The Rheocasting of Al-Cu alloy A201 with different silver content

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PRESENTATION OUTLINE

- Introduction
- Experimental Procedure
- Results and discussion
- Conclusions

INTRODUCTION

- Semi-solid metal (SSM) forming is considered an established technology for the automotive industry.
- Very little attention has been given to applications in the aerospace industry.
- Aluminium alloy A201 possesses the highest mechanical strength of all the aluminium casting alloys.

INTRODUCTION

AA specification (wt%) of Al-Cu alloy A201

	Cu	Fe	Si	Mn	Mg	Ti	Ag
Min	4.0	-	-	0.2	0.15	0.15	0.40
Max	5.2	0.15	0.1	0.5	0.55	0.35	1.0

In Al-Cu alloys, the main strengthening precipitate is $CuAl_2$ (θ').

INTRODUCTION

- Iron and Silicon should be kept at minimum allowable percentages as they have an adverse effect on the mechanical properties of the alloy.

- Addition of silver with high Cu:Mg ratio changes the precipitation process, causing a form of $CuAl_2$ (Ω) to precipitate as thin plates on the {111} matrix planes rather than the {100} planes.

- Although the alloy is expensive, the benefits in terms of high specific strength make it suitable for aerospace and military applications.

INTRODUCTION

- **Objective**

  To establish the influence of silver on the microstrutural and mechanical properties of a rheo-processed A201. In addiction, alloy A206 was investigated as it has the same AA specification, but with 0%Ag.

EXPERIMENTAL PROCEDURE

Alloys A (no silver – alloy A206) and C (1.12% Ag) were produced in-house, and alloy B (0.63% Ag) was supplied by an external supplier.

Chemical composition (wt%) of Al-Cu alloys

Alloy	Cu	Fe	Si	Mn	Mg	Ti	Ag
Nominal	4.60	<0.15	<0.1	0.35	0.25	0.25	0.7
A	4.54	0.15	0.10	0.46	0.47	0.17	0.0
B	4.70	0.07	0.07	0.28	0.27	0.24	0.63
C	4.90	0.10	0.04	0.29	0.31	0.21	1.12

EXPERIMENTAL PROCEDURE

- An electric resistance furnace was used to melt to a pouring temperature of 670ºC.
- Chemical analysis was done using the CSIR thermal ARL Quantris Optical Emission Spectrometer (OES)
- Stainless steel cups were used for processing in the CSIR rheocasting machine.

EXPERIMENTAL PROCEDURE

- Casting parameters:
  rheo-processing time: 90s; casting temperature: 630°C; die temperature: 260°C, and injection velocity: 0.4 m/s.

- The cast bars were heat treated to the T6 condition which consisted of a solution treatment at 513°C/2h + 527°C /17h, quenching in water and artificial ageing at 153°C/20h.

- To ensure good integrity of the cast samples, x-ray imaging was used.

EXPERIMENTAL PROCEDURE

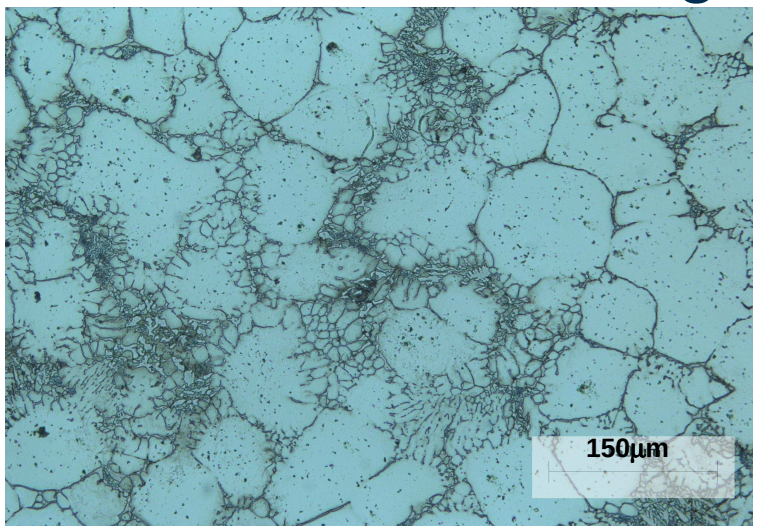
- The heat treated cast bars were machined to the final tensile test specimen dimensions and were subjected to a standard tensile test procedure using the Instron tensile testing machine.

