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A PATH TOWARDS PRINTED ELECTRONICS IN SPACE: TRANSFER AND EVAPORATION OF COLLOIDAL DROPLETS IN MICROGRAVITY

Abstract

To ensure the safety and reliability of increasingly frequent, long-duration, and long-distance space missions, there is an urgent need for a sufficient and timely supply of essential electronics and sensors that are crucial in maintaining and regenerating spacecraft while in space. Printed electronics, characterized by their simple processes, high efficiency, substrate compatibility, and remarkably low costs, have emerged as a disruptive technology for in situ manufacturing and maintenance of functional devices in the extraterrestrial environment. However, the environmental disparities between terrestrial conditions and outer space—particularly variations in gravity—pose limitations on the widespread adoption of printing technology for use in space. In recent years, the colloidal modeling system has been employed to investigate the two crucial dynamic processes of liquid transfer and evaporative solidification in typical printing techniques. To mitigate the wall climbing phenomenon in microgravity conditions, we conducted experiments on the generation, transfer, and precise control of a colloidal droplet using a wettability-patterned surface. This facilitated verification of droplet printing under microgravity conditions. In order to address the challenge posed by complex particle transport and morphology control during evaporative solidification of printed droplets, we developed a phase diagram that comprehensively considers the cooperative and competitive relationship among multiple physical effects. In addition, by employing colloidal self-assembly techniques, we have developed several efficient approaches to regulate and fabricate colloidal photonic crystals. This aforementioned research introduces a groundbreaking concept for the fabrication of high-performance printed electronics at both micro and nano scales, thereby offering promising prospects for manufacturing functional and structural devices in space such as flexible solar cells, soft and wearable sensors, as well as space-based antennas.