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3D-Characterization of AlCu4.5Mg0.3 and AlCu7 alloys

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Goal

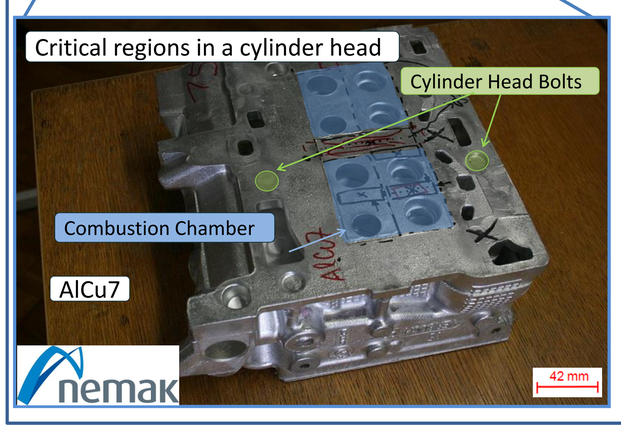
Downsizing of car engines in order to fulfil the enviromental regulations demands high temperature resistant materials to mantain/increase the current efficiency. Standard Al-Si alloys show limited high temperature resistance in comparison with cast Al-Cu alloys. On the contrary Al-Cu alloys present castability problems, in particular due to shrinkage porosity and hot tearing. Therefore, the current state of development of A206 and AlCu7 alloys is studied to determine their viability for specific automotive applications.

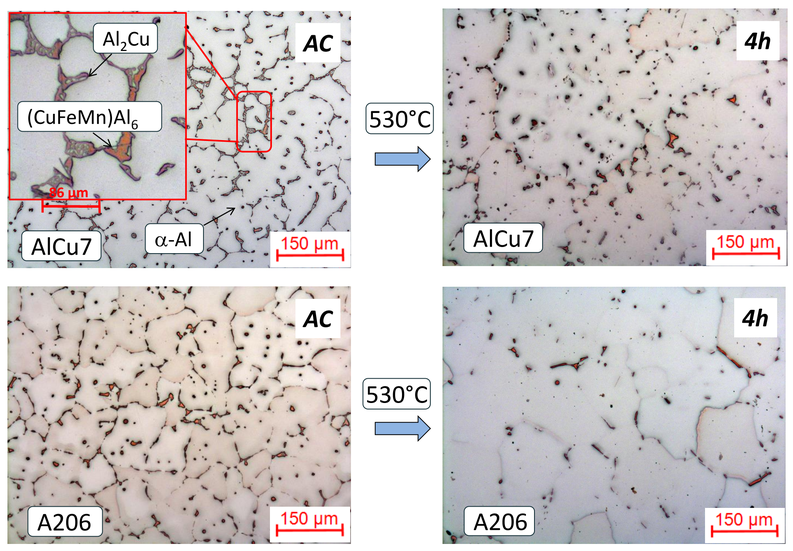
	AlSi7Cu0.5	A206 (AlCu4.5Mg0.3Mn0.3)	AlCu7
Castability	+	-	-
HT resistance	-	+	+

Materials

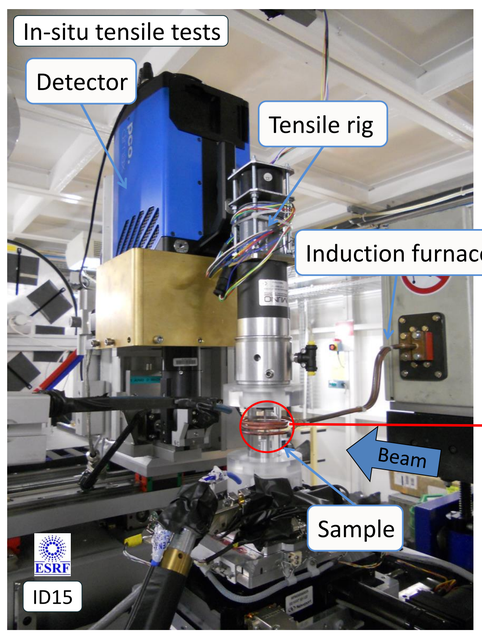
- AlCu7
- A206 (AlCu4.5Mg0.3Mn0.3)

