MODULAR MICROFLUIDIC GEOMETRIES FOR PASSIVE DROPLETS MANIPULATIONS - EXPERIMENTAL ANALYSIS

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Passive techniques for manipulation on droplets are an interesting and promising approach for the design of microfluidic devices which on one hand are easy-to-use and on the another hand, execute complex laboratory procedures[1, 2, 3]. We present the comprehensive study of basic microfluidic components allowing for encoding different operations on droplets into the structure of the device. The understanding of hydrodynamic interactions between the continuous flow and the movement of a droplet in confined space of different microfluidic geometries is crucial for a rational and effective design of new generation of modular microfluidic processors with embedded instructions. In the previous publication, we showed examples of passive microfluidic traps[4]. Traps were built with two basic geometries: obstacles and slit-bypasses. Modifications of these elements and their combination in different arrangements created traps with different functions such as: metering prescribed volume of a droplet; immobilisation of a droplet; combining consecutive drops. The previous publication demonstrated the potential of the new approach, however, it lacked a comprehensive analysis of principal mechanisms. It provided in rather intuitive remarks about the operation of traps, however, our observations showed that the behaviour of droplets in some microfluidic geometries is often counter-intuitive. Hence, the “intuitive” approach to the design of passive elements may cost numerous trials and resources. Therefore, effective applications of this technology require detailed investigations on mechanisms ruling movement of droplets. One of the most important parameters is the hydraulic resistance. In presented procedure, it is estimated in specially designed microfluidic networks. Two inputs are fed with equal flows of: a buffer and a buffer with an indicator. As the distribution of the initial amount of the indicator between both outputs corresponds to the ratio of resistances of the straight channel and the channel with investigated modules, the latter one can be estimated by direct measurement of the concentration of indicator. The results showed the intriguing fact that the addition of slit-bypasses to the channel does not change significantly the resistance although the increase of the cross-section. In the case of the obstacle, on the contrary, even short obstacle, introduces the significant rise of resistance. The other analysis of traps based on the application of optical techniques for observations of the kinetics of traps. We observed both – the movement of a droplet and the flow of continuous phase by a microscope and a camera. The image analysis of the contours of a droplet and particle image velocimetry provided information on the interaction between both flows and its dependence on the local geometry (Fig.1). As we expected, during the flow of droplet through traps-like structures the bypasses are activated or deactivated depending on the actual position of a droplet. The gathered knowledge is very important for the understanding of the principle of passive structures. As we will show, the appropriate arrangements of base elements allowed as for successful design and fabrication of new passive elements.

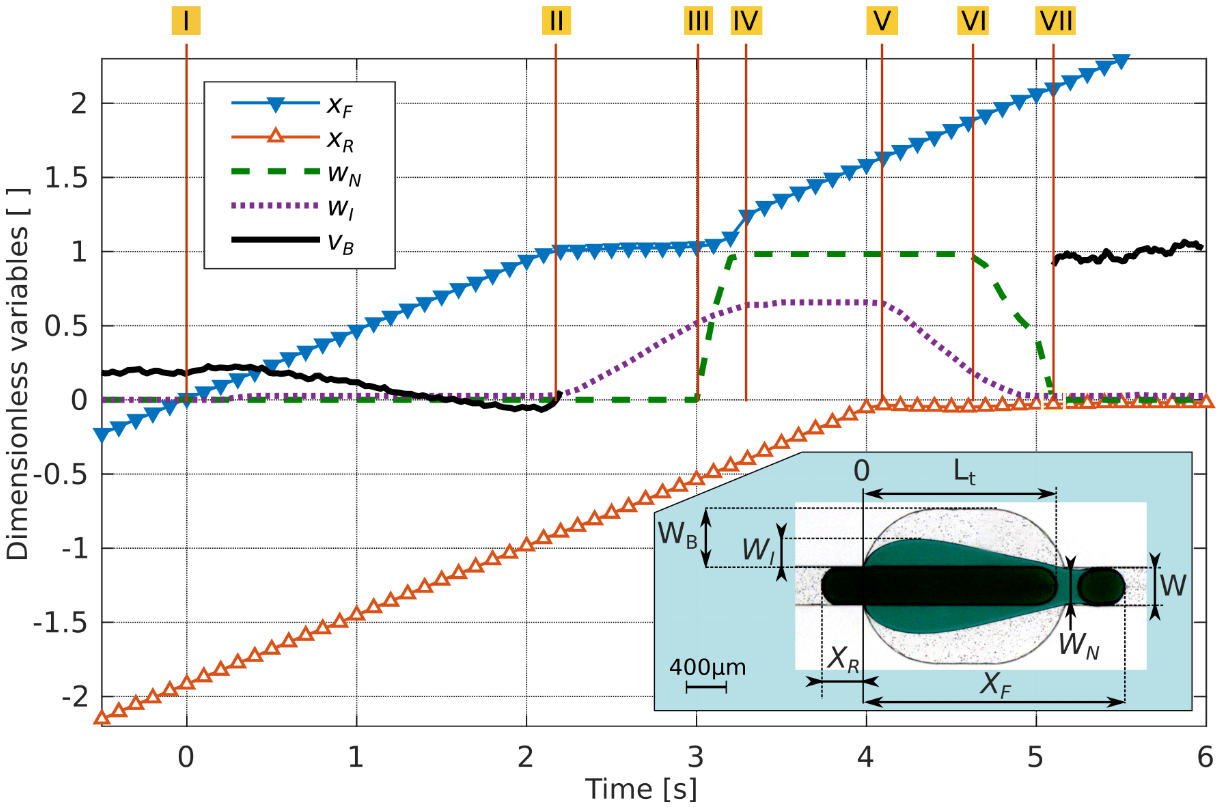

Figure 1: The analysis of the kinetics in the case of the passage of a long droplet through the metering trap. In the corner – the snapshot taken just before decomposition of a droplet. Plots of measured kinetic parameters: X_F - the position of the front of a droplet normalised by L_T(the length of the trap), X_R - the position of the back of a droplet normalised by L_T, W_N - the width of the neck normalised by W(the width of the channel), W_I - the width of intrusions from both sides of a droplet normalised by W_B(the width of the bypass), v_B - average velocity(only a parallel component to the main channel) of the continuous phase in the bypass slit normalised by its average value after the stage VII.

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