

SIMULATION AND EXPERIMENTAL INVESTIGATION OF PHASE EQUILIBRIA IN THE QUASICRYSTALLINE FORMING Al-Mn-Si-(X) SYSTEM

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Periodic Table of the Elements

Outline

Atomic Number → 1
← Symbol
Name → Hydrogen
← Atomic Weight
1.008

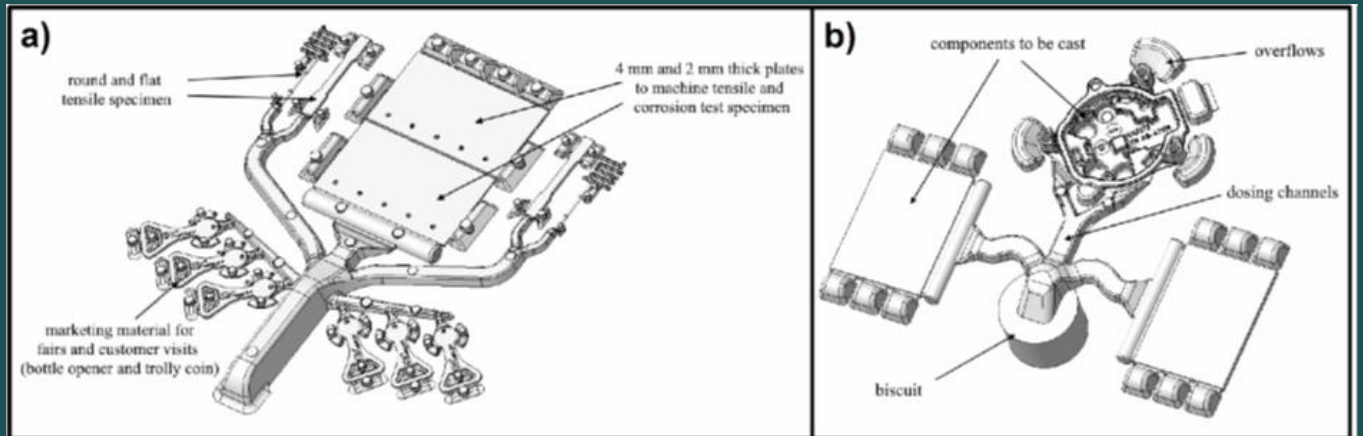
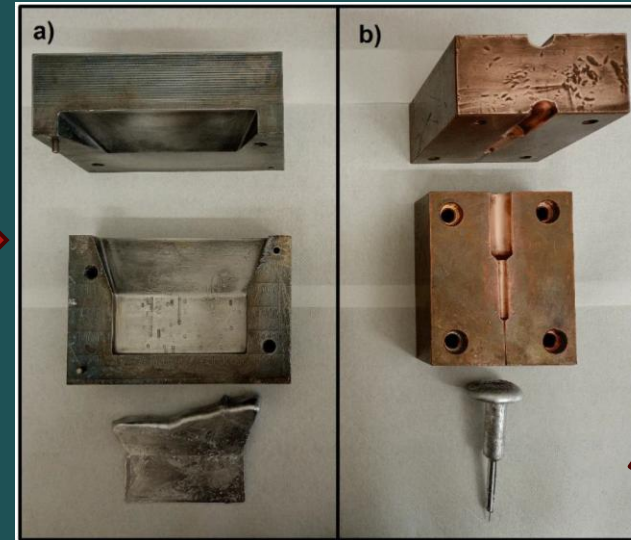
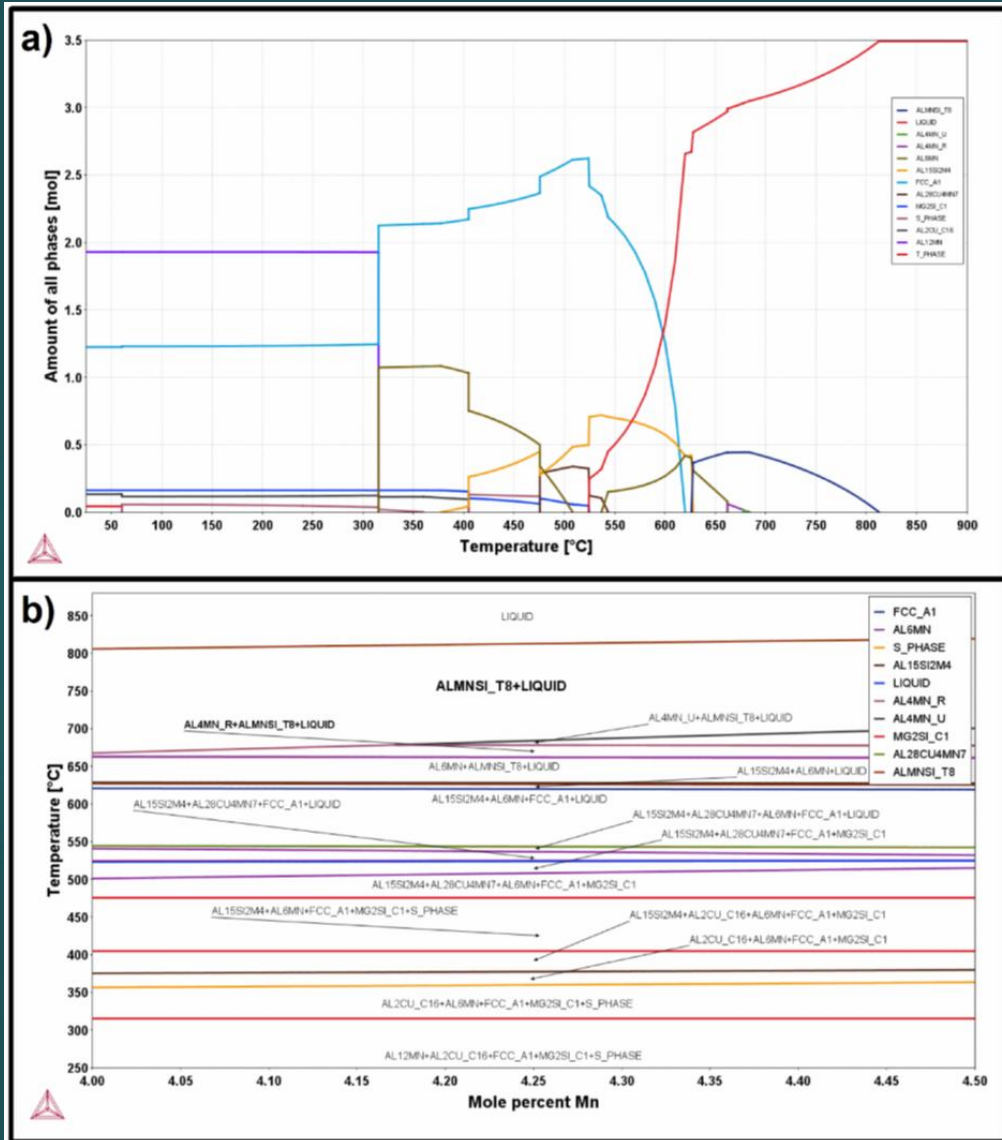
- ▶ Aim: to produce Al-based alloy with high amount of IQC phase
- ▶ Chemical composition
- ▶ Solidification simulation
- ▶ Analyses of alloys constitution
- ▶ Phase equilibria
- ▶ Conclusions

