Microfluidics and Microscale Transport Processes: Present Trends and Future Challenges

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ABSTRACT

Rapid advancements in microfabrication and nanofabrication technologies have triggered a wide range of scientific investigations involving the transportation and manipulation of fluids in micro and nano scale devices and systems. Such devices are capable of achieving some specialized functionalities as their larger-sized counterparts in the macroscopic world, such as clinical diagnostics, DNA scanning, cellular analysis, and separation processes, however with a dramatically reduced sample volume requirement, much shorter reaction and analysis time, higher throughput, automation, design flexibility, and portability. Inevitably, such applications necessitate the handling and processing of small amounts of fluids, and this is where fluid mechanics of small scale systems comes into play. Fluid mechanics at the small scale is often intriguing, exhibiting the dominance of surface effects and interfacial phenomena in flow actuation, manipulation, and control. Here, some salient features related to microscale fluid mechanics are delineated. These features include the principles of action of several flow actuation mechanisms (such as capillary, electrical, optical) and implications of fluid frictional characteristics over reduced length scales. Non-trivialities in some of these features are emphasized in particular, such as the possible role played by a rough surface in reducing fluid frictional resistance rather than amplifying the same. Emphasis is laid towards throwing focused physical insight on the underlying science, so as to highlight the underlying principles behind their implications in micro and nano technology.