

MICROSTRUCTURAL CHARACTERIZATION OF AA - 7050 ALLOY SLABS (PART I)

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În lucrare se prezintă microstructura sleburilor din aliajul 7050 turnate în instalația Wagstaff în diferite zone ale secțiunii transversale a sleburilor. S-a evidențiat morfologia fazelor intermetalice intergranulare cu conținut de Al,Mg, Cu, Zn și intragranulare cu conținut de Mg și Zn (SEM) și s-a determinat compoziția acestora (EDS). De asemenea s-au pus în evidență compuși de tipul Ca-Mo-Si care pot influența negativ prelucrarea plastică, conducând la fisurarea produselor plate.

The microstructure of 7050 DC slabs cast in Wagstaff installation, in different zones of the transverse section of the slabs is presented. By electron microscopy (SEM,EDS) the morphologies and composition of the intergrain phases which contains Al,Mg, Cu, Zn and intragrain phase with Mg and Zn content was put in evidence. The presence of intermetallic inclusions of Ca-Mo-Si has also revealed. Such inclusions may have a negative influence on the plastic deformation of the slabs, finally resulting in the cracking of plate products.

Keywords: aluminum alloy, 7050 alloy, slab, SEM, EDS

1. Introduction

AA 7050 series (Al-Zn-Mg-Cu) high strength aluminum alloys are used primarily for structural components in aerospace applications like rivets, aircraft structural parts, bolts and s.c [1-3]. The combination of high strength, resistance to stress corrosion cracking and high fracture toughness has made the alloy a major factor in the aerospace industry [4]. Alloy 7050 is typically used in applications where improved formability and toughness are desired.

2. Experimental procedures

The chemical composition of the investigated AA 7050 alloy is given in Table 1.

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Table 1.

Chemical composition of as-cast slabs of AA 7050

| Element | Zn | Mg | Mn | Cu | Fe | Si | Cr | Ti | Al |
|---------|------|------|-------|------|------|-------|--------|-------|---------|
| %wt | 5.95 | 2.28 | 0.021 | 2.20 | 0.11 | 0.065 | 0.0025 | 0.035 | balance |

The samples A, B, and C have been prevailed with 4 mm thickness from the half of free surface of a 500 mm thick slab. The samples polished and have been etched with Keller's reactant.

The samples were analyzed using a scanning electron microscope SEM FEI Quanta Inspect F with electron beam and energy dispersive X-ray spectrometry (EDS) analyzer. [5, 6].

3. Results and Discussion

The microstructure of the A, B, C samples in figure 1-3, puts in evidence the presence of the aluminum base solid solution, with different shape and sizes of the grains (50 -500 μm) also light intergrain phases (ss α -Al grains), dark colour phases and finely nucleated intergrain phases (polyhedral and acicular) (figure 1 and 2); at the grain boundaries one can see light colour formation, with similar aspect like in A and B samples (figure 3).

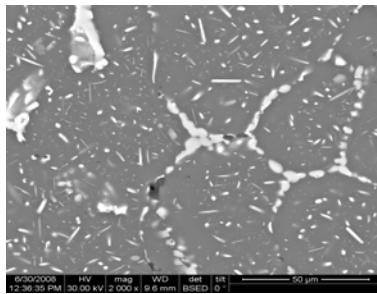


Fig.1. Sample microstructure taken from A zone of the slab (2000 x)

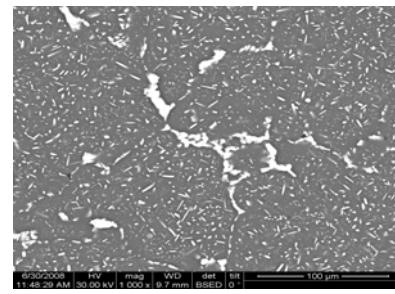


Fig.2. Sample microstructure taken from B zone of the slab (1000 x)

