Development of the Micro Metal Balloon Using Sirasu-balloons as a Core Material

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Abstract

Recently the Marangoni convention is supposed to be an important phenomenon that significantly affects the solidification. For understanding the Marangoni convection mechanism, visualizing the convention phenomenon of molten tin with ultrasonic has been conducted. This paper reports developing a tracer material of micro metal balloon that is used in the molten system. We have succeeded in coating the surface of Shirasu-ballons with nickel by plating process. The obtained metal balloon is spherical and some characterizations were conducted.

Keywords : hollow microspher, metal balloon, plating, Marangoni convention

1. Introduction

Recently the Marangoni convention is supposed to be an important phenomenon that significantly affects the solidification. For understanding the Marangoni convection mechanism, visualizing the convention phenomenon of molten tin with ultrasonic has been conducted. Since the target value of the reflectance is up to 95%, acoustic impedance of a tracer particle should by less than 0.4 x 106kg/m2/s [1]. Considering this acoustic impedance, it is only attainable to make a “balloonlike structured tracer particle” because acoustic velocity is extremely high, which is approximately 2,570 m/s in molten tin and balloons are not able to suspend in the molten tin under normal gravity. This paper reports developing a tracer material of micro metal balloon (MMB) that is used in the molten system. We have succeeded in coating the surface of Shirasu-ballons (SB) with nickel by plating process. The obtained micro metal balloon is spherical and some characterizations were conducted.

2. Experimental

The tracer particles have following characteristics: high thermal stability, high wettability and low reactivity with surrounding molten tin. With regard to the shape as a,high sphericity is also required. The high wettability and low reactivity strongly requires a thin metal coating layer on the SB particle. Therefore, the surface of SB is coated by Ni.

We have chosen two types of spherical SB with 1mm and 0.1 mm in diameter. The preparation method of expaned perlite (Shirasu) named as Shirasu-ballon were reported esleswhere [2,3]. We firstly studied the development of the plating technique since using a small SB particle makes it difficult to handle the particles during the plating and to analyze a plating layer. The trial experiment was conducted for development of electroless Ni plating technique [4]. In this experiment, a plating solution ($NiSO_4$ aqueous solution) and a reducing agent for Ni^{2+} (NaH_2PO_2) were simultaneously added to the SB particle which was dispersed mechanically in water, in which molar ratio of $H_2PO_2^-$: Ni^{2+} was kept constant at 3:1. The excess degree of $H_2PO_2^-$ in a reaction vessel will become larger in the case of the plating, resulting in accumulation of non-reacted $H_2PO_2^-$ in the plating layer by physical absorption. The cross-sectional observations by Optical Microscope (OM) and Scanning Electron Microscope (SEM), and the elemental analysis of the plating layer were conducted by Auger Electron Spectroscopy (AES).

3. Results and discussion

Fig. 1 shows optical, SEM photographs of Micro Metal Balloon (MMB) of 1mm diameter after Ni plating of SB. The SEM images showed that the Ni layer proceeded almost whole period of the reaction, and the thickness of the plating layer was about 10-20 ㎛. The columnar crystal growth was observed only on the surface of the Ni/SB. This was attributable to high concentration of $H_2PO_2^-$ in the final period of the plating; thus, no columnar crystal growth will be able to be attained by further improvement of the plating technique, such as the optimization of the feeding conditions.

