Liquid Metal Droplet Impact Dynamics

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Extended Abstract

Droplet on Demand (DOD) additive manufacturing is the application of inkjet technology to the realm of 3D printing. We seek to apply the concepts of droplets impacting the substrate to liquid metal 'ink'. DOD presents a more affordable alternative to other metal printing methods while still printing full density metal parts. Understanding and overcoming the complicated dynamics of small liquid metal droplet impact dynamics is critical for the progression of this technology. This work focuses on droplet impact, spreading and wetting behavior for room temperature liquid metal on an isothermal substrate, as well as thermoelectrically heated and cooled substrates.

We conducted the droplet impact at low Weber number $O(10^{-7})$ and low Ohnesorge number $O(10^{-4})$ indicating capillarity driven spreading resisted by fluid inertia[1]. By increasing the drop height, we increase droplet velocity, and therefore increase the impact Weber number to $O(10^{2})$ while maintaining $O(10^{-4})$ for the Ohnesorge number, leading to impact driven spreading resisted by the fluid inertia[2][3]. We studied droplet contact diameter as a function of time until contact line arrest as well as advancing and arrested contact angles. Furthermore, we measured droplet height as a function of time to model oscillation and damping after impact as these parameters are critical for the frequency of droplet deposition. These results are compared between the isothermal, cooled substrate, and heated substrate cases to quantify localized thermal effects on dynamic contact and wetting conditions.

Analysis is further complicated by the effect of oxidation at the surface. Figure 1a and Figure 1b show the droplet in flight and the final resting state of the droplet after impact for very low Weber number. Figure 1a shows the effect of the surface level oxidation, as surface energy cannot be released freely the distinctive 'tail' is seen as the droplet falls [4]. In its arrested configuration, the droplet also displays a distinctive shape and wetting behavior. Deviating from the drop shape seen in other liquids such as water.

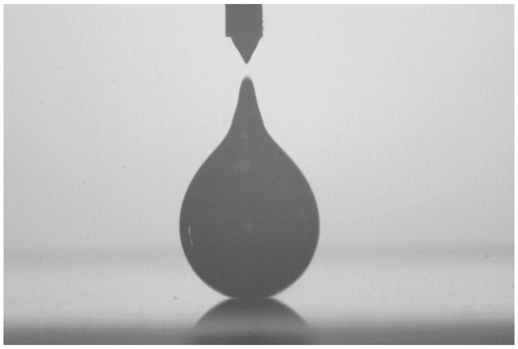

Figure 1a. Liquid metal droplet in flight

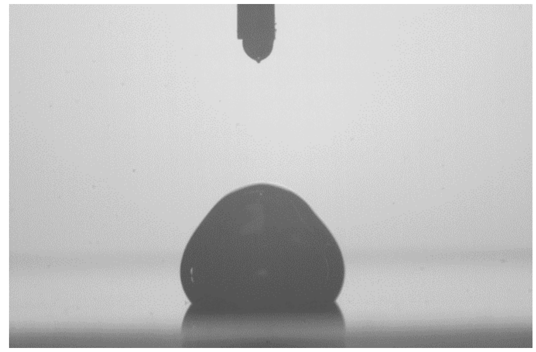

Figure 1b Liquid metal droplet at rest

References

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