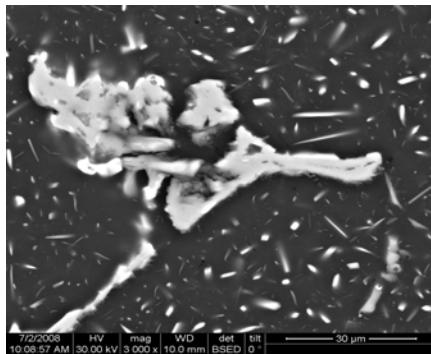


Fig.3. Sample microstructure taken from C zone of the slab (3000 x)

To put in evidence the intergrain phases in A sample : AlK_α , CuK_α MgK_α , and ZnK_α X - ray analysis images have been recorded (figure 5). The presence of dark Mg_2Si , compound and grey, hexagonal $\text{CuMgAl} - \text{MgZn}_2$ - solid solution was identified in this way.

The presence of large size light intergrain compounds and fine accicular compounds was observed in the backscattering images at high magnification 6000x and 12000 x (figure 4).

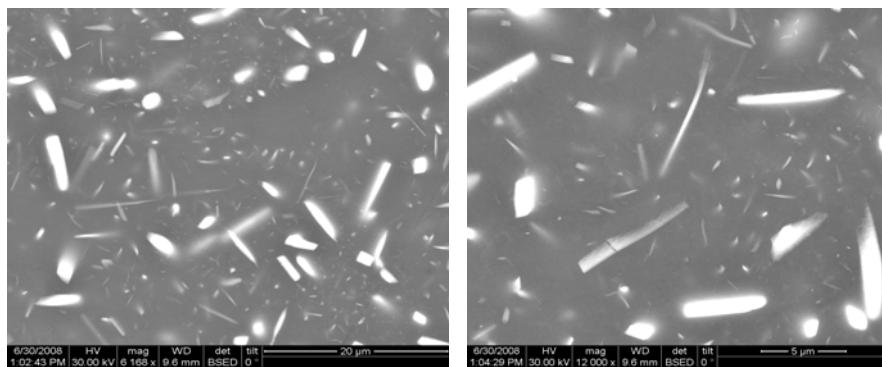


Fig. 4. BSE micrographs of the A sample at high magnifications: a) x 6000 and b) x 12000

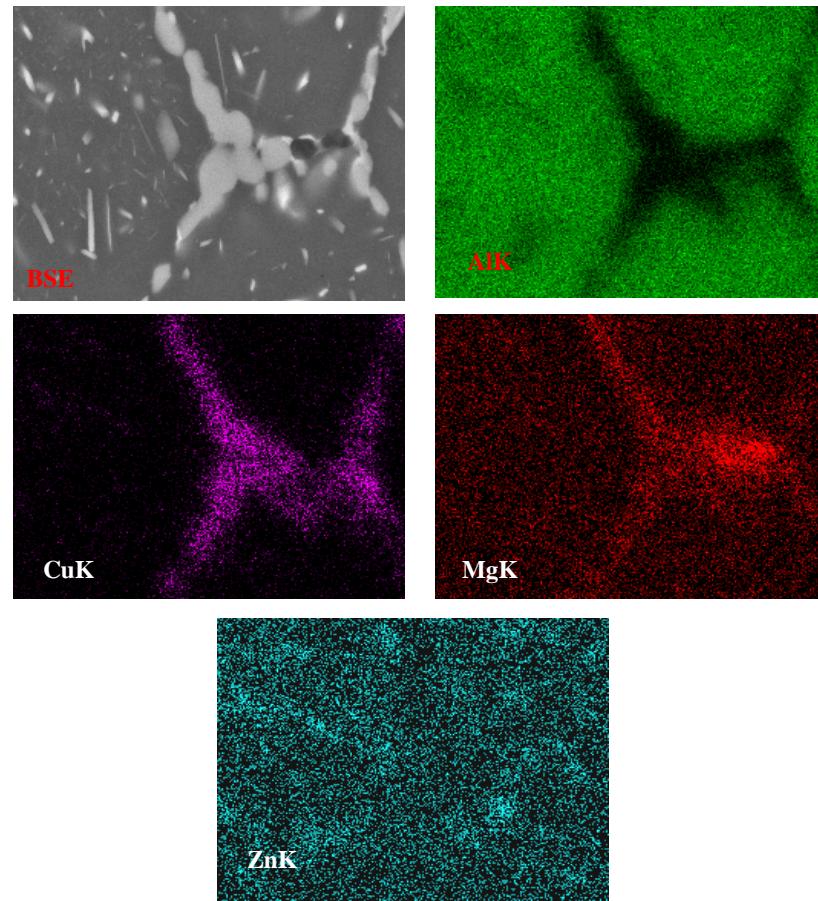


Fig. 5. BSE micrographs of the A sample at high magnification (5000x) and X-ray maps of AlK_α , CuK_α , MgK_α , and ZnK_α for A sample

