Abstract of Main Thesis

Title of Thesis

Numerical and Experimental Investigations of Formation and Breakup of Compound Jets

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Abstract on the Content of the Applicant's Thesis

Motivated by formation of hollow spherical Si solar cells, the central goal of this thesis is to develop a comprehensive understanding of the dynamics leading to the formation and breakup of a compound jet. Accordingly, we perform numerical and experimental investigations of compound jets that are hollow jets as the core fluid is gas. At the start, a compound jet formed in ambient fluid at rest is numerically simulated. We employ a front-tracking method that represents the compound jet interfaces by connected Lagrangian markers that move on a stationary Cartesian grid. The jet interfaces evolve in time as more fluid is supplied through a coaxial nozzle, and finally break up into compound drops due to capillary effects. Next, by using the same numerical method, the problem is extended to a co-flowing system in which the ambient fluid is ejected through the annular space between the outer nozzle of the coaxial nozzle and an outer tube. Various breakup modes including inner dripping-outer dripping, inner jetting-outer jetting, and mixed dripping-jetting have been found. These modes produce various types of drops: simple drops, single-core compound drops and multi-core compound drops. The understanding is then supported by experimental investigations of a hollow jet, i.e. a compound jet with a gas core. First, a hollow jet of water is conducted. Experimental results show that similarly to the compound jet computations, the hollow jet of water breaks up into simple drops, single-core hollow drops and multi-core hollow drops. Then, experiments on a hollow metal jet, which is closer to future work on hollow Si drop formation, are investigated. Raw solder melted in a crucible is extruded through the coaxial nozzle to form a hollow molten solder jet that forms hollow drops. These drops after solidifying during falling are hermetic and have a smooth surface. With these investigations and understanding, a hollow-jet-based technology for formation of hollow Si spheres has been proposed, and method development has been started.