***Part I* 45%**

Answer problems 1-15 based on the following excerpts of conference papers. You will have 3 points for each in problems 1-15. There is no minus point for problems in this part so try your best to have the correct answes.

(A)

Capacitive sensing is commonly used for humidity sensing due to the high dielectric constant of water. Large capacitance changes have been demonstrated using vertical parallel plate sensors consisting of a polyimide film sandwiched between two metal electrodes (Figure 1a). Sensitivities reported are approximately 0.2% change in capacitance for every 1% change in relative humidity [1]. This structure is difficult to integrate with CMOS circuitry, so past integrated capacitive sensors have consisted of interdigitated electrodes coated with adsorbent material (Figure 1b). Since the electrodes sit on the substrate, a parallel capacitance through the substrate exists that can be as large as or larger than through the adsorbent material, resulting in significantly lower sensitivity. CMOS chips also contain a layer of oxide between the metal electrodes, decreasing the sensitivity even further. In [2], the second layer of metal in CMOS is used to force more electric field lines to pass through the sensitive polymer to improve the sensitivity of the interdigitated electrode approach (Figure 1c). Despite this technique, a large parallel capacitance remains. In [2], the sensing capacitance is 1.4 pF in parallel with a substrate capacitance of 6.4 pF. Since 18% of the total capacitance is affected by analyte, the sensitivity is at most 18% of that of the parallel plate sensor, or about 0.04% change in capacitance per percent relative humidity.

This paper demonstrates a technique to eliminate the parallel substrate capacitance by removing the underlying substrate and releasing the structure (Figure 1d). By using the metal layers available in CMOS to create a horizontal parallel plate capacitor, a comparable sensitivity to the vertical parallel plate can be integrated with CMOS.

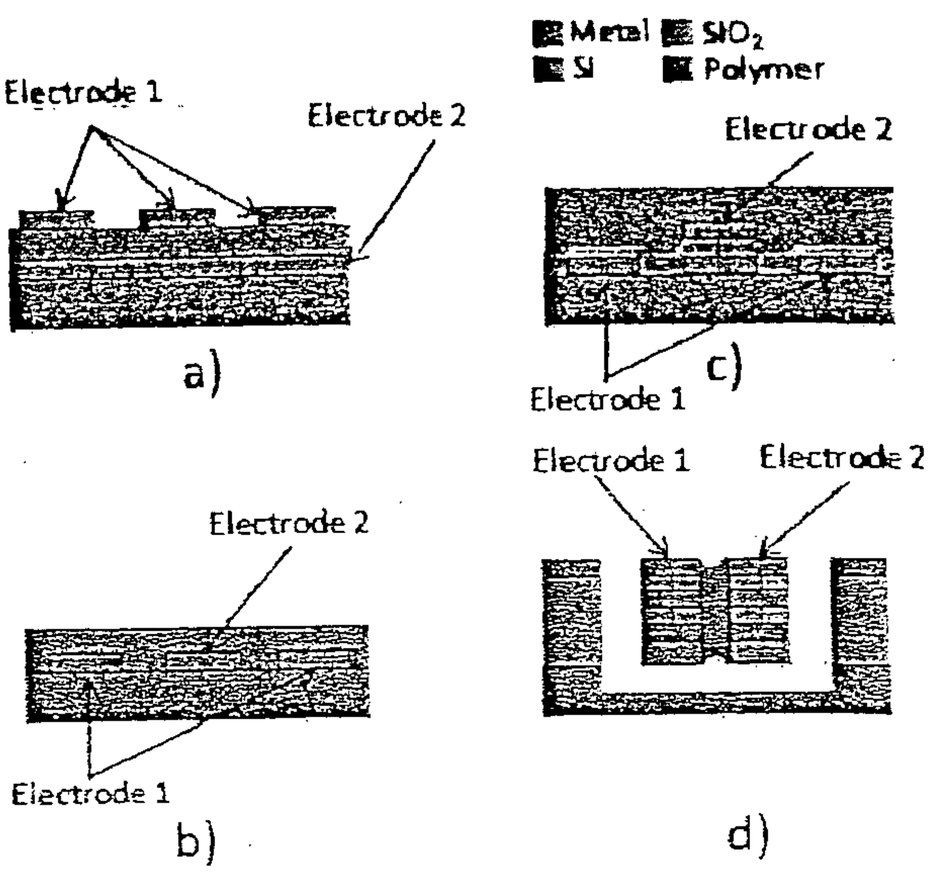

Figure 1: Designs of capacitive humidity sensors

1. [ ] What degrades the sensitivity of the integrated humidity sensors of Fig. 1(b)? (A) Smaller capacitance due to interdigitated electrodes (B) Lower dielectric constant of adsorbent material (C) A layer of oxide between electrodes (D) Parallel capacitance through the substrate

2. [ ] Why are the interdigitated electrodes adopted for humidity sensing? (A) Integration with CMOS circuits (B) Larger transduction areas of humidity sensors (C) Higher sensitivity than parallel-plate capacitors (D) Wider-measured range of humidity sensing

