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RESEARCH PAPER

Enhancement of microfluidic efficiency with nanocrystalline diamond interlayer in the ZnO-based surface acoustic wave device

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Abstract Ultra-smooth nanocrystalline diamond (UNCD) films with high-acoustic wave velocity were introduced into ZnO-based surface acoustic wave (SAW) devices to enhance their microfluidic efficiency by reducing the acoustic energy dissipation into the silicon substrate and improving the acoustic properties of the SAW devices. Microfluidic efficiency of the ZnO-based SAW devices with and without UNCD inter layers was investigated and compared. Results showed that the pumping velocities increase with the input power and those of the ZnO/UNCD/Si devices are much larger than those of the ZnO/Si devices at the same power. The jetting efficiency of the droplet was improved by introducing the UNCD interlayer into the ZnO/Si SAW device. Improvement in the microfluidic efficiency is mainly attributed to the diamond layer, which restrains the acoustic wave to propagate in the top layer rather than dissipating into the substrate.

Keywords Nanocrystalline diamond film · Surface acoustic wave · Pumping and jetting · Efficiency

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1 Introduction

Surface acoustic wave (SAW) induced manipulation of liquid at the microscale has attracted much attention for integrated microfluidics and lab-on-chip applications (Franke and Wixforth 2008; Mark et al. 2010; Friend and Yeo 2011). Various SAW-based microfluidic functions have been widely reported, including transportation, mixing, splitting, jetting, nebulization, and concentration of particles in the droplet (Wixforth et al. 2004; Nguyen and Wu 2005; Yeo and Friend 2009; Yoon et al. 2012). Functionality of the SAW-based microfluidics device is dependent on the interdigitated transducer (IDT) electrode design and the structure and acoustic properties of the piezoelectric material substrate, which modulate the droplet actuation through the SAW/liquid interaction (Wood et al. 2009; Glass et al. 2012; Hashimoto 2011). Therefore, an optimum design of the structure (i.e., IDT pattern or multi-layer thin films) and controllable growth of high-quality piezoelectric materials are important to improve the performance of SAW-based microfluidic devices.

In order to enhance the microfluidic efficiency and reduce the input radio frequency (RF) power for manipulation of liquid using SAW devices, different approaches