Solution treatment: 530°C 4h, 8h, 16h

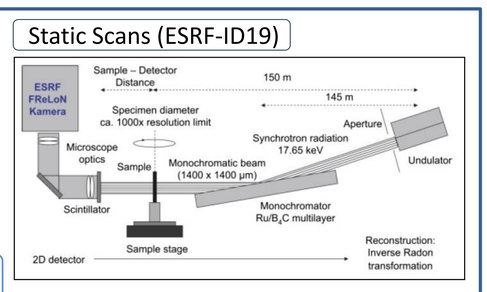


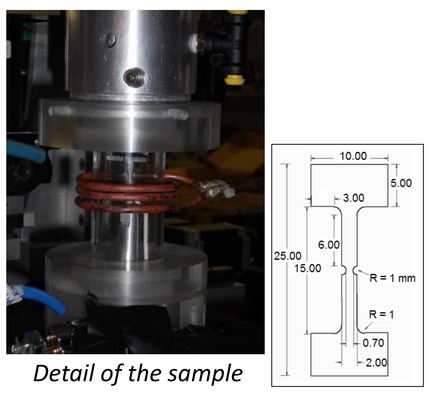


Experimental



In Situ Tensile Test Set up

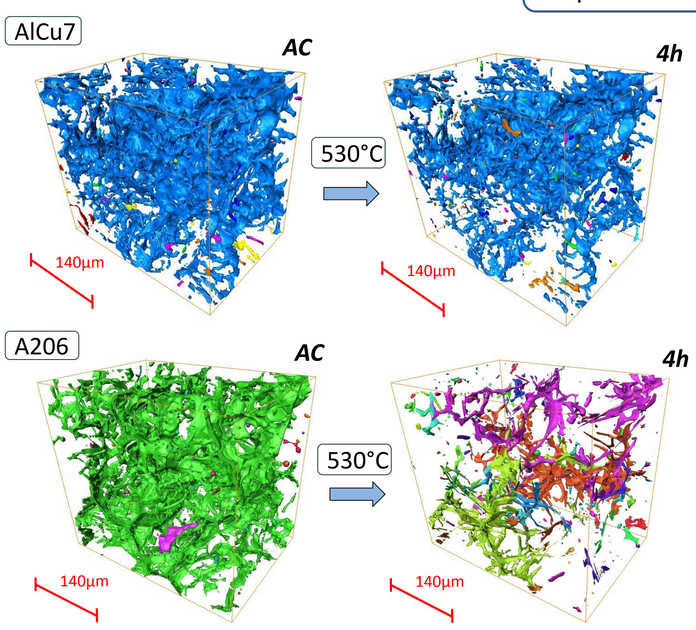




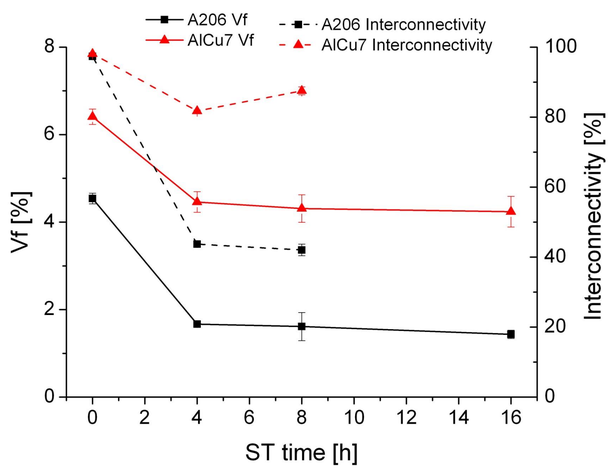
Detail of the sample

Results

Dissolution + Loss of Interconnectivity of intermetallic phases with increasing solution treatment time



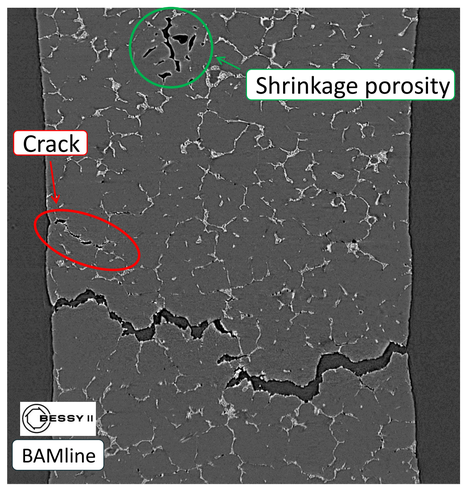
$$Interconnectivity = \frac{Vf\ biggest\ particle}{Vf\ total\ aluminides}$$



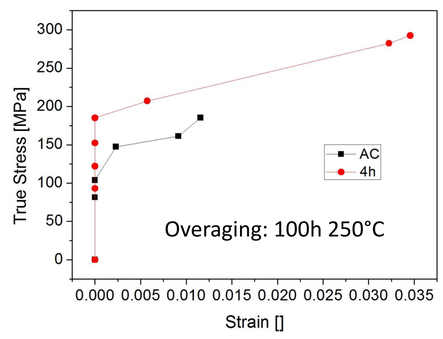
Solution Treatment of the same sample
ESRF
ID19
Voxel size = (0.28µm)³
Min. particle size ≈ (7.6µm)³
E = 17.6keV