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考試科目（代碼）：1902 科技英文、

3. [ ] What is the principle of humidity sensor to make capacitance change? (A) The gap between electrodes of the capacitor changes because of containing water (B) The overlap area between electrodes of the capacitor changes because of containing water (C) The dielectric constant change because of containing water (D) Water introduces stress in the sensing capacitor

4. [ ] How dose the capacitive sensor of Fig. 1(c) improve the sensitivity of the integrated sensor of Fig. 1(b) by using the second layer of metal in CMOS? (A) Generate large substrate parallel capacitance (B) Force the electric field lines to pass through the polymer (C) Reduce the capacitance from the layer of oxide (D) Generate large vertical parallel capacitance

5. [ ] What is NOT the key factor for the proposed approach to increase the sensitivity by using a horizontal parallel plate capacitor? (A) Removing the substrate (B) Releasing the sensor structure (C) Eliminating the substrate capacitance (D) Using the high-k dielectric material between the electrodes

(B)

Single-cell analysis has generated a wealth of information in cell population studies [1]. Using single-cell analysis, the characteristics of cells in a heterogeneous population can be analyzed without the loss of information that results from averaging the population as a whole. Until now, most single-cell analysis, such as flowcytometry and automated microscopy, has been focused on cell surface properties due to the lack of proper cytosolic analysis tools. Studies that report on single-cell analysis of cytosolic components can be categorized by the access methods to cytosolic components: biochemical [2] or physical [3,4]. In the biochemical access methods (Figure 1a), fluorescence markers penetrate through the plasma membrane into the cytosol or are expressed in the cytosol. Subsequently, using continuous fluidics, the automated microscope or flowcytometer successively measures the fluorescent light from individual cells as a measure of the target cytosolic component. However, only limited markers, such as fluorescent probes for calcium, can penetrate the membrane and report on the cytosol. For other components, the cell membrane needs to be made permeable in order to give access to compounds such as antibodies, while maintaining the cytosolic component to be measured inside the cell. In other approaches, the cell membranes are pierced (Figure 1b) or removed to release cytosol (Figure 1c) using MEMS devices that can manipulate single cells individually. In these methods, however, the cells are maintained in a stationary or quasi-stationary liquid to prevent diffusion of the cytosolic component. This in turn does not allow fast successive measurements of a significant number of cells, important to analyze cell populations. Thus, Many important cytosolic components are difficult to measure in single cells in a heterogeneous population. While these cellular compounds can be sensitively measured in a (lysed) cell population as a whole, the measurement of individual cells in a heterogeneous population is difficult.

The proposed flow-lysometer technique (Figure 1d) achieves high-throughput measurements using the continuous flow microchannel, while maintaining the target flexibility of the physical access methods. We propose to successively lyse single cells one by one, and sense the released cytosolic component in a continuous flow channel. Since the cell lysis in continuous flow causes unstable measurements, we also add a synchronizing cell detector. The cell-detector enables the synchronization of the cytosolic sensing signals with detected cell positions. Thus, the proposed flow-lysometry technique can analyze cytosolic components in single cells from heterogeneous cell populations.

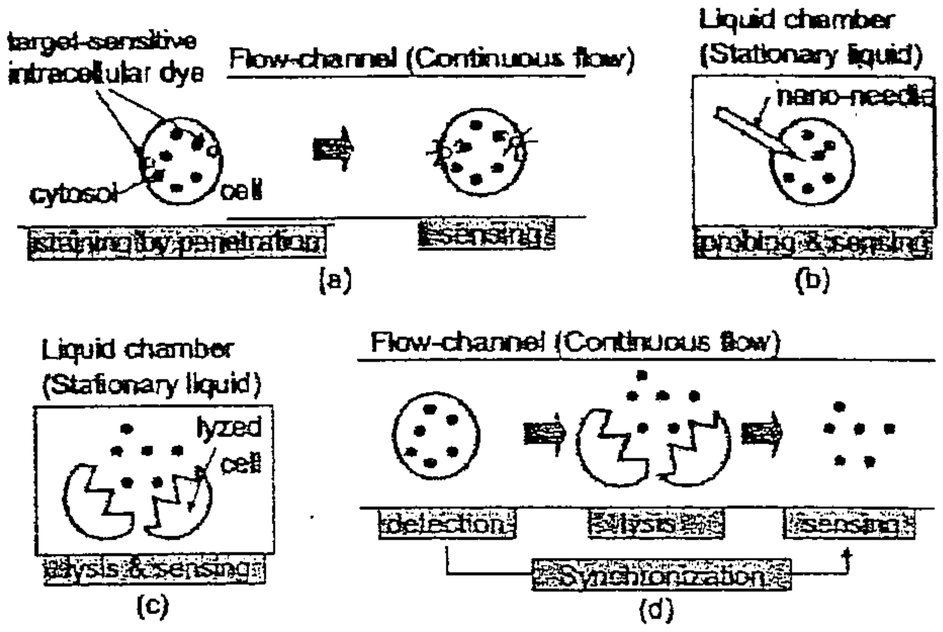

Figure 1: Single-cell cytosol analyzers: (a) the conventional method based on intracellular staining [2]; (b) the conventional method based on single-cell probing [3]; (c) the conventional method based on single-cell lysis [4]; (d) the proposed flow-lysometry.

