Laser Microcladding of Al-Si Alloys: Solidification Behavior and Structure Features

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Laser microcladding is a promising technique of laser deposition technology. It is used for repairing and manufacturing of high-precision parts and small-scale production. Modern laser sources enable one to focus the laser beam in a spot of about 50 μm, allowing the creation of single tracks with the lateral resolution of up to 100 microns and thus increasing the resolution of the method. The two-dimensional approach to the heat dissipation problem typically used for laser cladding process is inapplicable for laser microcladding because of the treatment zone microminiaturization. The thermal gradient increase, the cooling rate increase, and the melt pool lifetime decrease cause changes in the solidification behavior compared with laser macrocladding. Therefore, there are many difficulties encountered when trying to find the optimal parameters and predict the final microstructure and mechanical properties even for the alloys successfully treated by laser macrocladding.

In this research, clad tracks of submillimeter width were successfully produced by laser microcladding of low-density Al–Si hypereutectic alloys. Structure formation mechanisms of hypereutectic Al –Si alloys during laser microcladding were studied. The melt pool solidification processes in laser micro- and macrocladding were compared with each other. The deposition parameter influence on the structure and geometric characteristics of single tracks was analyzed. The main factors influencing the structure formation by laser microcladding were determined. The melt pool flow and its posterior solidification behavior during wall and cube build-up process were discussed. The structure components morphology of AlSi30 alloy produced by different microcladding parameters was studied. Assumptions in relation to local growth conditions of primary Si crystal and irregular Al–Si eutectic were made. Recommendations for laser microcladding of hypereutectic Al–Si alloys were given.