- Vickers hardness measurements were done using a 20 kg load.

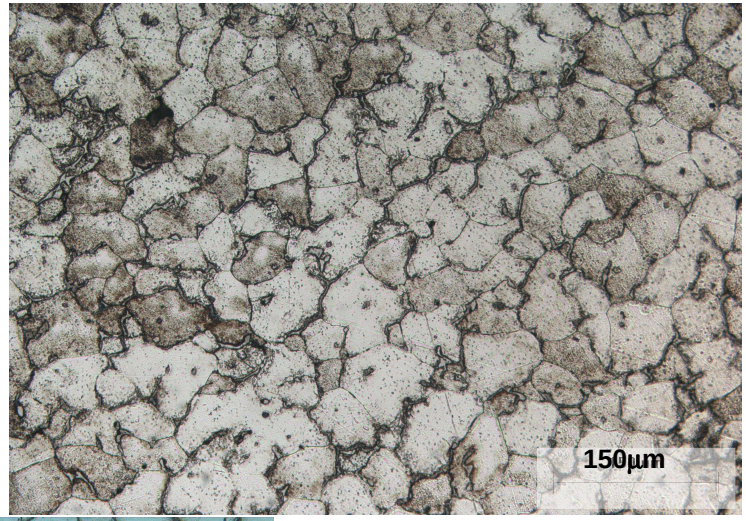
- The samples for scanning electron microscopy and optical microscopy (using 0.5% solution of HF as an etchant) were prepared.

