Ternary V_{ss}-V_3Si-V_5SiB_2 eutectic formation in the V-Si-B system

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Refractory metals can be used to design alloys for high-temperature structural applications due to their high melting temperatures. The three-phase V_{ss}-V_3Si-V_5SiB_2 alloys are a class of vanadium-based alloys. To produce the three-phase V_{ss}-V_3Si-V_5SiB_2 alloys via a casting process, a precisely determined liquidus projection would be useful for the choice of alloy compositions. Thus, the solidification behavior close to the ternary V_{ss}-V_3Si-V_5SiB_2 eutectic reaction in the V-Si-B system has been experimentally investigated in this work.

Alloys near the ternary eutectic reaction were produced via arc-melting. Their microstructures were characterized using scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDS), electron backscatter diffraction (EBSD) measurements and X-ray diffraction (XRD) analysis. The composition of the ternary eutectic reaction has been determined as V-9Si-6.5B (at%). Different microstructures were observed in two different sample parts in the ternary eutectic alloy V-9Si-6.5B corresponding to different cooling rates indicating a competitive solidification behavior between the two-phase V_{ss}-V_5SiB_2 and three-phase V_{ss}-V_3Si-V_5SiB_2 eutectic growth. To investigate this phenomenon, a eutectic growth model based on the Jackson-Hunt theory was developed and applied to both the two-phase V_{ss}-V_5SiB_2 and the three-phase Vss-V_3Si-V_5SiB_2 eutectics. The calculated results agree well with the experimental observations.

As a result, the liquidus projection around the ternary eutectic reaction has been modified and the cross section of the ternary V_{ss}-V_3Si-V_5SiB_2 eutectic coupled zone along the monovariant V_{ss}-V_5SiB_2 and V_3Si-V_5SiB_2 reaction lines proposed. The modified liquidus projection can be used to design as-cast V-Si-B alloys with different microstructures close to the ternary eutectic reaction. Some of them having representative microstructures, e.g. two-phase V_{ss}-V_5SiB_2 and three-phase V_{ss}-V_3Si-V_5SiB_2 eutectic microstructures, will be mechanically tested in the future.