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Machining Simulation Model of Integration of Two Horizontal Straight-line Connected with Curved and Vertical Straight-line Nanochannel as well as Experimental Verification by Atomic Force Microscopy

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Keywords: curved nanochannel, vertical straight-line nanochannel, atomic force microscopy (AFM), two-pass offset machining method

ABSTRACT

First of all, the paper uses specific downward force energy (SDFE) equation and two-pass offset machining method to further derive the relevant equations and simulation models. Further, the paper proposes a simulated calculation method of a near-curve that is formed by connecting multiple tiny line segments. As to the simulated machining method of connecting a vertical straight-line nanochannel with the middle of two horizontal straight-line nanochannels, the paper suggests a machining method that uses the shape stacking concept and changes the downward force for machining to the expected width and expected depth. The paper also proposes the method of applying a smaller downward force to remove the slightly raised edge from the vertical straight-line nanochannel. The paper also mentions the cross-section measurement method and the required straight line equation in the AFM measurement experiment. Finally, the paper compares the measurement results obtained in AFM experimental machining with the simulation results, and proves that the paper's simulation model as well as the AFM experimental machining method are reasonable and acceptable.

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INTRODUCTION

In recent years, the related scholars have proved that atomic force microscopy (AFM) can be used to conduct surface machining of nanostructure. Fang et al. (2000) used AFM probe to conduct nano-scratching experiments of silicon (Si) substrate coated with crystal-free aluminum (Al.) film. Schumacher et al. (2000) used AFM to carry out mechanical cutting on the surface of heterogeneous structures of GaAs/AlGaAs, and then machined a single-electron transistor. Wang et al. (2010) used AFM for machining of nanochannel on the surface of silicon oxide, and explored through experiments how normal force was related to cutting speed and cutting depth.

Lin and Hsu (2012)used the theory of specific downward force energy (SDFE) to explore the V-shaped groove produced on the sapphire being cut at different downward forces, and explore the method of reaching the expected machining depth with the fewest cutting passes when machining a V-shaped groove on each cutting layer for a single cutting pass only. Yeh et al. (2002) used the calculation equation of the chord height tolerance between the near-field optical lithography processed curve and the tiny line segment, and then used the straight-line near-curve method to calculate the near-curve straight line formed by connecting many tiny line segments. Teerasong and McClain (2011) used photolithographic technology to establish microfluidic device. The microfluidic