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Electrospray Plume Characterisation of a Single Source Cone-Jet for Micro-Electronic Cooling

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Abstract : Increasing expectations on small form factor electronics to be more compact while increasing performance has driven conventional cooling technologies to a thermal management threshold. An emerging solution to this problem is electrospray (ES) cooling. ES cooling enables two phase cooling by utilising Coulomb forces for energy efficient fluid atomization. Generated charged droplets are accelerated to the grounded target surface by the applied electric field and surrounding gravitational force. While in transit the like charged droplets enable plume dispersion and inhibit droplet coalescence. If the electric field is increased in the cone-jet regime, a subsequent increase in the plume spray angle has been shown. Droplet segregation in the spray plume has been observed, with primary droplets in the plume core and satellite droplets positioned on the periphery of the plume. This segregation is facilitated by inertial and electrostatic effects. This result has been corroborated by numerous authors. These satellite droplets are usually more densely charged and move at a lower relative velocity to that of the spray core due to the radial decay of the electric field. Previous experimental research by Gomez and Tang has shown that the number of droplets deposited on the periphery can be up to twice that of the spray core. This result has been substantiated by a numerical models derived by Wilhelm et al., Oh et al. and Yang et al. Yang et al. showed from their numerical model, that by varying the extractor potential the dispersion radius of the plume also varies proportionally. This research aims to investigate this dispersion density and the role it plays in the local heat transfer coefficient profile (h) of ES cooling. This will be carried out for different extractor – target separation heights (H2), working fluid flow rates (Q), and extractor applied potential (V2). The plume dispersion will be recorded by spraying a 25 µm thick, joule heated steel foil and by recording the thermal footprint of the ES plume using a Flir A-40 thermal imaging camera. The recorded results will then be analysed by in-house developed MATLAB code.

Keywords : electronic cooling, electrospray, electrospray plume dispersion, spray cooling
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