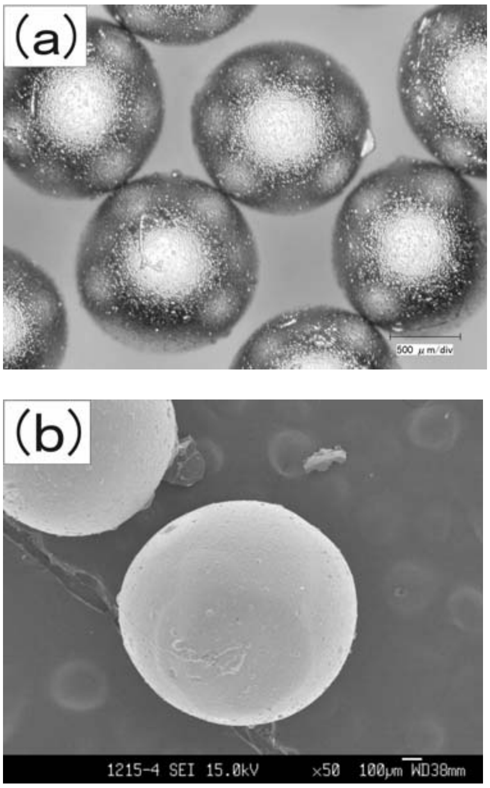

Fig. 1 MMB photos by (a) OP and (b) SEM.

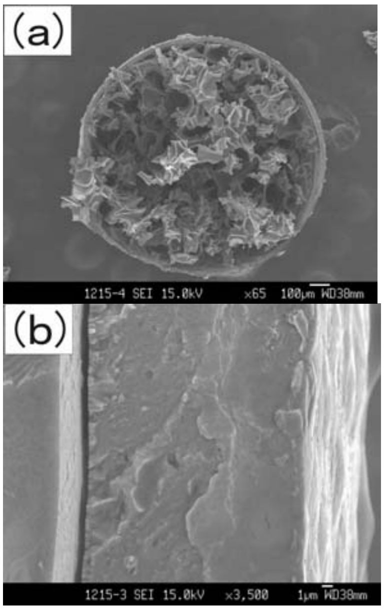

Fig. 2 Cross-sectional SEM microstructures of MMB. (a) Low magnification, (b) High Magnification.

Fig. 2 shows cross-sectional SEM microstructures of MMB. It is seen that the Ni film thickness is about 20 μm and homogeneous. AES analysis of the plating layer revealed that the thickness of Ni-oxide(s) film decreased from 5.0 nm to 1.6 nm and metallic Ni also existed on the surface (Table 1 and Fig. 3).

Similar results were also obtained using a Shirasu-ballon with 0.1 mm in diameter.

Table 1 The comparison of MMB surface determined by AES.

mass%

	Ni	P	Na	O	C
As-plated	32.8	2.3	13.2	16.7	35.0
After 5min sputtered	83.4	16.6	···	···	···
After 10min sputtered	83.8	16.2	···	···	···

1)The value was calculated using the PHI relative sensitivity coefficient.
Ni:0.220, P:0.300, Na:0.230, O:0.350, C:0.080

2)sputter rate: 7.8nm·min^{-1} (SiO_2 Conversion)

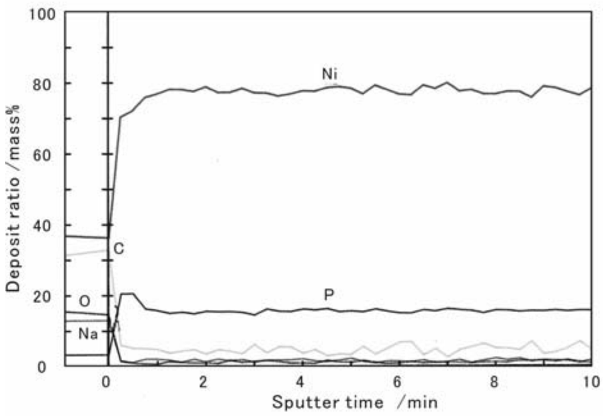

Fig. 3 Comparison of each element as a function of sputtered time

4. Conclusion

In this research, we have conducted an equipmentof plating process and succeeded in coating the surface of Shirasu Ballon with nickel. The composition of MMB was almost fixed in a weight of Ni:P=84:16, the distributuion of Ni thickness was sharp, and finally it was confirmed that the MMB was suitable for the tracer material.

5. References

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