To put in evidence the presence of the intergrain phases X-ray analysis have been recorded (figure 6).

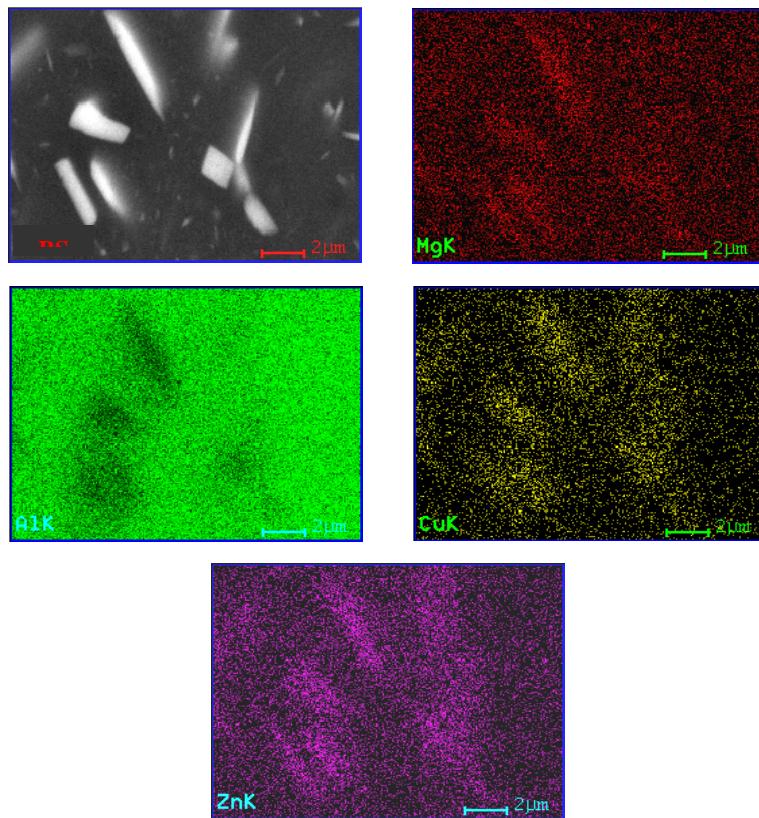


Fig 6. BSE micrographs of the A sample at high magnification (x 5000) and X-ray maps of MgK_α , AlK_α , CuK_α , and ZnK_α for A sample microzone

In figure 6 one can observe the precipitation of cubic CuAl_6Mg_4 – $\text{Mg}_3\text{Zn}_3\text{Al}_2$ compound solid solution phase and acicular particles of Mg_3Zn (2–3 μm) phase precipitated from the solid solution in Mg and Zn supersaturated alloy

Backscattering images at high magnifications (figure 7) and X-ray maps of MgK_α , AlK_α , CuK_α , and ZnK_α for B sample put in evidence the presence of CuAlMg - MgZn_2 solid solution phases and of $\text{Al}_7\text{Cu}_2\text{Fe}$ compound.

