Functions and mechanism of modification elements in eutectic solidification of Al-Si alloys: A brief review

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Abstract: Being used more and more widely in engineering, Al-Si alloys comprise about 80% of all kinds of aluminum alloys, which are the most widely utilized nonferrous alloys. Although most Al-Si alloys consist of multiple components, the eutectics in the structure accounts for 50%–90% of the sum volume of such alloys. Therefore, understanding the modification mechanism and function rules of the Al-Si eutectic solidification is the technical key in controlling the structures and properties of such casting alloys. The present paper chiefly reviews recent investigation developments and important conclusions along the lines of the functions of modification elements and their modification mechanism in the eutectic solidification of Al-Si alloys.

Key words: Al-Si alloys; eutectic solidification; modification; silicon morphology; growth kinetics

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Al-Si eutectics accord with general characteristics of nonfaceted-faceted irregular eutectics, and the eutectic Si phase grows with an alternant divergent and convergent pattern [1]. Under common casting conditions, the morphology of Si crystals is shown in Fig. 1 (a) and (c) when solidified from Al-Si alloy melts without the modification treatment. Although eutectic Si crystals look like needles or strips on a polished surface of a metallographic specimen, they are spatially connected thick plate structures, with no directional irregular distribution. There is often a small amount of primary Si in eutectic and near-eutectic composition Al-Si alloys. Such a metallographic structure would result in lower mechanical properties of Al-Si alloys, so Al-Si alloy liquid is usually modified with an alterant containing Na or Sr, etc. in casting practice. The modification purpose is to achieve "flake to fibrous" morphological transformation for eutectic silicon and to eliminate the primary Si crystals, finally changing into a tiny fibrous shape, as shown in Fig. 1(b) and (d). But the treatment sometimes accompanies with a small amount of fine flake shape. The microstructure changes have great significance for improving the properties of Al-Si cast alloys. For example, the tensile strength can be increased by about 50%, and ductility even increases to about three times.

Why is it then that modification treatment can change the Al-Si alloy microstructures? Understanding its effect rule and modification mechanism would undoubtedly be of great significance for the improvement of casting quality. Since the invention of modification technology for Al-Si alloys, various theories have been put forward to explain the modification mechanism of alterant elements to eutectic Si based on production practices and experimental studies. These theories can broadly come down to two aspects: affecting