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Exploring Possibility of the Chromium (Cr) Removal from Molten Aluminum by adding Boron Bearing Additive (Aluminum-Boron Master Alloy)

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It is well documented that transition metals including chromium (Cr) deteriorates electrical conductivity of the aluminum alloys. Concentration of the transition metals varies from few parts per million (ppm) to 1400 ppm that are removed in casthouse by the addition of boron bearing substances and the process is called boron treatment. Aluminum- boron (Al-B) master alloys containing AlB_2 or AlB_{12} are commonly used to tie up transition metals in solution to their stable borides. In our previous work, removal of the Zirconium (Zr) and Vanadium (V) from molten aluminum by inoculation with Al-B(AlB_2 and AlB_{12}) has been reported [1, 2]. Phase diagram analysis of Al-Cr system showed that Al_7Cr is the stable phase in the Al-1wt%Cr at room temperature [3]. It has been reported that Cr forms series of borides (CrB_2, Cr_2B, CrB, Cr_3B_4, Cr_5B_3 and CrB_4) in the Cr-B binary system [4].

It has been reported that electrical conductivity of the smelter grade aluminum is increased by 22 times when Cr is removed from solution into borides or some other intermetallic structure. However, it is not yet clear in literature whether Cr can be isolated from molten aluminum similar to Zr and V in the form of their stable diborides (CrB_2). There are conflicting reports about the removal of Cr from molten that can be found elsewhere [5]. The aim of this paper is to explore the possibility of Cr removal from molten aluminum alloy by the adding Al-B(AlB_{12}) master alloy at 750^{o}C.

For this study, Al-1wt%Cr alloy was prepared using induction furnace. Experimental setup and procedure is reported elsewhere [5]. Aluminum boron master alloy ingots containing AlB_{12} phase were added in the molten alloy. It was assumed CrB_2 will form by reaction of Cr and B from AlB_{12}. Alloy samples were taken at regular intervals and analyzed using scanning electron microscope (SEM) and inductively coupled plasma atomic emission spectroscopy (ICP-AES).

Figure 1(a) shows the SEM(SI) of Al-1wt%Cr-0.415wt%B alloy taken at 15 minutes after the addition of Al-B master alloys. There is no evidence of reaction product similar to that shown in Figure 1(b). In the case of reaction between Cr and AlB_{12}/B there should be continuous or discontinuous layers of reaction product (Cr-borides) at interface. Energy dispersive X-ray (EDS) spectrum of position X (Figure 2(a)) revealed that the grey particles are made of Al and Cr which are most likely Al_7Cr. Such particles nucleated on the existing particles (AlB_{12}/undissolved Al_7Cr) and aggregated during solidification process.

The concentration of Cr in the Al-1wt%Cr-0.415wt%B alloy was determined by ICP and is plotted with melt holding (Cr/AlB_{12} reaction) time, as shown in Figure 2(b). Surprisingly the concentration of Cr in samples were much less than 1wt% and also increased with time. This is due to the dissolution of Al_7Cr intermetallic particles that releases Cr into molten alloy. Overall, there no evidence of decrease in Cr level with Cr/AlB_{12} reaction time. Therefore, it may be not feasible to remove Cr from molten Al by adding Al-B master alloys. Existence of Cr in sludge as reported by previous investigators could be attributed due to presence of small Al-Cr intermetallic rather than borides.