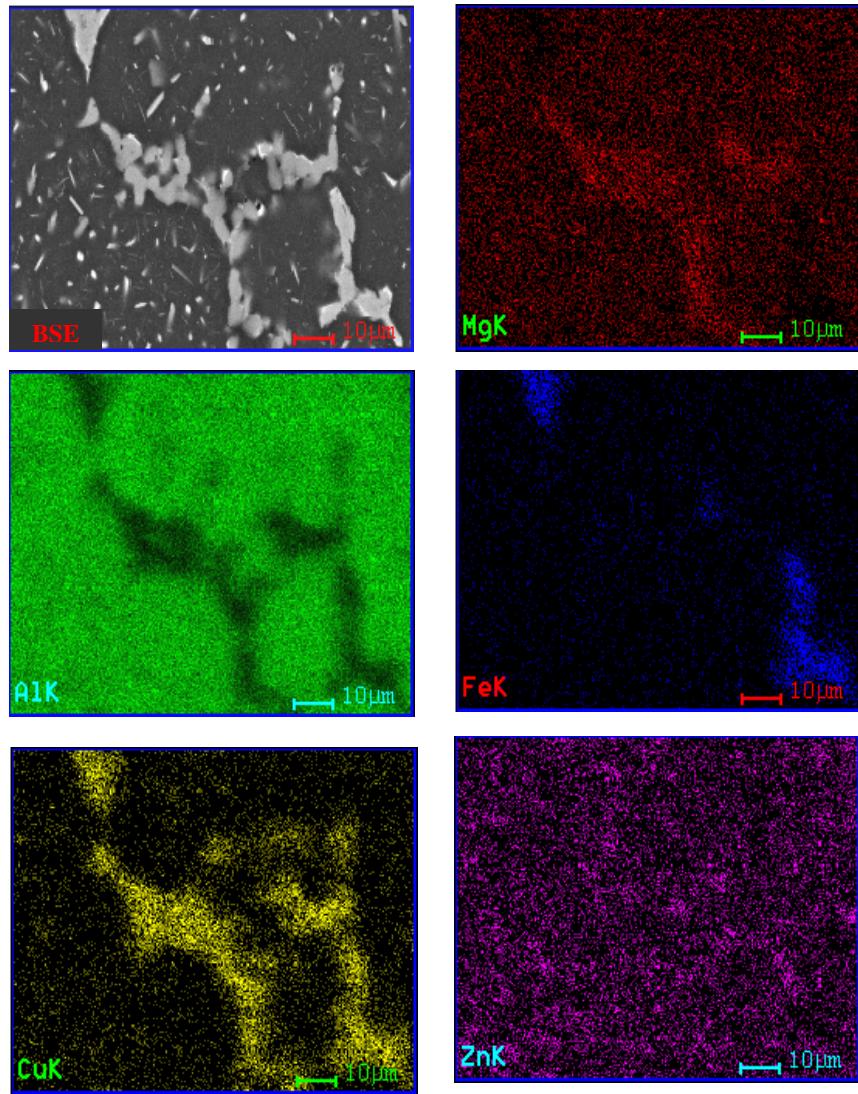


Fig. 7. BSE micrographs of the B sample at high magnification (x 3000) and X-ray maps of AlK_α , MgK_α , FeK_α , CuK_α , and ZnK_α for B sample microzone

The presence of $\text{CuAlMg}-\text{MgZn}_2$ and FeAl_3 intergrain phases are clearly seen in figure 8.

