In situ observation of crystal/melt interface instability in pure Sb and $Sb_{1-x}Bi_x$ alloys

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Sb-Bi binary alloys are all-proportional solid solution type alloys. Bi-rich Sb_xBi_{1-x} alloys are useful as thermoelectric materials [1], and have also been actively investigated as topological insulators [2]. Apart from those physical interests, an interesting aspect of crystal growth is that Sb, Bi, and Sb-Bi alloys have a rhombohedral crystal structure with large anisotropy. In this study, *in situ* observation of the directional solidification process of pure Sb and Sb-rich $Sb_{1-x}Bi_x$ alloys was carried out. In pure Sb, the differences in the critical growth rate at which instability of crystal/melt interface occurs were investigated in the c-axis direction and in the direction perpendicular to the c-axis. In Sb-rich $Sb_{1-x}Bi_x$ alloys, the effects of Bi concentration on the interfacial instability and on the development of cellular interfaces were investigated.

Fig. 1(a) shows the morphological change of the crystal/melt interface of pure Sb in the direction perpendicular to the c-axis (upper) and parallel to the c-axis (lower). Fig. 1(b) is the result of measuring the moving distance of the interface with time, and the time when the interface shape changed from planar to zigzag is indicated by the red dotted line in the graph. The growth rates at which the interface instability occurred were $V \approx 50$ μm/s ($\perp$c) and $V \approx 30$ μm/s (//c), respectively, suggesting that there is a difference in thermal conductivity depending on the interfacial orientation. In Sb-rich $Sb_{1-x}Bi_x$ alloys, it was observed that Bi addition reduces the critical growth rate for the interface instability, and Bi-rich melts segregate at the cellular interface, as shown in Fig.2.

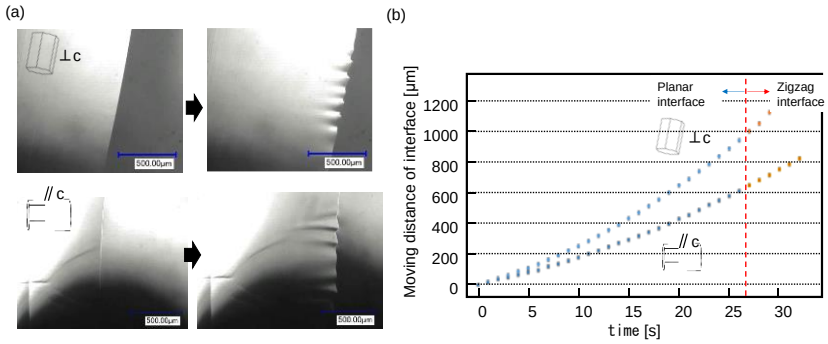

Fig. 1 (a) Instability of crystal/melt interface of pure Sb. (Upper panel) interface perpendicular to the c-axis, (Lower panel) interface parallel to the c-axis. (b) Moving distance of crystal/melt interface versus time.

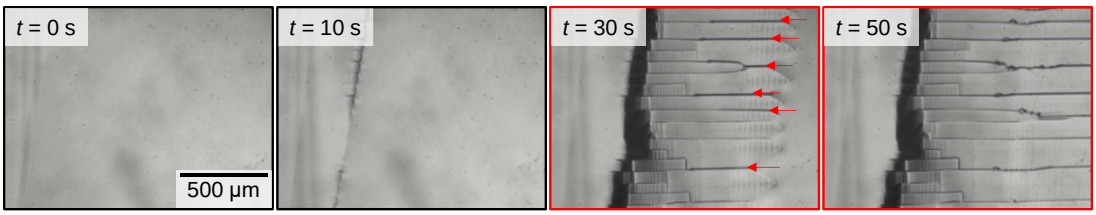

Fig. 2 Shape change of crystal/melt interface of $Sb_{0.925}Bi_{0.075}$. Bi-rich melts segregate at the cellular interface, as indicated by red arrows in the picture at t =30 s.

References

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