Low Cost Fabrication of Ultra-Sensitive Micro Structures and Its Characterization

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Ultra-low-stiffness structures are usually used to measured ultra-weak force, for example single electron spin detection by MRFM (Magnetic Resonance Force Microscope)[1], cell traction force detection by micro pillars array[2], and so on. The fabrication for ultra-low-stiffness structures needs high time and cost consumption, such as our previous researched Si cantilevers array[3]. Here, we present our latest research of low cost fabrication of micro cantilevers and bridges array for multi-functional cell culture substrate.

Fig. 1 shows the schematics of a cell culture substrate composed of micro bridges array. One of the functions of this bridges array is cell traction force measurement. And the typical force value of our cells is on the order of magnitude of 10nN. In consideration of easy fabrication, we chose SiN as the material for bridge; in order to successfully measure 10nN force, the dimension of bridge structure was designed as $2000\times10\times0.5\mu m^3$ and the stiffness in center point was theoretically calculated as 0.125nN/μm. But in the SiN deposition process, stress will be induced and the actual stiffness maybe tens or even hundreds of times larger.

Fig. 2 shows the fabrication flow for the bridge array. First, 500nm thick SiN thin film was deposited on Si substrate by PECVD (Plasma Enhanced Chemical Vapor Deposition). Then the SiN film was patterned to 2000μm-long and 10μm-wide bridges array by RIE (Reactive Ion Etching). Lastly, a cavity underneath SiN bridges was etched by XeF_2 to release bridges. Using XeF_2 dry etching is to avoid adhesion between SiN bridge and Si substrate. Fig. 3 shows SEM photos of some fabricated structures.

A laser Doppler vibrometer (MLD-821, NEOARK INC.) was used to measure the resonant frequency of bridge structure. And the stiffness was deduced as about 70nN/μm, which is about 560 times larger than the design stiffness. The difference between actual and design stiffness is mainly due to internal stress of SiN induced in PECVD deposition. Fig.3 (b) is an evidence of the stress existence and how to overcome the affection of the stress is under research.

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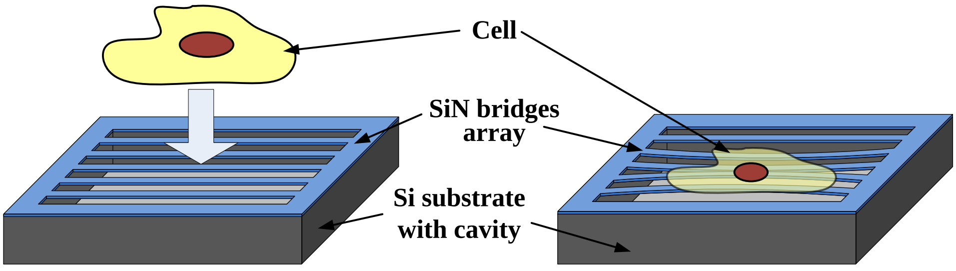
[3] Liu, Y., Zhao, G., Li, B., Wen, L., & Chu, J. (2011). Pattern buried oxide in silicon-on-insulator-based fabrication of floppy single-crystal-silicon cantilevers. Micro & Nano Letters, IET, 6(4), 240-243.



(a) (b)

Figure 1: Schematics of a cell culture substrate: (a) The substrate is composed of ultra-low-stiffness SiN bridges array and Si substrate with cavity. Cells will be cultured on this type of substrate. (b) When the cell exhibits some force, such as traction force, the bridge will deform. The force will be calculated out according to the bridge deformation.

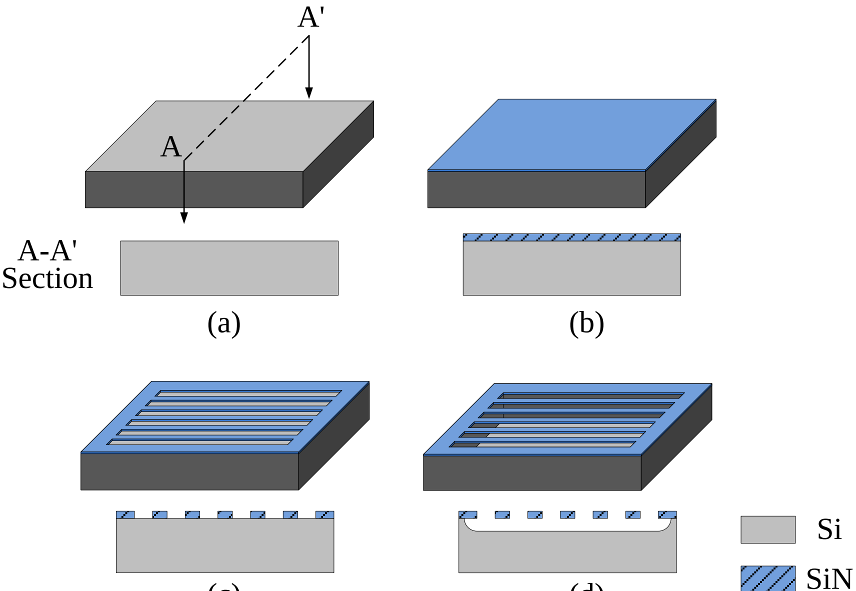
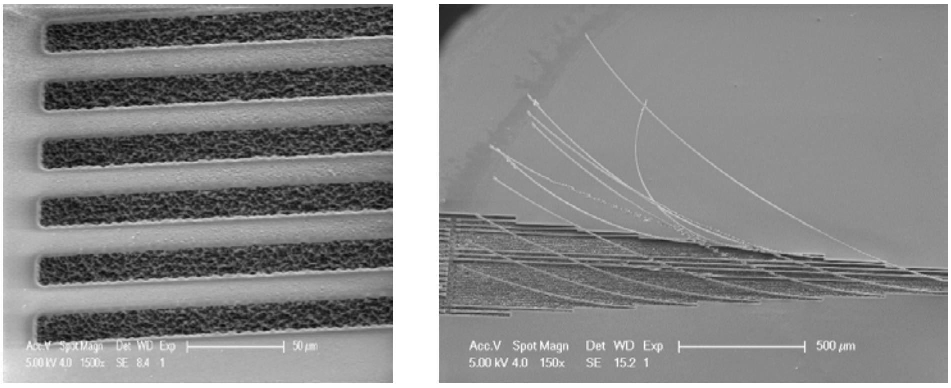


Figure 2: Process Flow: (a) Si substrate; (b) PECVD SiN film; (c) SiN bridges pattern by RIE; (d) Si cavity etching by XeF_2 to release SiN bridges.



(a) (b)

Figure 3: Some fabricated structures: (a) SiN bridges array (Local view); (b) SiN

cantilevers was bended due to internal stress.