Lamellar Precipitation in an Cu-4.5 at. % In Alloy

Z. Boumerzoug
Department of Metallurgy, Biskra University, Biskra- 07000 – Algeria
Tel/Fax : (213) 33 732127

The decomposition of supersaturated solid solution of numerous alloys during aging occurs throughout discontinuous cellular reaction resulting in the formation of the alternating structure α and β phases. The discontinuous precipitation is characterized by the presence of sharp reaction front which separates the initial state from the reaction product.

In this contribution, the morphology of cellular precipitation in an Cu-4.5 at. % In alloy has been investigated by optical microscopy and electron microscopy (TEM and SEM). The lamellar precipitates develop from the grain boundary into the grain by discontinuous reaction during aging at 673 K. The discontinuous precipitation clearly revealed by optical and scanning electron micrographs was observed to decompose into lamellar structure. It has been observed different orientations of lamellae in the same cell and the discontinuous reaction is more developed in certain sites of matrix, like grain boundaries and interphases of matrix. On the other hand, the shape of reaction front is analyzed by transmission electron microscopy.

I. INTRODUCTION

In discontinuous precipitation (DP), also known as cellular precipitation (or lamellar precipitation), a supersaturated α_0 phase decomposes into a new β phase, and an α phase structurally identical to α_0 but depleted in solute. It is generally accepted that high angle incoherent boundaries are the most likely candidates for DP reaction fronts. The transformed zone is separated from original phase by an interface called the reaction front (RF) in which all the diffusion process that are involved in the reaction take place [1]. The product phases formed as an aggregate of amellar structure consisting of alternate lamellae of α and β phases. The constancy of the repeat distance of the precipitate phase behind a curved reaction front within a DP colony is maintained either by branching of the existing lamellae, or by repeated nucleation of the precipitate on the advancing RF or in its recess [2].

II. EXPERIMENTAL METHODS

The alloy used for this study was Cu-4.5 at. % In, prepared from high purity components. The ingot was homogenized at 873 K and quenched in water to obtain supersaturated solid solution. Information on the treatment conditions were obtained from the existent literature on the discontinuous reaction and from the equilibrium phase diagram of the Cu-In system [3–7]. The investigations of the structure during aging at 673 K were carried out using, optical microscope, scanning electron microscope and Philips EM-301transmission electron microscope

III. RESULTS AND DISCUSSION

Studies of the DP are usually performed isothermally. Generally, After a short period of incubation time individual precipitation cells are observed. The microstructure observed through optical and transmission electron microscopy revealed that the supersaturated solid solution decomposed into α and δ (Cu_{11}-In_9) [8] phases at 673 K. The product phases formed as an aggregate of lamellar structure consisting of alternate lamellae of α and δ phases (Fig.1).

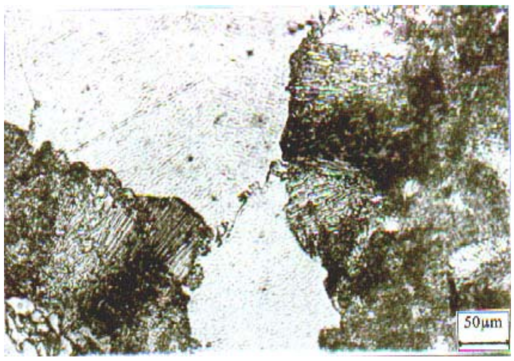

FIG.1: Cellular precipitation in an isothermally aged Cu-4.5 at. % In alloy at 673K during 2 hours.

It is generally believed that only the large–angle matrix grain boundaries can support the process of heterogeneous precipitation and the concurrent boundary migration required for DP [9]. Fig.2 evidences initiation of discontinuous precipitation from the boundary between a eutectic colony and matrix phase (α_0) at 673 K in a Cu-4.5 at. % In alloy.

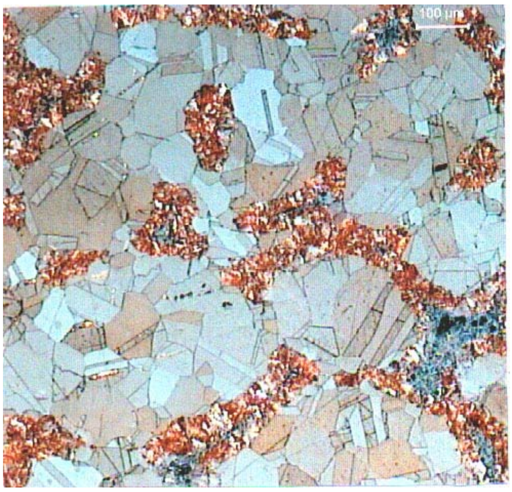

FIG.2: Development of cellular precipitation from a eutectic colony in an isothermally aged Cu-4.5 at. % In alloy at 673K during 1 hour.

