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Shaped Crystal Growth of Fe-Ga and Fe-Al Alloy Plates by the Micro Pulling down Method

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Abstract : Techniques of energy harvesting y have been widely developed in recent years, due to high demand on the power supply for 'Internet of things' devices such as wireless sensor nodes. In these applications, conversion technique of mechanical vibration energy into electrical energy using magnetostrictive materials n have been brought to attention. Among the magnetostrictive materials, Fe-Ga and Fe-Al alloys are attractive materials due to the figure of merits such price, mechanical strength, high magnetostrictive constant. Up to now, bulk crystals of these alloys are produced by the Bridgman–Stockbarger method or the Czochralski method. Using these method big bulk crystal up to 2~3 inch diameter can be grown. However, non-uniformity of chemical composition along to the crystal growth direction cannot be avoid, which results in non-uniformity of magnetostriction constant and reduction of the production yield. The micro-pulling down (μ-PD) method has been developed as a shaped crystal growth technique. Our group have reported shaped crystal growth of oxide, fluoride single crystals with different shape such rod, plate tube, thin fiber, etc. Advantages of this method is low segregation due to high growth rate and small diffusion of melt at the solid-liquid interface, and small kerf loss due to near net shape crystal. In this presentation, we report the shaped long plate crystal growth of Fe-Ga and Fe-Al alloys using the μ-PD method. Alloy crystals were grown by the μ-PD method using calcium oxide crucible and induction heating system under the nitrogen atmosphere. The bottom hole of crucibles was 5 x 1mm^2 size. A <100> oriented iron-based alloy was used as a seed crystal. 5 x 1 x 320 mm^3 alloy crystal plates were successfully grown. The results of crystal growth, chemical composition analysis, magnetostrictive properties and a prototype vibration energy harvester are reported. Furthermore, continuous crystal growth using powder supply system will be reported to minimize the chemical composition non-uniformity along the growth direction.

Keywords : crystal growth, micro-pulling-down method, Fe-Ga, Fe-Al
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