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Chemical composition

Alloy	Al	Mn	Si	Cu/Fe	Mg	V/Ti
BIO1	bal	7.7	1.5	3 (Cu)	3	/
BI01-2	bal	6.5	1.5	3	3	/
QC-2 (HPDC)	bal	4.4	1.6	2.8 (Cu) 0.2 (Fe)	2.1	/
QC-3 (HPDC)	bal	5.1	0.9	2.9 (Cu) 1.9 (Fe)	2.3	1.0 (V)
QC- 5 (HPDC)	bal	6.2	1.0	2.6 (Cu) 0.4 (Fe)	1.5	0.5 (V) 0.4 (Ti)
QC-7 (HPDC)	bal	7.4	0.5	2.7 (Cu) 0.3 (Fe)	0	0.5 (V) 0.4 (Ti)

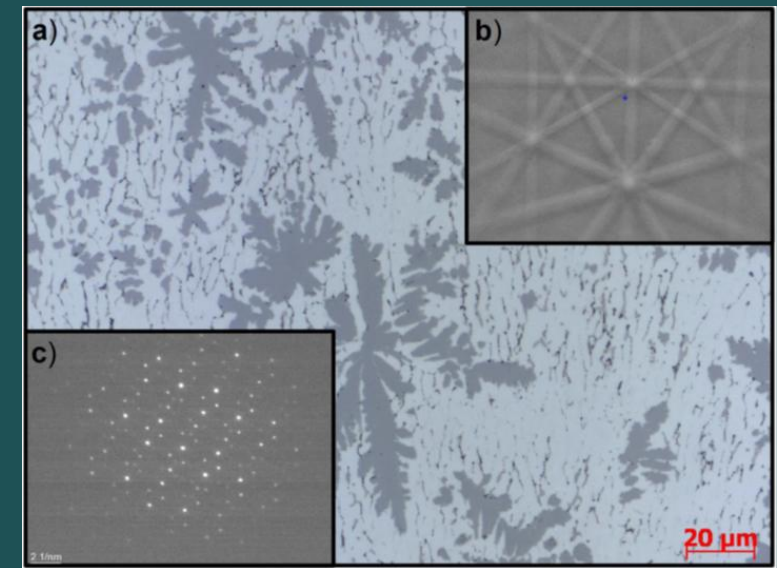
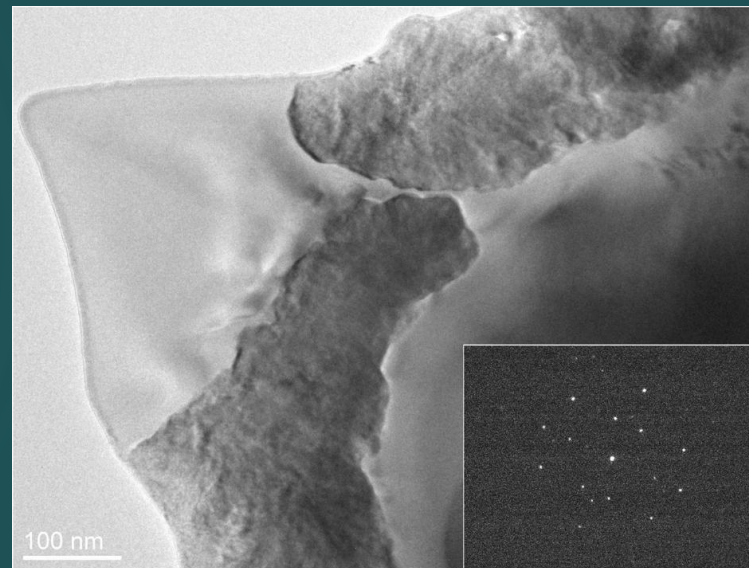
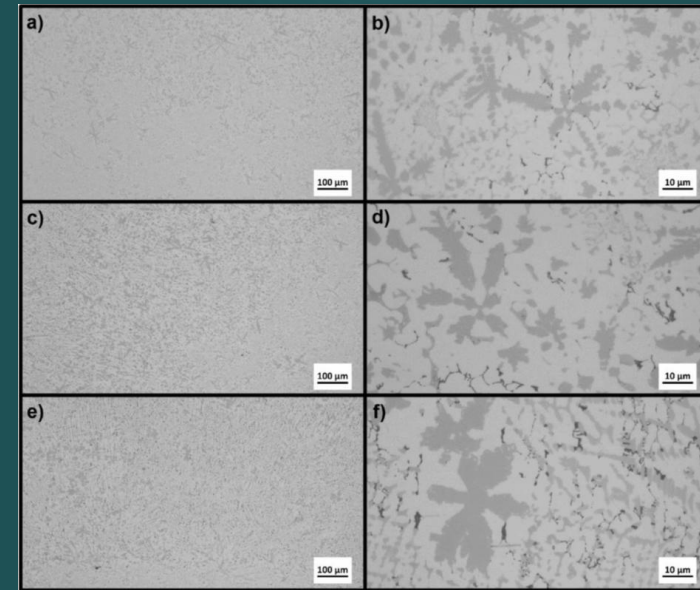
Solidification simulation vs industrial casting



