Sn-Pb ALLOY STRUCTURE SOLIDIFIED UNDER THE SIMULTANEOUS IMPOSITION OF DC MAGNETIC FIELD AND AC ELECTRIC CURRENT

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Introduction. Mechanical properties of materials such as strength, elongation and toughness highly depend upon their grain sizes, which are almost determined in a solidification process. Then the control of their solidified structure is essential for products with good mechanical properties. Heat flow control during solidification is an ordinary method to control grain sizes of solidified structures though it is difficult to apply this method to casting of large size products. Though inoculation can also refine solidified structures, it is sometimes harmful for recycling of products because of added elements.

In this paper, the effect of operating parameters in the refining method proposed by the authors [1,2] on the solidified structure has been experimentally examined.

1. Experimental Apparatus. A sample of a Sn-10mass%Pb alloy was prepared by alloying a pure molten Sn(99.9%) and a pure molten Pb(99.9%). Its liquidus and eutectic temperatures are 219C and 183C, respectively. The experimental apparatus and experimental method are preciously mentioned in the previous papers [1, 2].

2. Effect of electromagnetic vibration on solidified structure. The macrostructures of the vertical cross-section with and without the electrical current are shown in Fig. 1. When the static magnetic field and the alternating current were simultaneously imposed on the sample, an electromagnetic vibration was excited in it. In this case, the solidified structure was refined in the whole region of the sample, while in the case without the electromagnetic vibration (without electrical current) coarse grains are observed in the whole region. That is, the electromagnetic vibration excited in the local region can refine the structure.

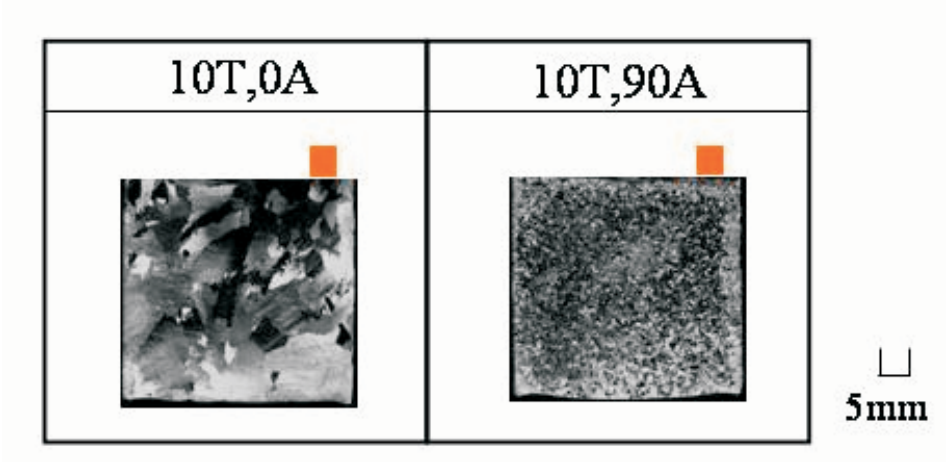

Fig. 1. Macrostructures of the vertical cross-section with and without electrical current.

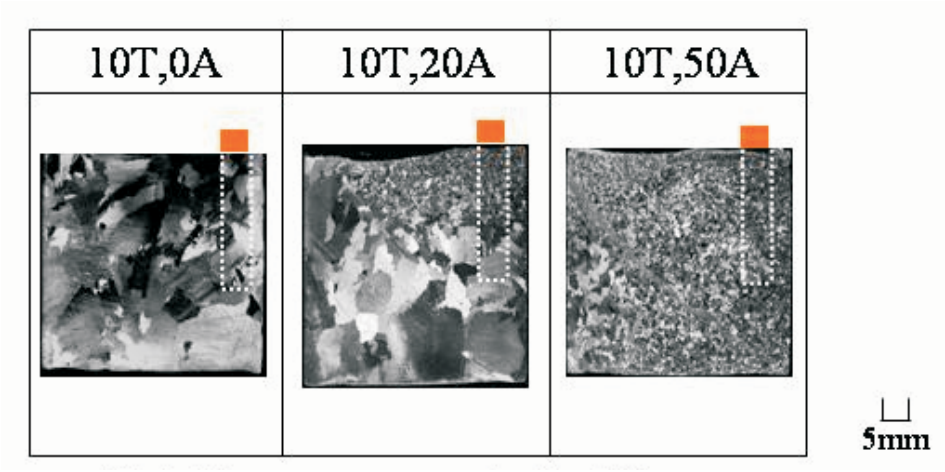

Fig. 2. Macrostructures under the different magnitude of the electrical current.

3. Effect of electrical current magnitude. The samples were solidified under the different magnitude of the alternating electrical current while the intensity of the static magnetic field was fixed at 10T. The macrostructures are shown in Fig. 2. The structures are not refined if the current is not applied on the sample while it is refined when the magnitude is 50A. The refining effect is observed only in the vicinity of the electrode in the case of 20A. That is, threshold of the electrical current intensity for refinement must exist around 20A in this experimental condition.