RESULTS

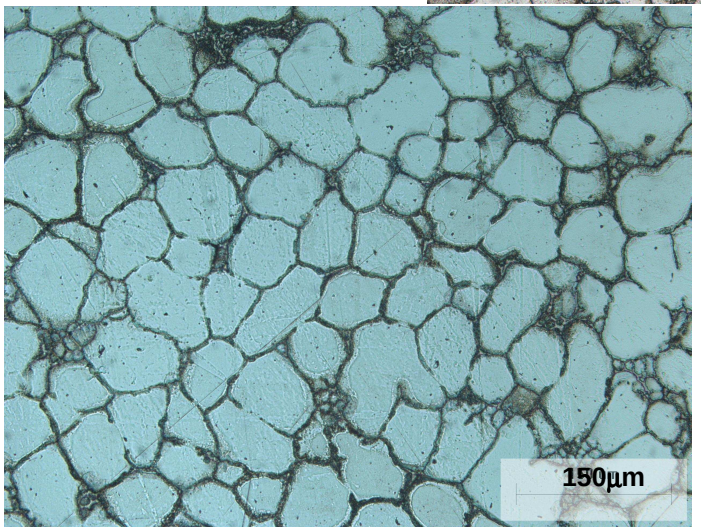
Light Microscopy



A(0.0%Ag)
As-Cast



C(1.12%Ag)
As-Cast



B(0.63%Ag)
As-Cast

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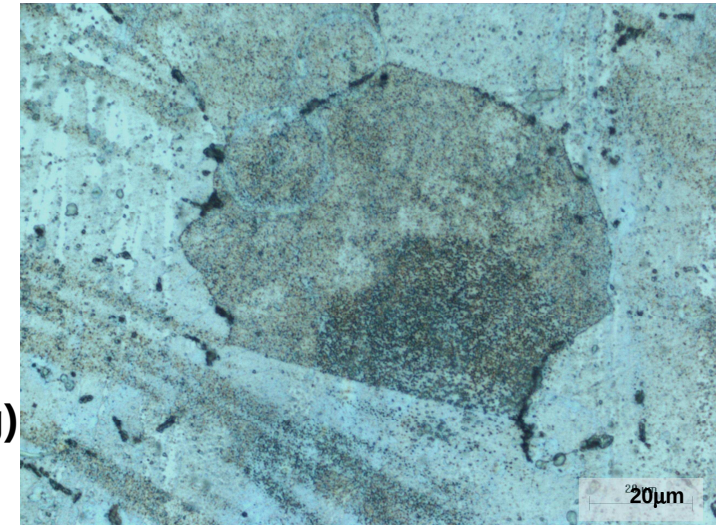
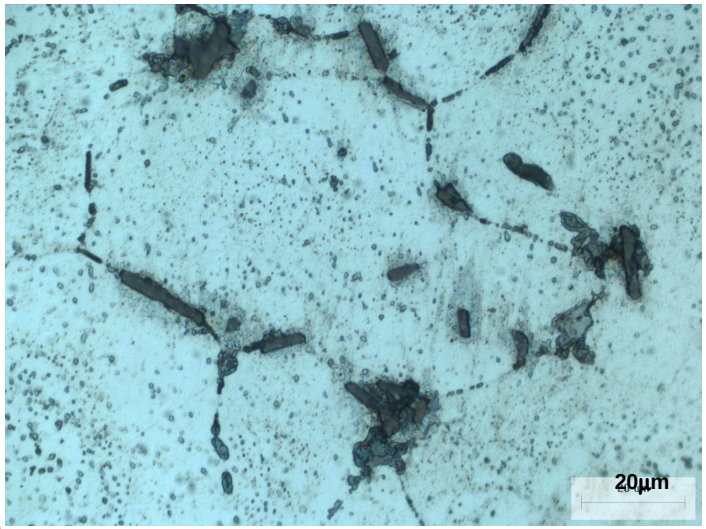
Light Microscopy

B(0.63%Ag)
T6



C(1.12%Ag)
T6



Solution treatment during T6 resulted in dissolution of the Cu-containing phases. However, a small amount of these phases remained after the solution treatment in alloy B and especially in alloy C.