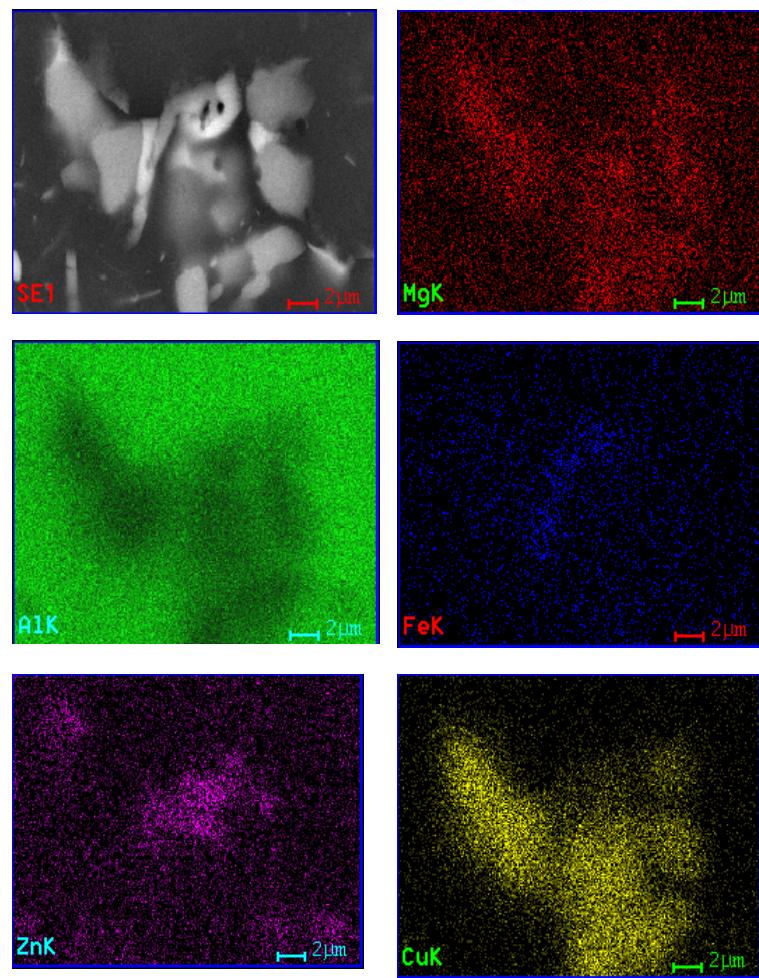


Fig. 8. BSE micrographs of the B sample at high magnification (x 5000) and X-ray maps of AlK_α ,

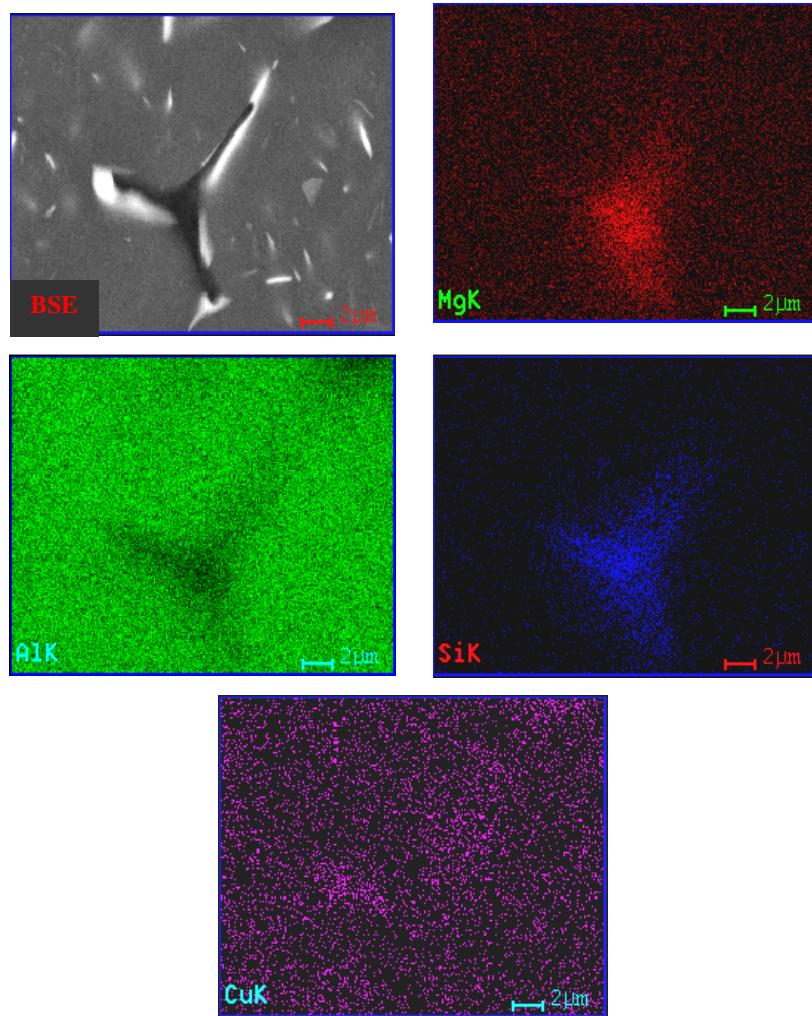


Fig. 9. BSE micrographs of the B sample at high magnification (x 5000) and X-ray maps of AlK_α , MgK_α , SiK_α and CuK_α for B sample microzone

MgK_α , FeK_α , CuK_α , and ZnK_α for B sample microzone

Fig. 9 put in evidence the presence of Mg_2Si compound nucleated on the CuAl_2 phase.

