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A Novel Method for In-situ Fabrication of Graded or Aligned Materials in High Magnetic Fields

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Summary

Recently, the application of high magnetic fields to materials processing is considering a promising approach to prepare functional materials with special performances. In the present study, based on the techniques of solidification, quenching, and isothermal annealing in both the semisolid and melting states in high magnetic fields, the solidified structure evolution of the Mn-Sb and Al-Ni alloy systems was systematically studied under different magnetic field conditions. A novel method was proposed to in situ fabricate the graded or aligned materials using gradient or uniform high magnetic fields. The results show that the primary MnSb particles were gathered in one certain side of the specimens with a graded distribution during isothermal annealing of a hypoeutectic Mn-Sb alloy in the semisolid state in a gradient high magnetic field. Steeper field gradients produced the MnSb/Sb-MnSb graded microstructures during this semi-solid forming process. After isothermal annealing of a hypoeutectic Mn-Sb alloy in the melting condition followed by solidification in a high gradient magnetic field, the coexistence of both primary MnSb and Sb dendrites in the alloy and gathering of them in certain regions was obtained during this solidification process. This can be used to fabricate the MnSb-MnSb/Sb-Sb graded materials. These graded structures mentioned above result from the migration and gathering of the MnSb particles and Mn clusters driven by the magnetic buoyancy force and indicate that it is possible to control the migration of the particles and solute elements in a melt using gradient high magnetic fields. In addition, after the uniform magnetic field treatment during the solidification of Al-Ni alloy, the easy magnetization axis of the primary Al3Ni crystal is oriented parallel to the imposed magnetic field. Due to the combined effects of magnetic orientation, crystal growth mechanism and the effects of magnetic field on mass transport, the Al3Ni phase is aligned perpendicular to the magnetic field. These graded or aligned materials will be developed in many fields in the future because of their special structure and related performances.