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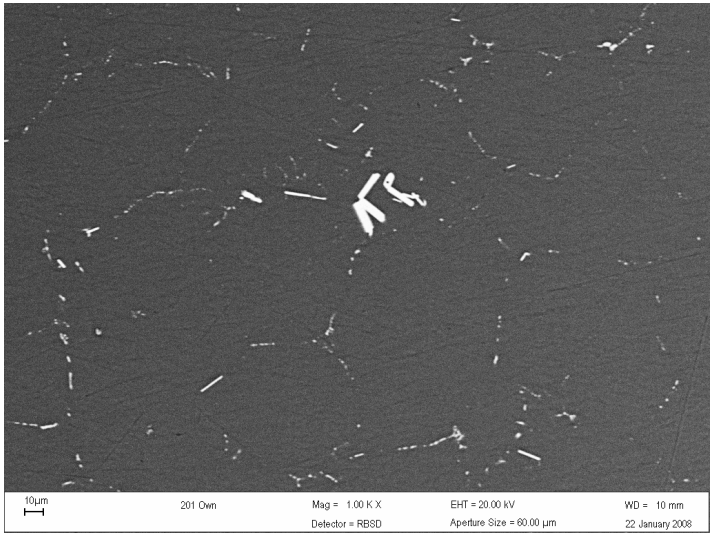
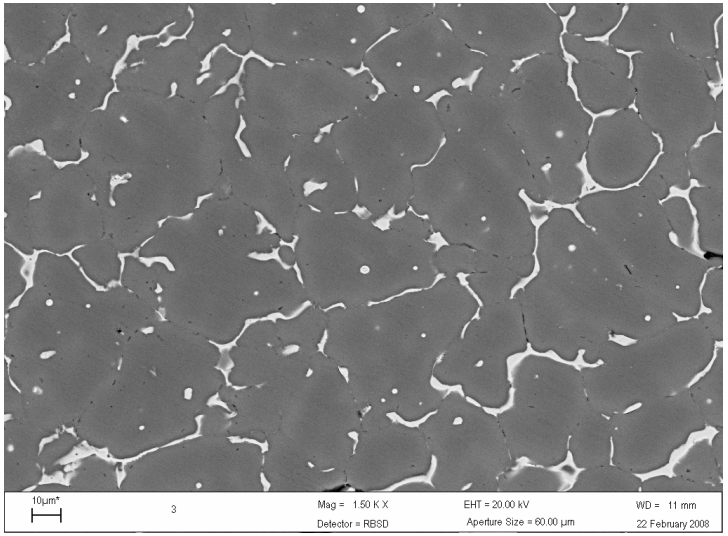
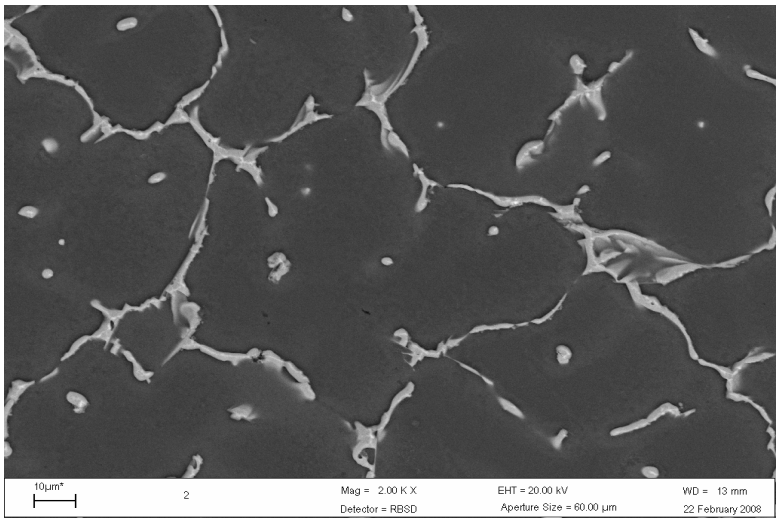
SEM



A(0.0%Ag)
As-Cast



C(1.12%Ag)
As-Cast



B(0.63%Ag)
As-Cast

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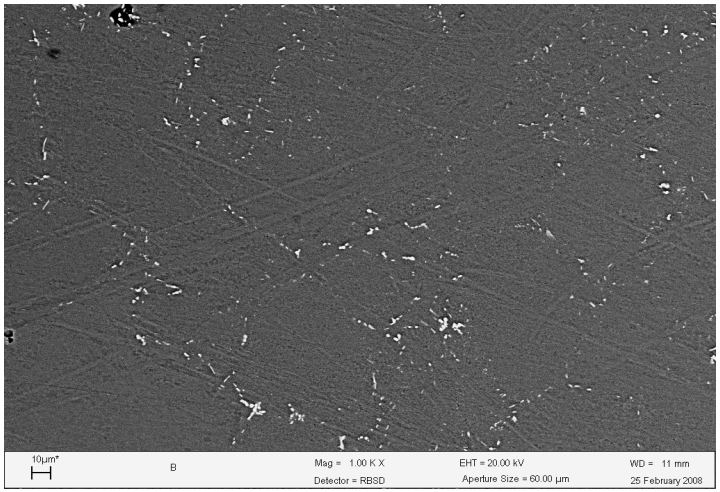
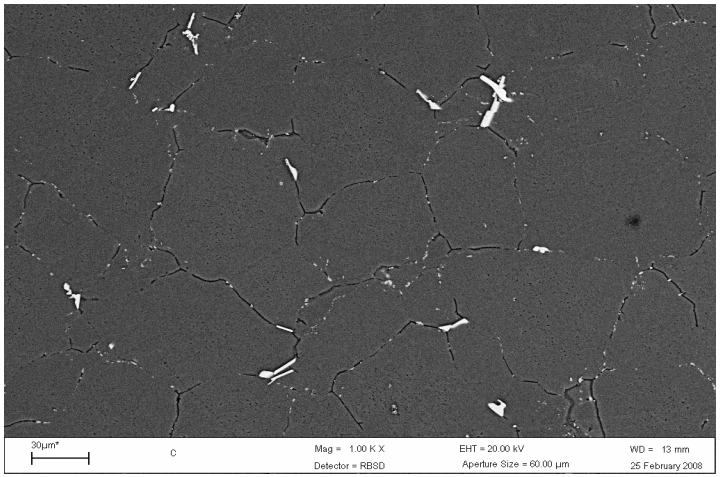
SEM