The morphology of intragrain and intergrain compounds in B sample is shown in figure 10.

The presence of polyhedral $\text{Al}_2\text{CuMg} - \text{MgZn}_2$ compounds and Mg_2Zn_2 phase was put in evidence in figure 11.

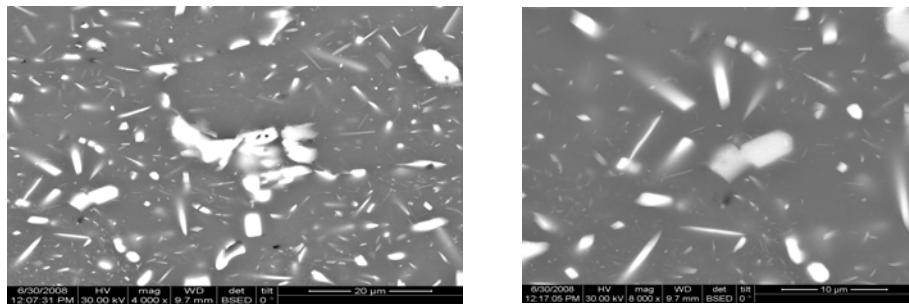


Fig.10. Morphology of : intergrain phase - $\times 4000$ (a) and intragrain phase (b) - $\times 8000$, in B sample

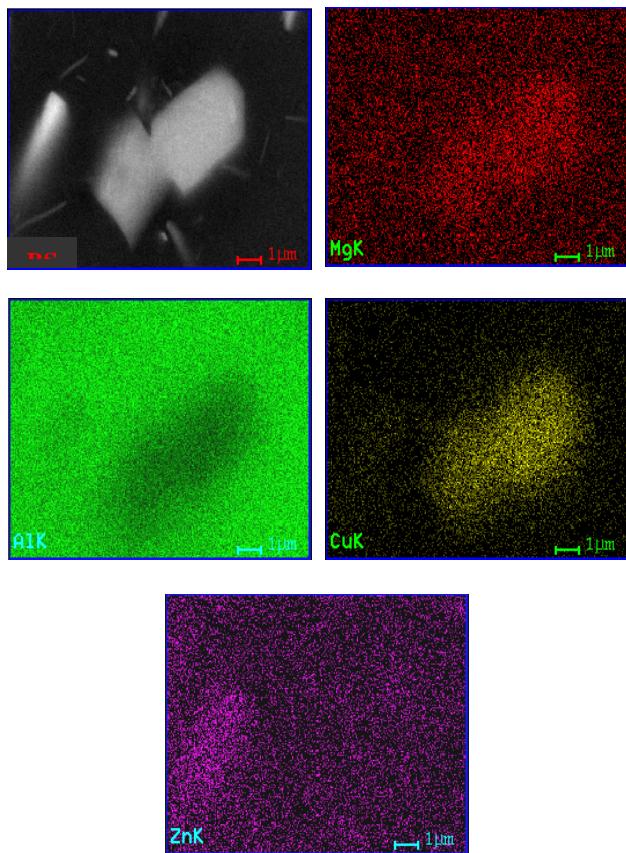


Fig. 11. BSE micrographs of the B sample at high magnification ($\times 5000$) and X-ray maps of AlK_α , MgK_α , CuK_α and ZnK_α for B sample microzone

The presence of dark Mg_2Si compound in the C sample, nucleated on white coloured compound was observed in figure 12. Figure 13 put in evidence the presence of light coloured polyhedral intragrain phases.