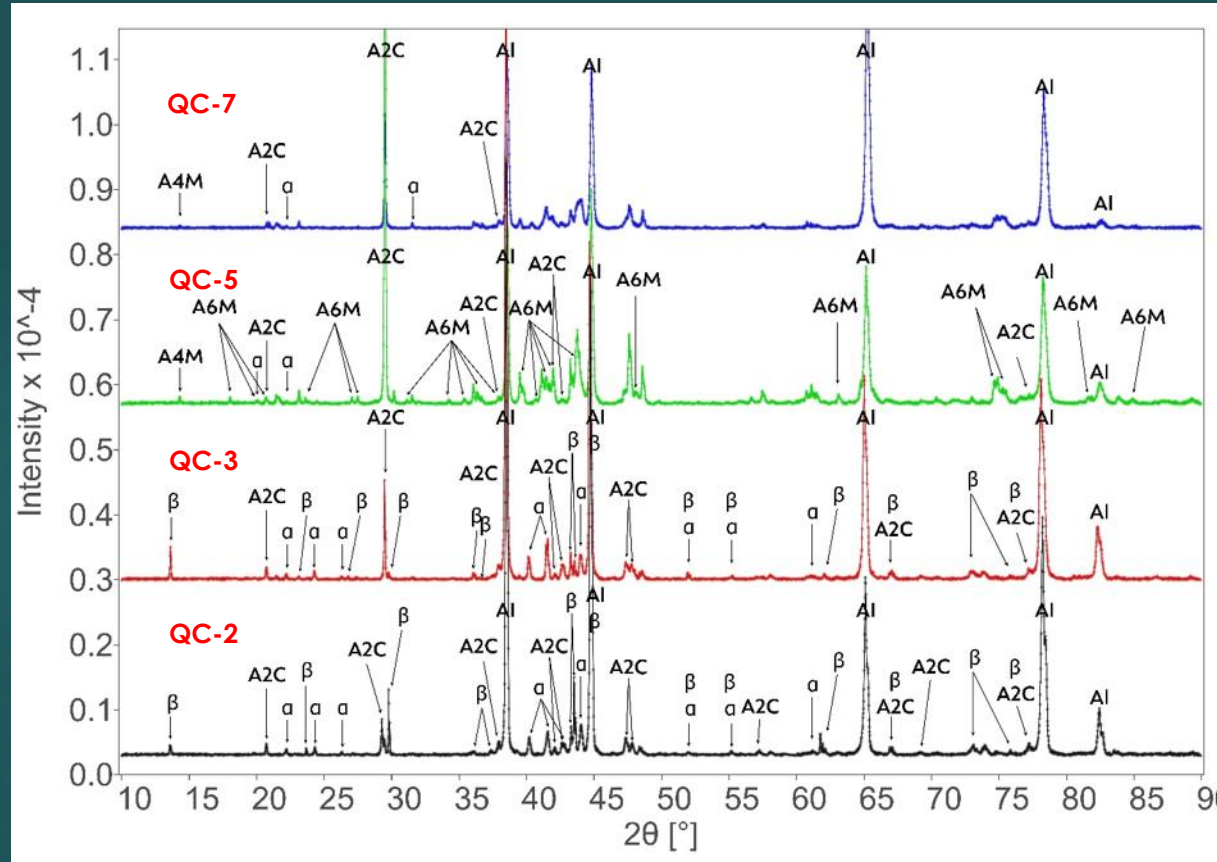


Analyses of alloys constitution

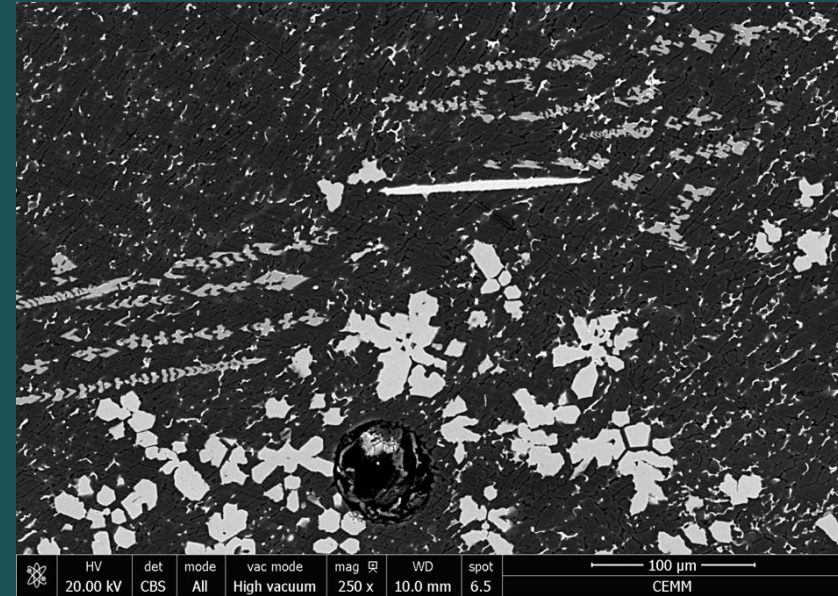
Lab trials-casting in Cu moulds



Analyses of alloys constitution



