Intricacies of 3D printing in μ-gravity

Additive manufacturing has become a lucrative option for every space mission because it can produce products on demand. The ulterior motive for this talk is to discuss a benchtop platform named FrizCast^{TM}. This platform allowed us to study the fundamental understanding of different processes involved in a typical additive manufacturing process. We critically investigate the intricacies of 3D printing in a microgravity environment and the effect of interfacial force-driven phenomena on 3D printing. Three primary stages of 3D printing are investigated, material delivery combined with growth, multilayer mass addition, and solidification. For material delivery, we have proposed a novel jet-based deposition technique while considering the constraints associated with health hazards, limited space, surrounding environment and strong dominance of surface tension. We have observed three distinctive metastable stages for a deposited drop for the parabolic maneuver. To explain the underlying physics of the solidification of the deposited material, we analyzed the freezing dynamics of the water droplet. This solidification via freezing study motivates us to conduct further investigations on harnessing the low temperature of the outer space condition for the solidification of the 3D printed object. With this device, we further extended our reach to 4D printing. This project has the potential to become a blueprint of an instrument for space missions where frequent measurements of surface tension and surface energy, and 3D printing of metal and biomaterials, are required.