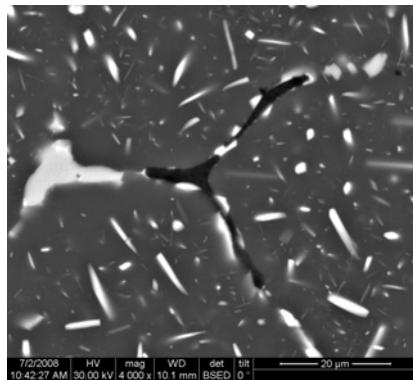


Fig. 12. Mg_2Si dark intermetallic phase in C sample (x 4000)

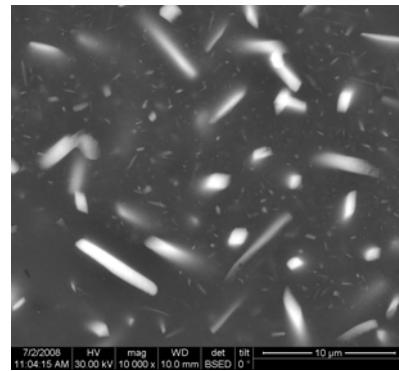


Fig. 13. Polyhedral intragrain compounds, in C sample (x 10000)

The identification of intergrain and intragrain intermetallic phases shown in figure 12 was done by backscattering images at high magnifications and X-ray images of AlK_{α} , MgK_{α} , SiK_{α} , FeK_{α} , CuK_{α} and ZnK_{α} for C sample microzone (figure 14).

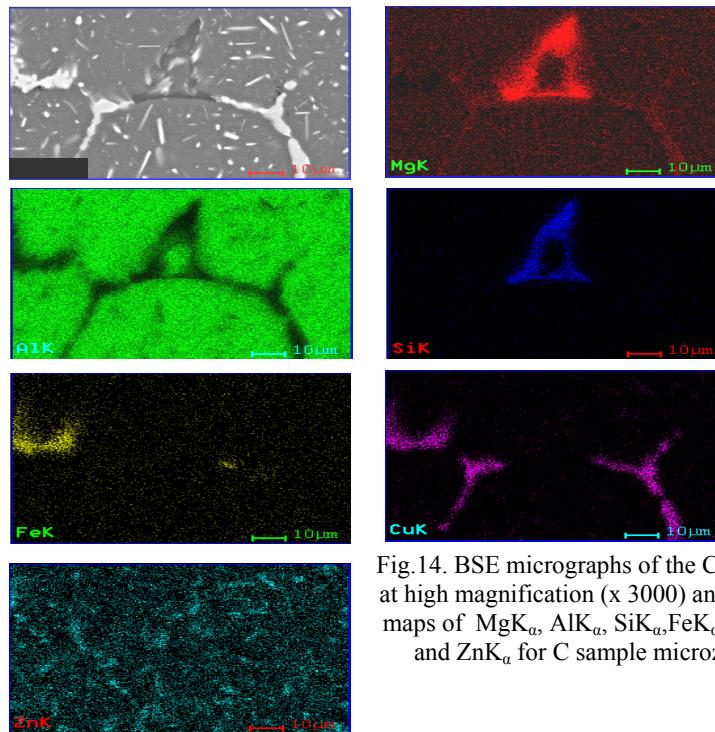


Fig.14. BSE micrographs of the C sample at high magnification (x 3000) and X-ray maps of MgK_{α} , AlK_{α} , SiK_{α} , FeK_{α} , CuK_{α} and ZnK_{α} for C sample microzone

We can observe the presence of intergrain phases: Mg_2Si , $FeAl_3$ and ss $CuMgAl - MgZn_2$, confirm by EDS micrographs.

The identification of elements was done by EDS microanalysis (figure 15).