Eutectic transformation itself being a discontinuous mode of reaction, the boundary between the eutectic colony and α0 may be maintaining a statistically constant interlamellar spacing in our alloy.

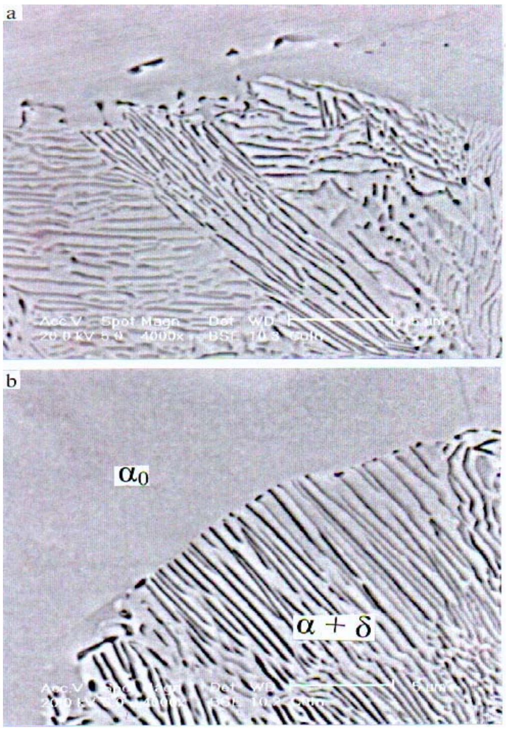

FIG.3: Two types of cells: (a) : cell characterized by irregular lamellar spacing (b) : ideal DP colony in aged Cu-4.5 at. % In alloy at 673K during 2 hours.

assumed to be a large-angle boundary capable of supporting discontinuous reactions [10]. Recently it has been demonstrated that the precipitate-matrix-type phase boundaries may also initiate DP in a Cu-12 at. % In alloy [11].

Contrary to Fig. 3a, Fig. 3b shows an ideal DP colony, where the precipitate lamellae are equidistant, parallel to each other, and aligned normal to a planar RF advancing into the supersaturated matrix. Irregular lamellar spacing observed in Fig.3a it is due probably to existence of dislocations in matrix.

Structural observations using an electron microscope show a formation of new lamellae on the advancing reaction front by branching mechanism. Fig. 4 shows formation of new δ lamella by branching at the RF in the area indicated by narrow. This mechanism contributes towards

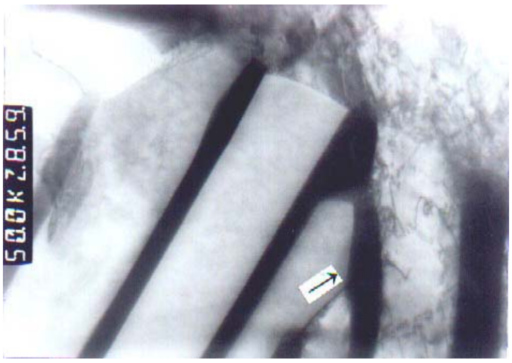

FIG. 4: Typical branching mechanism observed by MET in aged Cu-4.5 at. % In alloy at 673K during 2 hours.

Regular spacing was observed to exist only after a steady-state of cooperative growth was attained. In other alloys , for example , in Fe-Zn [12], it has been observed the mechanism of renucleation of new lamellae at RF. According to Williams and Butler[12], there is strong experimental evidence to support a branching mechanism to explain multiplication of lamellae during cellular growth.

Figure 5 illustrates this mechanism of branching during aging which based on our observation.

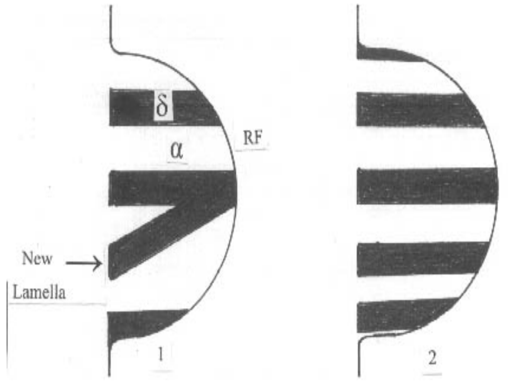

FIG.5: Illustration of branching mechanism observed in aged Cu-4.5 at. % In alloy: (a) : Formation of new δ lamella by branching at the RF in the area indicated by narrow . (b) : an ideal DP colony, where the precipitate lamellae are equidistant, parallel to each other.

IV. CONCLUSION

The investigation performed in Cu-4.5 at. % In alloy revealed the occurrence of DP at the boundary between the eutectic colony and α_0. The Formation of new lamellae is characterized by branching mechanism at RF.

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