6. [ ] What is the major disadvantage of the approach in Fig. 1(a). (A) Limited markers (B) Low speed of analysis (C) Require continuous fluidics (D) Need fluorescence markers

7. [ ] What is the main shortcoming of the approaches of Fig. 1(b) and (c) for analyzing cell populations? (A) Difficult to prevent diffusion of the cytosolic components (B) Require stationary liquids (C) Slow measurement of large numbers of cells (D) Cannot penetrate the cell membrane

8. [ ] What is the definition of "lysis" in cell analysis? (A) Piercing the cell membrane (B) Detecting the cell membrane (C) Constructing the cell membrane (D) Removing the cell membrane

9. [ ] What is the purpose of synchronization of the cytosolic sensing signals with detected cell positions in Fig. 1(d)? (A) Count the number of cells passing through the channel (B) Avoid unstable measurements (C) Calculate the speed of the continuous flow (D) Achieve high-through measurements

10. [ ] What is the major problem for analyzing cells in a heterogeneous population? (A) difficult to distinguish cells (B) varieties of cell species (C) loss of information (D) equipment limitation

11. [ ] What is NOT one of the advantages of proposed flow-lysometer technique in Fig. 1(d)? (A) High-throughput measurements (B) Wide target components (C) Can verify population analysis of single cells in mixed cell populations (D) Fastest successive measurements in biochemical approaches

12. [ ] People often use ----- to categorize the studies on single-cell analysis into biochemical and physical aspects. (A) Radiation methods (B) Heating methods (C) Lightening methods (D) Access methods

13. [ ] What is the reason causing the loss of information in the analysis of cells in a heterogeneous? (A) cell mixing in the population (B) cell averaging of the population (C) cell contamination within the population (D) the size of the population is too small

14. [ ] Why do the most single-cell analyses focus on cell surface properties only? (A) Due to the mixed cell populations (B) Due to the high-throughput measurements (C) Due to the wide target components (D) Due to the lack of analysis tools

15. [ ] What kind of substances CANNOT penetrate the membrane of the cell in the approach of Fig. 1(a)? (A) Antibodies (B) Water (C) Oxygen (D) Calcium

***Part II* (Translation) 30%**

Please translate the below paragraphs from English to Chinese.

The field of microfluidics has four parents: molecular analysis, biodefence, molecular biology and microelectronics. First came analysis. The distant origins of microfluidics lie in microanalytical methods — gas-phase chromatography (GPC), high-pressure liquid chromatography (HPLC) and capillary electrophoresis (CE) — which, in capillary format, revolutionized chemical analysis. These methods (combined with the power of the laser in optical detection) made it possible to simultaneously achieve high sensitivity and high resolution using very small amounts of sample. With the successes of these microanalytical methods, it seemed obvious to develop new, more compact and more versatile formats for them, and to look for other applications of microscale methods in chemistry and biochemistry.

A second, different, motivation for the development of microfluidic systems came with the realization — after the end of the cold war — that chemical and biological weapons posed major military and terrorist threats. To counter these threats, the Defense Advanced Research Projects Agency (DARPA) of the US Department of Defense supported a series of programmes in the 1990s aimed at developing field-deployable microfluidic systems designed to serve as detectors for chemical and biological threats. These programmes were the main stimulus for the rapid growth of academic microfluidic technology.

The third motivational force came from the field of molecular biology. The explosion of genomics in the 1980s, followed by the advent of other areas of microanalysis related to molecular biology, such as high-throughput DNA sequencing, required analytical methods with much greater throughput, and higher sensitivity and resolution than had previously been contemplated in biology. Microfluidics offered approaches to overcome these problems.

The fourth contribution was from microelectronics. The original hope of microfluidics was that photolithography and associated technologies that had been so successful in

silicon microelectronics, and in microelectromechanical systems (MEMS), would be directly applicable to microfluidics. Some of the earliest work in fluidic microsystems did, in fact, use silicon and glass, but these materials have largely been displaced by plastics. For analyses of biological samples in water, devices fabricated in glass and silicon are usually unnecessary or inappropriate. Silicon, in particular, is expensive, and opaque to visible and ultraviolet light, so cannot be used with conventional optical methods of detection. It is easier to fabricate the components required for microanalytical systems — especially pumps and valves — in elastomers than in rigid materials. Neither glass nor silicon has all the properties (especially permeability to gases) required for work with living mammalian cells.

***Part III* (Writing) 25%**

Write three paragraphs (five sentences, at least, per paragraph) to address (i) what you would think is necessary for a successful graduate student and (ii) what your future career goals are.