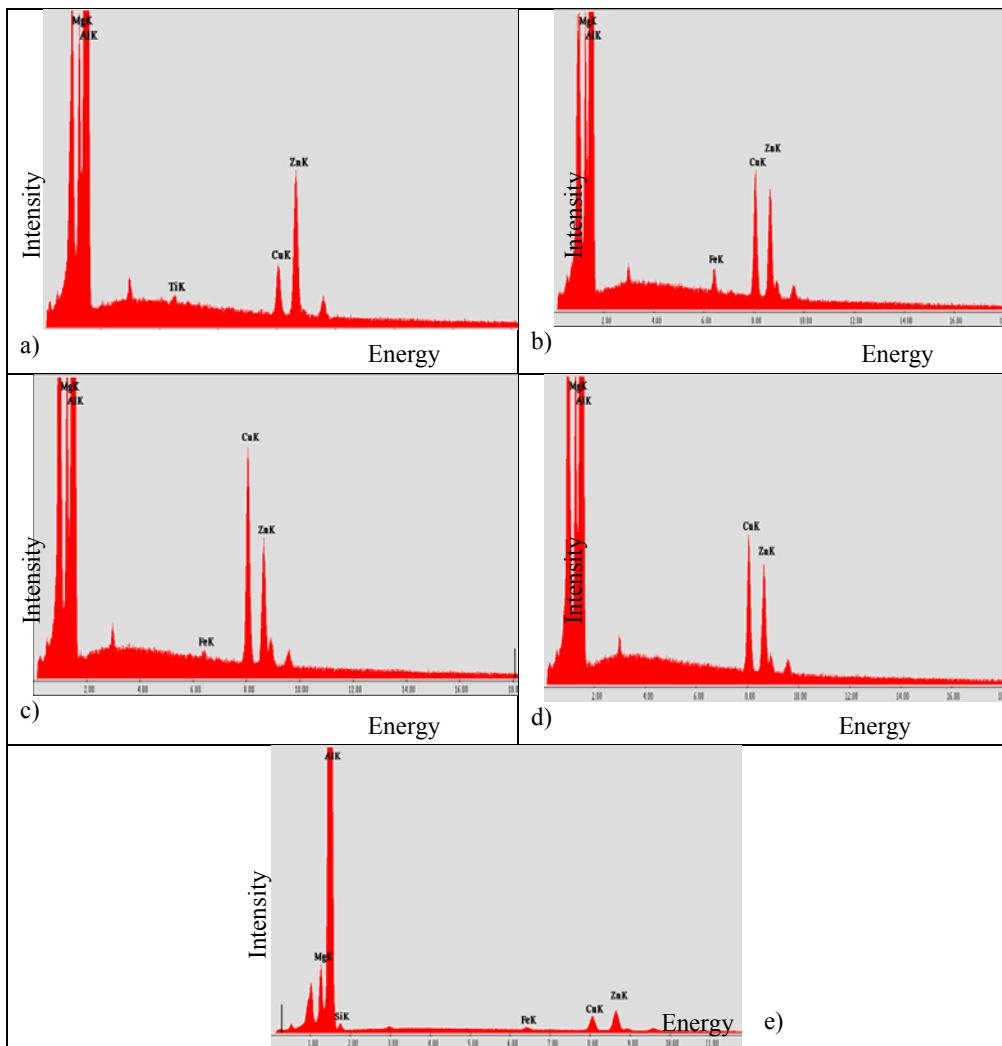


Fig. 15. EDS microanalysis of the A (a), B (b,c,d) and C (e) samples

The EDS microanalysis confirm the presence of the intergrain and intragrain phases: $CuMgAl - MgZn_2$ for A sample (figure 15 a); $CuMgAl - MgZn_2$ and Al_7Cu_2Fe for B sample (figure 15 b); $CuMgAl - MgZn_2$ and $FeAl_3$ for B sample (figure 15 c); the presence of Al,Cu,Mg and Zn in intermetallic compounds (figure 15d); $CuMgAl - MgZn_2$, Mg_2Si and $FeAl_3$ for C sample (figure 15 e).

4. Conclusions

The presence of intergrain intermetallic phases with Al, Mg, Cu, Zn as well as polyhedral precipitates within the grains that contained Mg and Zn was identified by scanning electron microscopy (SEM).

X-ray image analysis and EDS analysis reveals the presence of many compounds like $FeAl_3$, Al_7Cu_2Fe and solid solution like $CuMgAl - MgZn_2$ and Mg_2Si fine grain precipitate.

Some inclusions like CaMoSi which were also detected have a negative influence on the plasticity of the material.

The second part of this paper (II) will presents the microstructure characteriyation of D,E, and F zones of 7050 slab.

R E F E R E N C E S

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