MICROSTRUCTURE DEVELOPMENT IN SINGLE CRYSTAL WELDS

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With the expanded utilization of single crystal nickel-base superalloys in land-based and aero turbine engines, there is an increasing need to be able to weld these materials for repair and refurbishment while maintaining the single crystal nature of the component. One of the primary difficulties associated with welding is the formation of new grains ("stray grains") with orientations that are different from the original base material. These new grains destroy the single crystal nature of the alloy, they compromise properties, and they often act as initiation sites for weld cracking. This paper reviews the work on the welding of single crystal materials, both in model systems and in commercial nickel-base superalloys.

Previous work on Fe-15Cr-15Ni single crystals has led to the development of a geometric model that describes the orientation and growth of dendrites. This paper describes the extension of that work using the Fe-15Cr-15Ni alloy with selected additions to study the details and mechanisms that control stray grain formation. The propensity to form stray grains has been related to solidification conditions such as thermal gradient, growth velocity, and solidification temperature range. The models developed for the Fe-Cr-Ni system have also been applied to welding of single crystal nickel-base superalloys. The formation of stray grains has been studied as a function of welding conditions. Examples will also be presented that show that the grain boundaries that are produced by stray grains are susceptible to weld cracking. Some early results are promising in that welds made under certain conditions have been shown to yield perfect single crystal welds with the same orientation as the base material. However, the tendency to form stray grains is still quite strong and complete avoidance of stray grain formation may require strategic alloy modifications.

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