References

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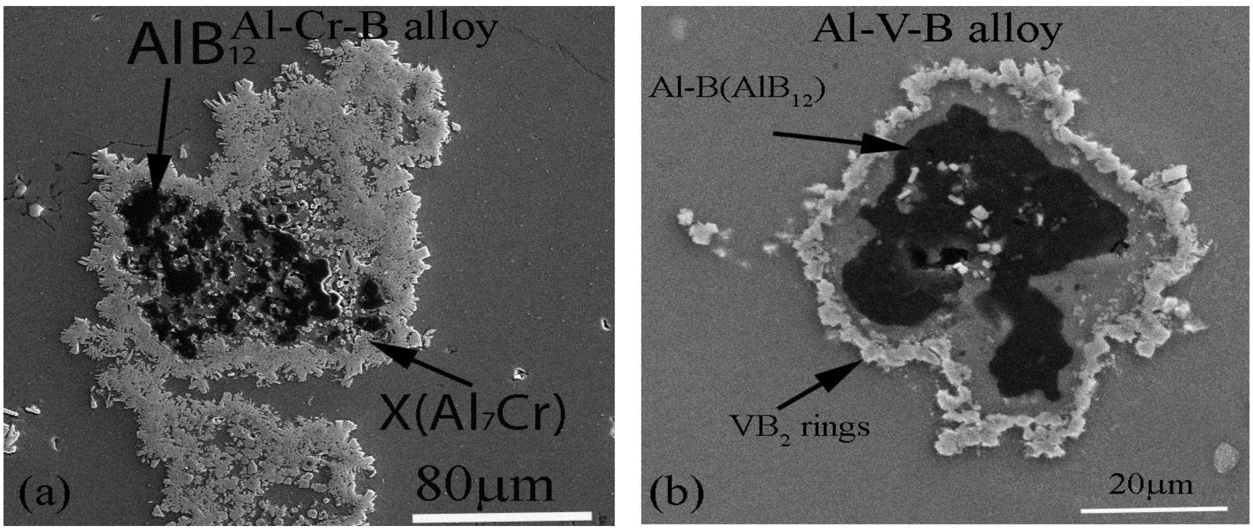

Figure 1. Scanning electron images (SI) of (a) Al-1wt%Cr-0.415wt%B and (b) Al-1wt%V-0.721wt%B alloys [5].

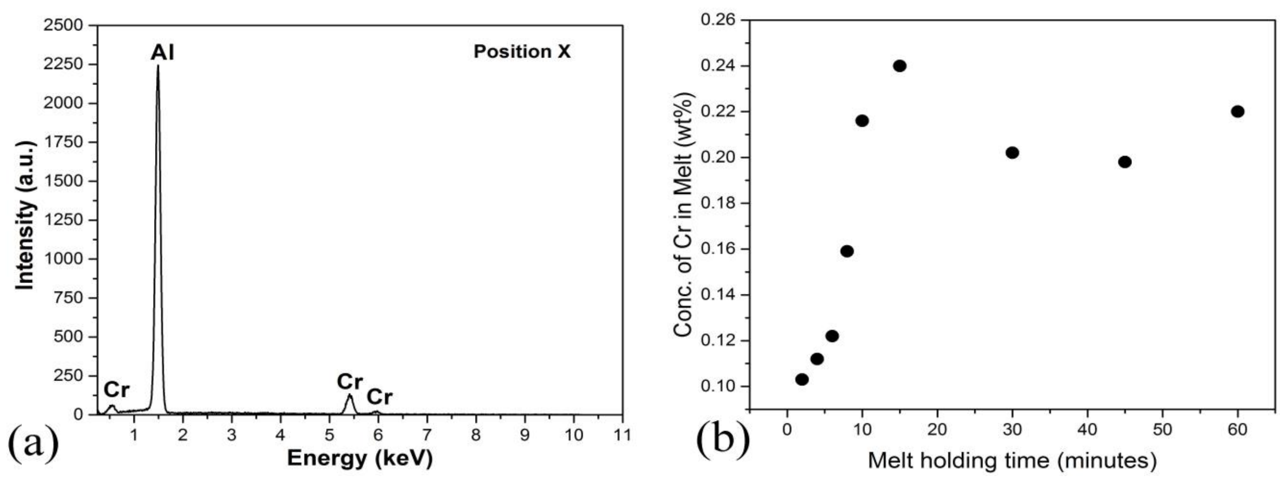

Figure 2. (a) EDS analysis of position X (see Figure 1(a)) and (b) ICP analysis of Cr in molten Al-1wt%Cr-0.415wt%B alloy