B(0.63%Ag) T6



C(1.12%Ag) T6



- The figures show that the volume fraction of the Cu-containing phases increases as the %Ag is increased.

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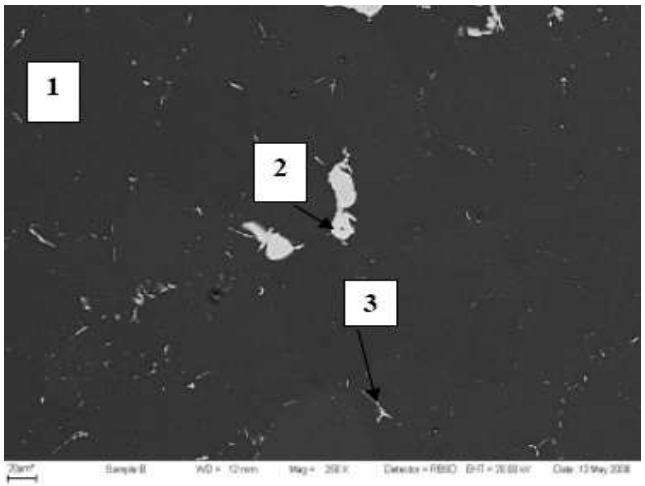
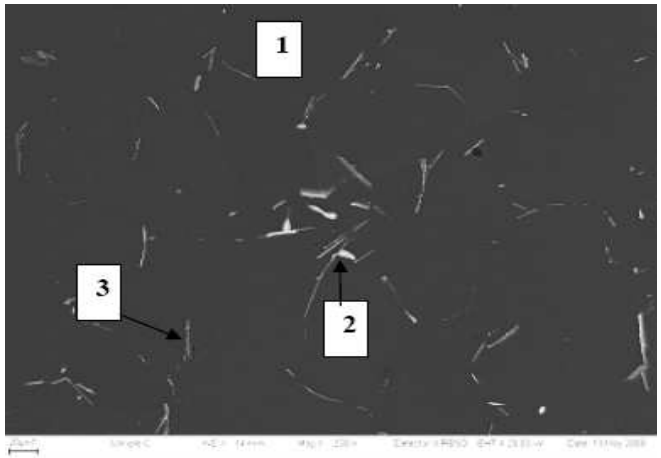
B(0.63%Ag) T6



C(1.12%Ag) T6



Alloy B in T6				
Points	%Cu	%Mg	%Ag	%Fe
1	5.2	0.24	1.8	
2	55.0	-	-	-
3	35.2	-	-	12.4
Alloy C in T6				
Points	%Cu	%Mg	% Ag	%Fe
1	4.7	0.20	2.7	-
2	54.4	-	-	-
3	33.0	-	-	12.4

$CuAl_2$

Cu_2FeAl_7

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Mechanical Properties

Mechanical properties for the three different Ag-containing alloys (T6)

Alloy	HV20	YS $R_{0.2}$ (MPa)	UTS R_m (MPa)	Elongation A (%)
A	105	330	379	8
B	155	399	445	4
C	146	365	422	7

CONCLUSIONS

- Addition of silver results in better mechanical properties, however, addition of silver also caused the precipitation of Cu-rich phases in the as-cast material.

- The solution treatment employed did not dissolve all of these phases, especially in the high Ag-containing alloy C. This resulted in a lower supersaturation of copper during artificial aging and a decrease in strength in the T6 condition.

- A different solution treatment might be needed for A201 alloys with silver contents close to 1.0 %Ag.

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