In-situ Tensile Tests

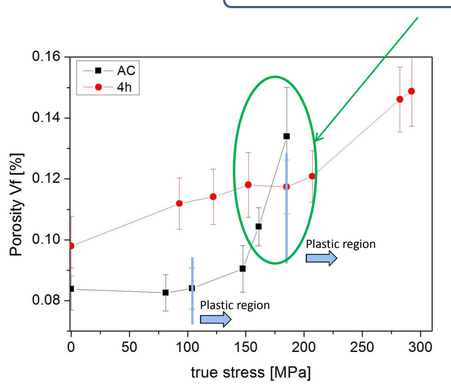
Damage initiates and propagates through the brittle aluminide network

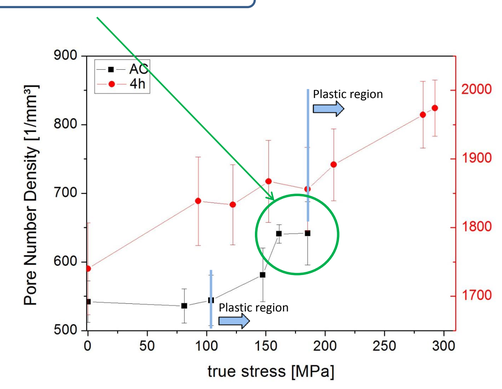


In-situ ST
ESRF
ID15
Voxel size = (1.1µm)³
Min. particle size ≈ (29.7µm)³
Pink beam

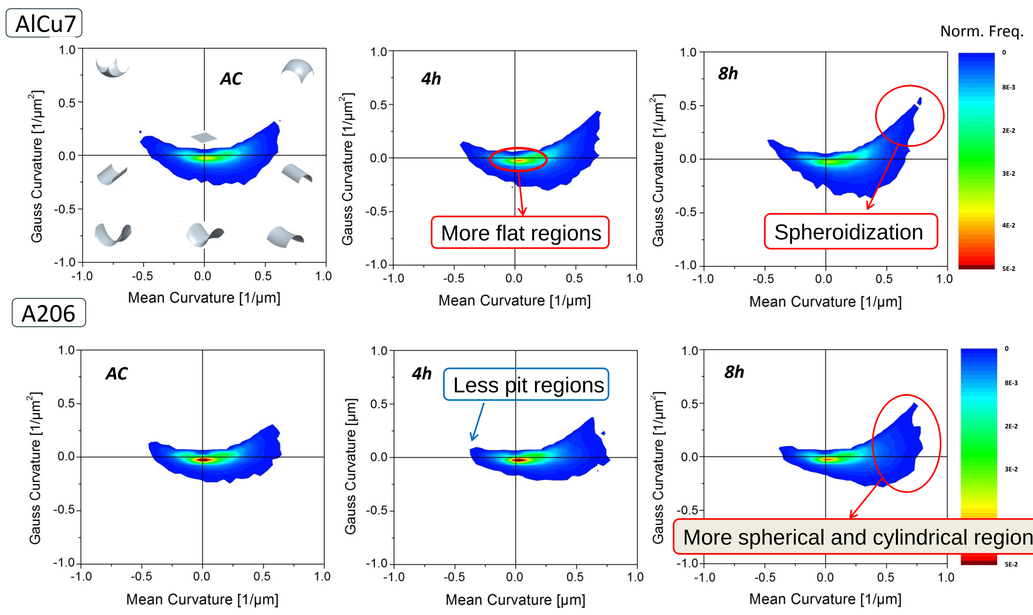


= Number of pores + Vf ⇧ ⇨ Coalescence





Morphological Analysis



Conclusions

1) 4h of solution treatment at 530°C is enough to stabilize the volume fraction of intermetallic phases in the studied Al-Cu alloys (dissolution of Cu in the Al-matrix).
2) The aluminides network in the AlCu7 remains highly interconnected even after 8h of solution treatment, while A206 shows a significant decrease after 4h.
3) Morphology of the aluminides changes with increasing solution treatment time. The amount of flat and cylindrical regions tend to increase after 4h at 530°C and disappear after 8h for both alloys. Pit regions tend to disappear and aluminides spheroidize becoming more cylindrical. This effect is more pronounced for the A206 alloy.
4) Damage tends to initiate at aluminides oriented perpendicularly to the load direction and propagates along the aluminides network. Shrinkage pores (< ca. 100 µm) do not play a significant role in damage initiation.
5) The A206 alloy in AC and 4h ST conditions is able to accommodate the same amount of damage (ca. 0.02 vol%) although strain at failure and initial porosity differ.

Acknowledgments

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