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REVIEW ARTICLE

Particle separation and sorting in microfluidic devices: a review

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Abstract Separation and sorting of micron-sized particles has great importance in diagnostics, chemical and biological analyses, food and chemical processing and environmental assessment. By employing the unique characteristics of microscale flow phenomena, various techniques have been established for fast and accurate separation and sorting of microparticles in a continuous manner. The advancements in microfluidics enable sorting technologies that combine the benefits of continuous operation with small-sized scale suitable for manipulation and probing of individual particles or cells. Microfluidic sorting platforms require smaller sample volume, which has several benefits in terms of reduced cost of reagents, analysis time and less invasiveness to patients for sample extraction. Additionally, smaller size of device together with lower fabrication cost allows massive parallelization, which makes high-throughput sorting possible. Both passive and active separation and sorting techniques have been reported in literature. Passive techniques utilize the interaction between particles, flow field and the channel structure and do not require external fields. On the other hand, active techniques make use of external fields in various forms but offer better performance. This paper provides an extensive review of various passive and active separation techniques including basic theories and experimental details. The working principles are explained in detail, and performances of the devices are discussed.

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1 Introduction

Microfluidics concerns design, fabrication and experiments of miniaturized fluidic systems, which has undergone rapid developments during the last decade (Whitesides 2006). As an interdisciplinary area, this rapidly growing field of technology has found numerous applications in biomedical, diagnostics, chemical analysis, automotive and electronics industries. One of the pivotal applications of microfluidics is the development of Lab-on-Chip (LOC) devices as point-of-care diagnostic tools. A typical Lab-on-Chip device includes various functional modules: sample transportation and preparation module, separation module and detection and analysis module. The separation module has importance in preparative applications where a sample is purified through separation of biological objects as well as in analytical applications where these separated objects are carefully studied. Besides this, size-based sorting of objects in a sample is one of the important technologies in the fields of industrial production, food and chemical industry, environmental assessment and chemical or biological research. The sorting of micron-sized objects in a continuous flow is required for a wide variety of applications, including chemical syntheses, mineral processing and biological analyses (Manz et al. 1992; Reyes et al. 2002; Toner and Irimia 2005). For example, in food industry, harmful bacterial activity is carefully monitored and can be prevented with the help of separation techniques. In defense sector, separation is required to detect threatening agents such as Anthrax. In diagnostics, the separation techniques can be utilized to separate living cells from dead cells, cancer cells from normal cells and malaria-infected cells from healthy cells (Suresh et al. 2005; Alshareef et al. 2011).

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