The intersection numbers between grain boundaries and each diagonal of a 10mm×10mm square were measured for the quantitative evaluation of the refinement. The positions of the four squares and the evaluated intersection numbers are shown in Fig. 3 as the function of the magnitude of the electrical current. The intersection number increases at the all positions as the magnitude of the electrical current increases. Refining effect is remarkable at the position C which is

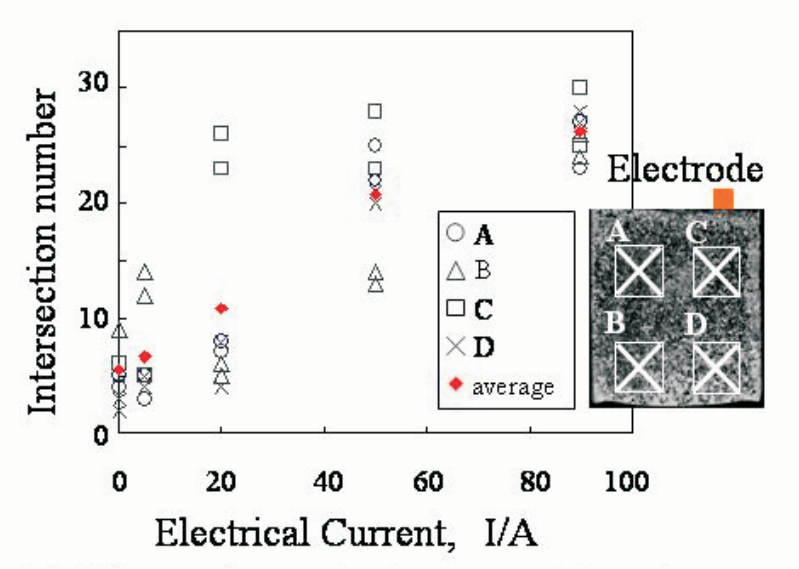

Fig. 3. Intersection number between grain boundary and diagonal of 10mm×10mm square as a function of electrical current magnitude.

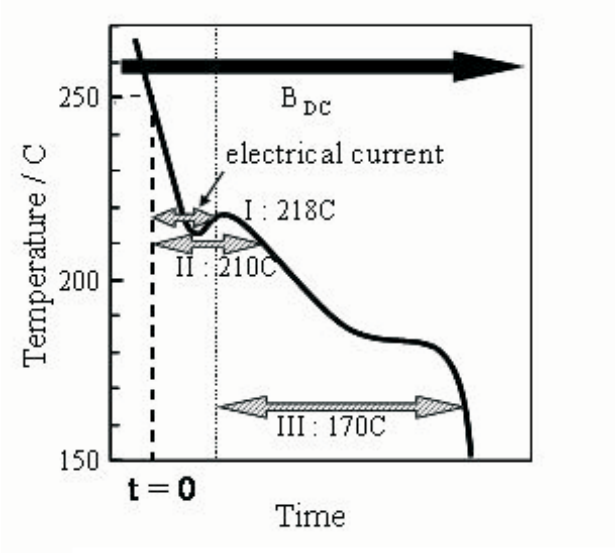

Fig. 4. Improsing duration of electrical current.

the nearest the electrodes. In the case of 50A, the refinement is achieved except the position **B**. This means that the refining effect decreases as the increase of distance from the electrode.

4. Effect of imposing duration of electrical current. The imposing durations of the alternating current of 90A adopted in this section and corresponding temperature when the electrical current was turned off are shown in Fig. 4. For the samples I and II, the electrical current was turned on when the sample temperature became 250°C at which the alloy was liquid. For the sample I, it was turned off when the recovery of the temperature accompanying recalescence finished. For the sample II, it was turned off when the temperature reached at 210C, where solid fraction was 0.44. For the sample III, the current was turned on when the temperature recovered and it was turned off when the temperature decreased to 170°C. The static magnetic field of 10T was imposed on the whole samples during solidification. The obtained macrostructures are shown in Fig. 5. Because a coarse structure is observed in the sample III, the imposition of the electrical current in initial stage of the solidification is crucial for refinement of the structure in this process. All of the region are refined in the sample II while some area in the sample I is coarse. Therefore, the imposition of the electromagnetic vibration only in the initial stage is not enough but until the time when solid frac-

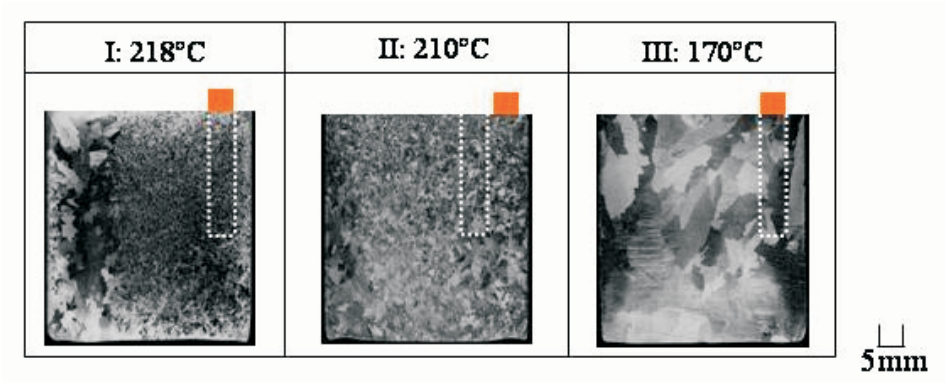

Fig. 5. Improsing duration of electrical current.

tion reaches 0.44 is enough for the refinement of the whole region of the sample in this experimental condition.

5. Conclusion. Effect of the operating parameter on the solidified structure of the Sn-Pb alloy in the electromagnetic refining process of the solidified structure in which a static magnetic field and an alternating current were locally imposed on a sample during solidification have been experimentally investigated.

The followings are main results obtained in this research.

- Threshold intensity of the electrical current for the refining of the solidified structure exists.
- Refining effect is mainly observed around the electrode in the case that the magnitude of the electrical current is around the threshold value.
- Imposition of the electromagnetic force in the initial stage of the solidification is crucial to obtain the refined structure in this process and the imposition in the middle stage has no refining function.

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