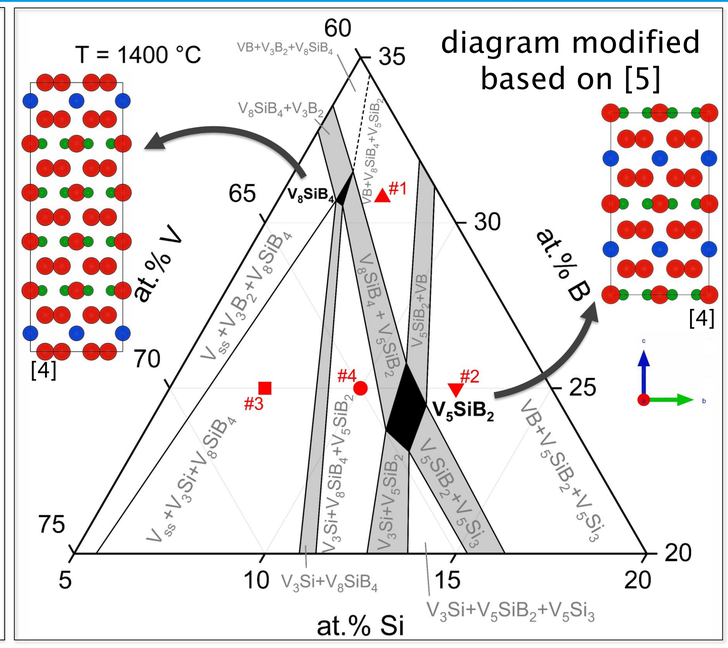
- T = 1400 °C
- t = 100 h
- in vacuum



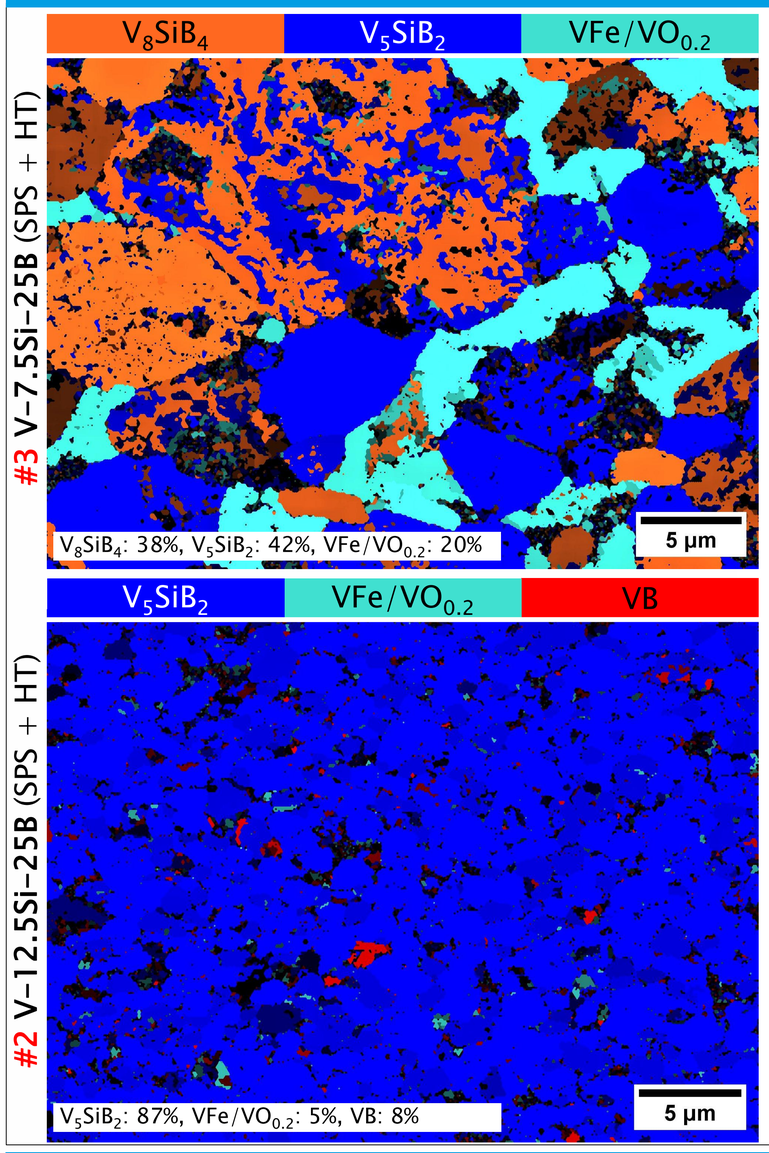
Analysis

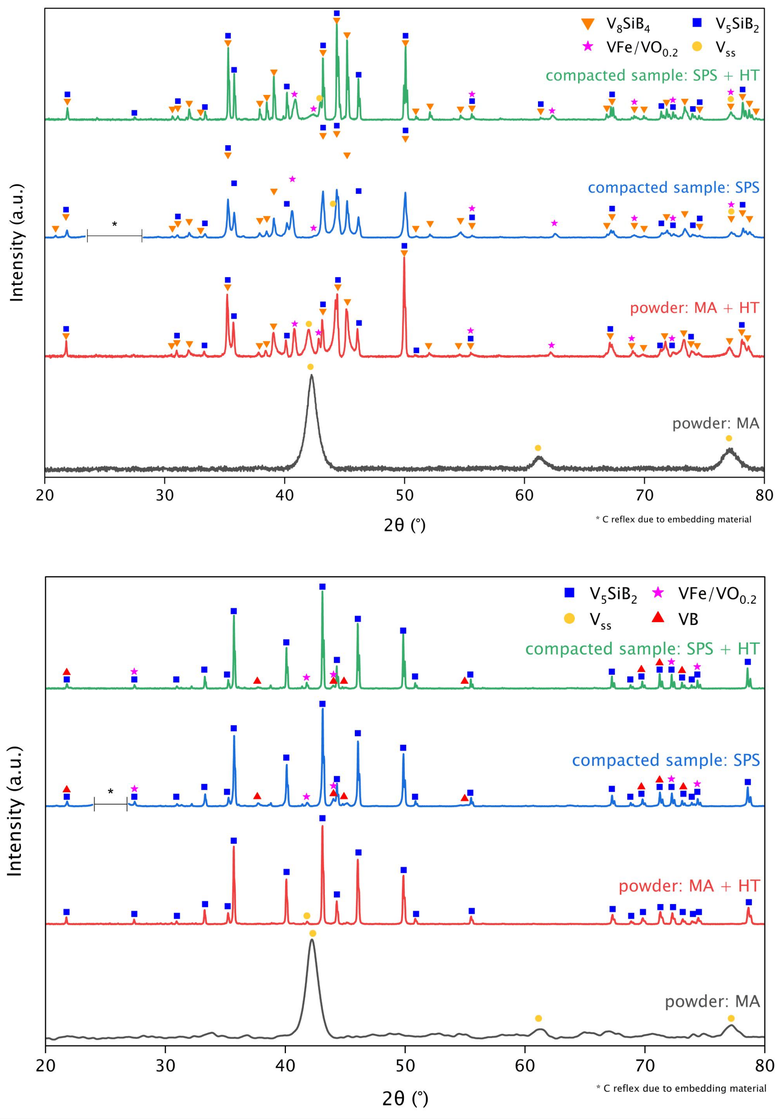
- inductively coupled plasma optical emission spectrometry
- X-ray diffraction
- scanning electron microscopy
- energy dispersive X-ray spectroscopy
- electron backscatter diffraction



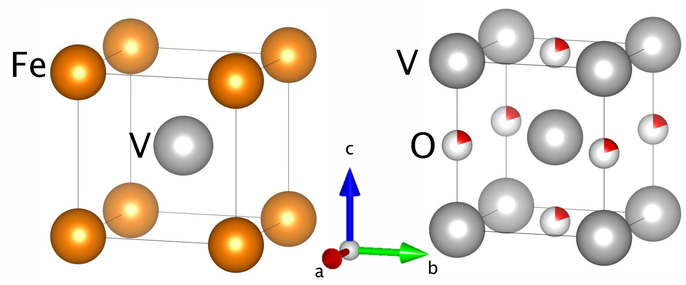


Results





possible solutions for unknown phases in diffractogram (VFe/$VO_{0.2}$)



Phase	Space group	Lattice Parameter (Å)	
		a	c
VFe	P4/mmm	2.9698	3.3572
$VO_{0.2}$ [6]	I4/mmm	2.9818	3.3027

A milling time of 20 h was identified as optimal for mechanical alloying, as it is long enough to form a supersaturated solid solution while minimizing Fe contamination. Alloy #2 V–12.5Si–25B exhibits a high fraction of the V_5SiB_2 phase, reaching approximately 95 wt. %. Alloy #3 V–7.5Si–25B contains the highest amount of V_8SiB_4, with about 50 wt. %.

Future Prospects

- determination of an alloy composition with the highest possible V_8SiB_4 phase fraction
- investigation on mechanical behaviour at elevated temperatures
- determining the origin of phase VFe/$VO_{0.2}$

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*Lars Thielemann: lars.thielemann@ovgu.de, +49 391 67-57034