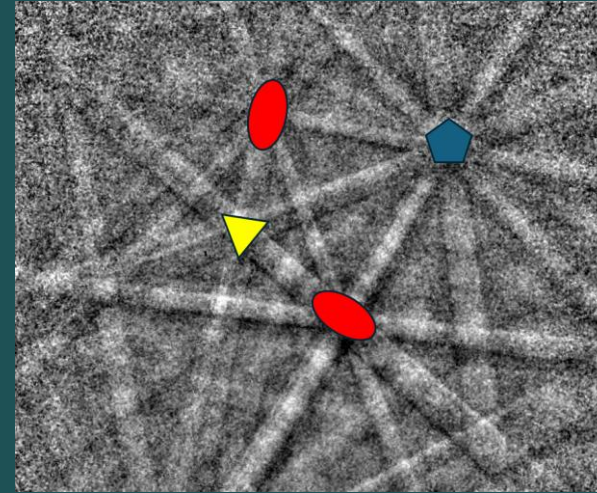
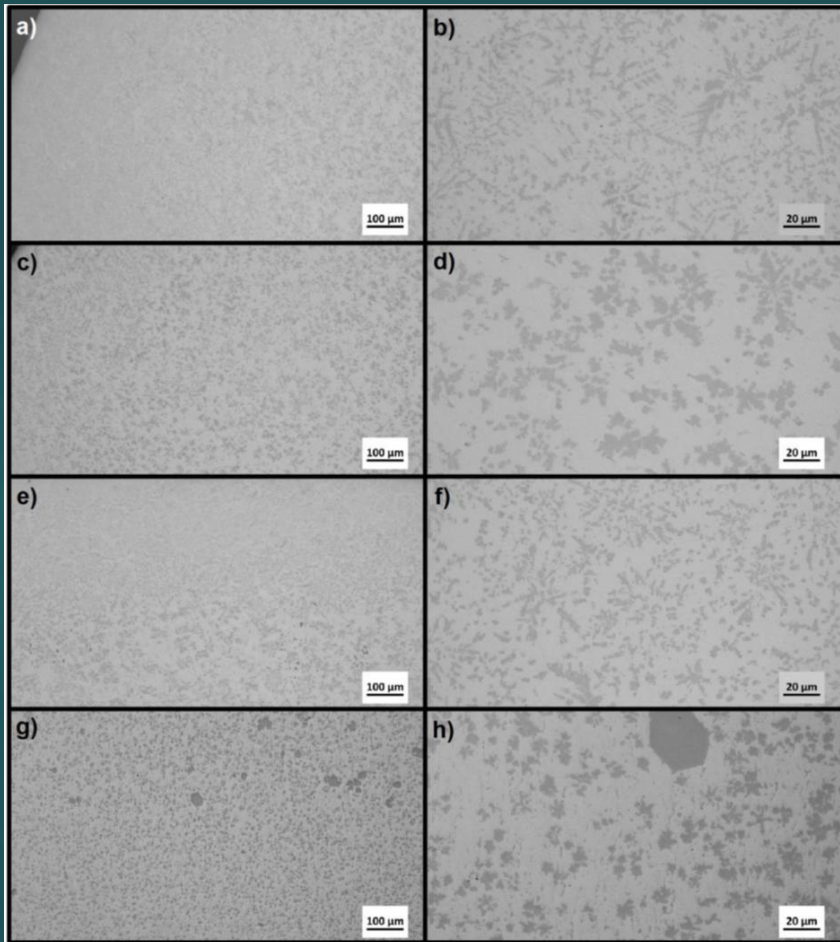
Industrial trials-casting in steel moulds



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Analyses of alloys constitution



