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ACTIVE CONTROL OF AUTONOMOUS CAPILLARY SYSTEMS FOR LAB-ON-CHIP DEVICES SUITABLE FOR MICRO- AND NANO-SATELLITES BIOLOGICAL EXPERIMENTS

Abstract

In the last decades space activities have increased in number and intensity, not only in fields of astronomical research, but also in others such as the medical or biology field. Understanding certain biological processes that could improve the human quality of life is a strongly desired goal, and space offers a scenario where, due to its characteristic properties that differ from the Earth environment, such as microgravity, particular biomolecular processes can be unmasked. Developing a technology that is reliable, simple, light, small and as a consequence, economic, is a need for the research activities in space. Lowering the costs of space activities is mandatory in order to make space accessible and affordable to all countries.

One of the main challenges for making autonomous devices suitable for automatic experiment aboard micro- and nano-satellites, is the ability to actively control the flow of samples and reagents. Autonomous capillary networks allow to implement complex fluidic operation without the need for external pumping systems which is an attractive feature for nanosatellites' payloads. However, such systems cannot be easily controlled to execute experiments with precisely defined timing. In order to add this ability, a novel system combining capillary microfluidics and electrowetting on dielectrics (EWOD) is proposed.

A test device combining the two techniques has been designed, fabricated and successfully tested. The difficulties encountered and solved are related to the development of the technological steps needed for the fabrication of regions characterized by different hydrophobicity on a single glass substrate. These peculiar characteristics are needed in order to combine capillary microfluidics with EWOD-controlled fluid actuation. In this work, the fabrication processes have been optimized in order to adapt them to work with different combinations of materials. The fabrication processes include photolithography as a way to pattern a specific configuration, metals evaporation to build electrodes, chemical attack to remove certain materials and ultrasound aided lift-off process. Tests on surfaces with different hydrophobicities and tests on EWOD are carried out experimenting with two different materials as hydrophobic surfaces, Teflon® and Cytop®, to prove their suitability for the final construction of the proposed lab-on-chip and learn the optimum fabrication process. The designed test-chip includes structures for the assessment of different functions as fluid dispensing in different directions, fluid rest between a set of electrodes that act as valves, and both natural and electrically forced mixing. Preliminary tests confirmed the correct operation of the device.