Industrial trials-casting in steel moulds (HPDC) after composition modification

Phase equilibria

Alloy	composition	DSC	$\approx 100\text{ }^{\circ}\text{C s}^{-1}$	$\approx 250\text{ }^{\circ}\text{C s}^{-1}$	$\approx 500\text{ }^{\circ}\text{C s}^{-1}$	HPDC
BIO1	Mn: 7,7 Si: 1,5 Cu/Fe: 3,0/0 Mg: 3,0, V/Ti: -	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu L+Al ₂ CuMg	L+IQC, L+DQC L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu, L+Al ₂ CuMg	L+IQC, L+DQC L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu, L+Al ₂ CuMg	L+IQC, L+ α_{Al} +IQC L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn L+ α_{Al} +Al ₆ Mn	L+IQC, L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn L+ α_{Al} +Al ₆ Mn
BIO1-2	Mn: 6,5 Si: 1,5 Cu/Fe: 3,0/0 Mg: 3,0, V/Ti: -	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu L+Al ₂ CuMg	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₆ Mn L+Al ₂ Cu, L+Al ₂ CuMg	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₆ Mn L+Al ₂ Cu, L+Al ₂ CuMg	L+IQC, L+ α_{Al} +IQC L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn, L+Al ₂ Cu L+ α_{Al} +Al ₆ Mn	L+IQC, L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn, L+Al ₂ Cu L+ α_{Al} +Al ₆ Mn
QC-2	Mn: 4,4 Si: 1,6 Cu/Fe: 2,8/0,2 Mg: 2,1, V/Ti: -	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu+ α -AlMnSi+ Al ₁₅ (Fe,Mn) ₃ Si ₂ +Al ₂ CuMg	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₆ Mn	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₆ Mn	L+IQC L+ α_{Al} +IQC L+ β -AlMnSi+ α -AlMnSi	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu L+Mg ₂ Si
QC-3	Mn: 5,1 Si: 0,9 Cu/Fe: 2,9/1,9 Mg: 2,3, V/Ti: 1,0/0	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu+ α - AlMnSi+Al ₁₅ (Fe,Mn) ₃ Si ₂ +Al ₂ CuMg	L+ β -AlMnSi L+Al ₃ V, L+Mg ₂ Si L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₆ Mn, L+Al ₂ CuMg	L+ β -AlMnSi L+Al ₃ V, L+Mg ₂ Si L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₆ Mn, L+Al ₂ CuMg	L+IQC L+ α_{Al} +IQC L+ β -AlMnSi+ α -AlMnSi	L+ β -AlMnSi L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu, L+Mg ₂ Si
QC-5	Mn: 6,2 Si: 1,0 Cu/Fe: 2,6/0,4 Mg: 1,5 V/Ti: 0,5/0,4	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu+ α - AlMnSi+Al ₁₅ (Fe,Mn) ₃ Si ₂ +Al ₂ CuMg	L+ β -AlMnSi L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₄ Mn L+Al ₂ CuMg	L+ β -AlMnSi L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₄ Mn L+Al ₂ CuMg	L+IQC L+ α_{Al} +IQC L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn	L+ β -AlMnSi L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₄ Mn L+Al ₂ CuMg
QC-7	Mn: 7,4 Si: 0,5 Cu/Fe: 2,7/0,3 Mg: 0, V/Ti: 0,5/0,4	L+ β -AlMnSi L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu+ α - AlMnSi+Al ₁₅ (Fe,Mn) ₃ Si ₂	L+ β -AlMnSi, L+Al ₃ V, L+ α_{Al} +Al ₄ Mn L+ β -AlMnSi+ α -AlMnSi L+Al ₂ Cu+ α - AlMnSi+Al ₁₅ (Fe,Mn) ₃ Si ₂	L+IQC, L+ α_{Al} +IQC L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn	L+IQC, L+ α_{Al} +IQC L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+Al ₄ Mn	L+IQC, L+ β -AlMnSi L+Al ₃ V L+ β -AlMnSi+ α -AlMnSi L+ α_{Al} +Al ₄ Mn

Conclusions

- ▶ Newly developed alloys based on the Al-Mn system—with additions of copper, silicon, magnesium, titanium, and vanadium, and utilizing a commercial TiC modifier—exhibit a complex multicomponent constitution; in addition to the intended icosahedral quasicrystalline phase, this includes other non-equilibrium and equilibrium phases as well as quasicrystalline approximants.
- ▶ In addition to the dominant α_{Al} matrix and the IQC phase, the β -AlMnSi phase and the α -AlMnSi quasicrystal approximant, as well as Mg_2Si , Al_6Mn , and Al_2Cu are present in significant proportions; however, the localized presence of the Al_4Mn , $\text{Al}_{15}(\text{Fe},\text{Mn})_3\text{Si}_2$, Al_3V and Al_2CuMg phases and other quasicrystal approximants cannot be ruled out.
- ▶ We found that these phases—with the exception of β -AlMnSi—occur primarily in binary or ternary constituents formed in accordance with the heterogeneous equilibria established during the solidification process of the alloys in question.