國立清華大學 105 學年度碩士班考試入學試題

系所班組別：奈米工程與微系統研究所

考試科目：科技英文

科目代碼：1802

Time: 10:20 ~ 12:00 (100 minutes)
(60 problems in this exam with 100 points in total)

Part I. There are 30 problems in this part. You have to choose the best answer, marked A, B, C, or D, to each question and write down your answer in the associated blank. You will have 1 point for each correct answer and there is no penalty with wrong answers.

1. [ ] The primary source of energy for tropical hurricanes is the potential heat released when -----. (A) the condensation of water vapor (B) does water vapor condense (C) condensed water vapor (D) water vapor condenses
2. [ ] Not until 1864 ----- the thirty-sixth state of the United States. (A) Nevada became (B) Nevada did become (C) did Nevada become (D) became Nevada
3. [ ] The operating principles of the telecommunication are ----- they were in the nineteenth century. (A) the same today (B) the same as today (C) the same today as (D) today what the same
4. [ ] ----- in cases where special oxidants are used, fires are the result of a fuel rapidly combining with the oxygen in the air. (A) Except (B) Even though (C) There are (D) How
5. [ ] In 1880, ----- that the piezoelectric effect occurs when the charge balance within the crystal lattice of a material is disturbed. (A) it was discovered (B) the discovery (C) with the discovery (D) if it was discovered
6. [ ] Experiments related to the sense of force and displacement are more easily ----- than those related to measurement of stress and strain. (A) sets up those (B) set up (C) to set up (D) setting them up
7. [ ] Not only ----- all the positive charge of an atom, but it is also the site of the weight of every atom. (A) does the nucleus hold (B) holds the nucleus (C) the nucleus does hold (D) the nucleus holding

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8. [ ] Fingerprints, an impression of the friction ridges of all part of the finger, form an unchangeable signature, and ----- for identification, despite changes in the individual's age or appearance. (A) with the use of fingerprint records (B) when fingerprint records are used (C) the use of fingerprint records (D) fingerprint records can be used
9. [ ] Human beings obtain their energy from -----. (A) their food to eat (B) eat their food (C) the food they eat (D) they eat the food
10. [ ] Liquid water has fewer hydrogen bonds than ice, so more molecules can occupy the same space, making liquid water ----- than ice. (A) as more dense (B) more dense (C) more than dense (D) is more dense
11. [ ] The lower ----- in a room, the more slowly and difficultly our eyes can focus. (A) lighting is level (B) leveling of light (C) light level (D) the level of lighting
12. [ ] Manufacturing is Taiwan's most important economic activity, ----- most of the workforce. (A) that it engages (B) engages (C) and to engage (D) engaging
13. [ ] Whatever information the company will supply shall be keeping strictly -----. (A) confidentially (B) confident (C) confidently (D) confidential
14. [ ] It is essential that our invention is clearly -----. (A) understandability (B) understand (C) understanding (D) understood
15. [ ] We are looking forward to ----- you all in the MEMS conference next year. (A) seeing (B) see (C) saw (D) be seeing
16. [ ] Viruses can be ----- only with a powerful electronic microscope such as SEM. (A) having seen (B) seeing (C) to see (D) seen
17. [ ] The melting point is the temperature ----- a solid changes to a liquid. (A) which (B) at which (C) which at (D) at
18. [ ] CMOS foundries provide the standard process flow ----- to produce nowadays integrated circuits. (A) are needed (B) need (C) needing (D) needed
19. [ ] Hydrogen is a chemical element ----- one proton and one electron. (A) that (B) has (C) having (D) to have

20. [ ] Graphite is a soft, slippery solid that is a good conductor of ----- heat and electricity. (A) both (B) and (C) not just (D) moreover
21. [ ] Scientific problem solving follows a pattern of behaviors ----- collectively known as the scientific method. (A) are which (B) which are (C) and which (D) which they are
22. [ ] Learning a language other ----- introduces students to other languages as means of accessing other peoples, ideas and ways of thinking. (A) English (B) being English (C) than English (D) than English is
23. [ ] ----- unstable and explodes as a supernova is not known. (A) How a star becomes (B) For a star to become (C) A star becomes (D) That a star is becoming
24. [ ] A car must be strong enough to support its own weight ----- the weight of the driver and passengers who use it. (A) as well (B) so well (C) as well as (D) so well as
25. [ ] Many people ----- stay at home than go out for a walk in the rain. (A) even rather (B) would rather (C) better (D) like
26. [ ] Thomas Edison's first patented invention was a device ----- in Congress. (A) votes counted for (B) for counting votes (C) had been counting votes (D) be a counted vote
27. [ ] Jupiter, the fifth planet from the Sun and the largest planet within the Solar System, has ----- solid surface and is primarily composed of hydrogen with a small proportion of helium. (A) no (B) not (C) nor (D) neither
28. [ ] ----- created traditionally has been a subject of debate among scholars. (A) Poems were how (B) How poems that were (C) Were poems how (D) How poems were
29. [ ] ----- a necessary dimension for measuring the distance between celestial bodies and the Earth. (A) It is time (B) The time (C) Time is (D) Once in time
30. [ ] Earthquakes can damage a bridge ----- violently, and it can take several months for the bridge to be rebuilt. (A) by causing it to shake (B) when shaking it causes (C) to cause shaking (D) to cause to shake it

Part II. There are 20 problems in this part. You have to choose the best answer, marked A, B, C, or D, to each question and write down your answer in the associated blank. You will have 2 points for each correct answer and there is no penalty with wrong answers.

31. [ ] Microelectromechanical systems (MEMS) is the technology of very small devices with size at micrometer scale. MEMS are also referred to ----- micromachines in Japan, or micro systems technology (MST) in Europe. (A) with (B) as (C) for (D) be
32. [ ] MEMS concept has grown to encompass many other types of small things, ----- thermal, magnetic, fluidic, and optical devices and systems, with or without moving parts. (A) including (B) includes (C) have included (D) being included
33. [ ] The most successful MEMS have been those ----- involve paradigm shifts from the "macro" way of doing things, more than simply reducing the size scale. (A) of (B) with (C) towards (D) which
34. [ ] Most MEMS devices and systems involve some form of lithography-based microfabrication, ----- from the microelectronics industry and enhanced with specialized techniques generally called "micromachining". (A) borrowing (B) which borrows (C) borrowed (D) has borrowed
35. [ ] The batch fabrication ----- is characteristic of the microelectronics industry offers the potential for great cost reduction when manufacturing in high volume. (A) it (B) where (C) whose (D) that
36. [ ] Thin-film deposition and etching techniques in ----- with wafer-bonding techniques allow patterning of the thickness dimension, making possible the creation of movable parts. (A) combined (B) combining (C) being combined (D) combination
37. [ ] The MEMS sensor is monolithically microfabricated ----- parylene as a biocompatible structural material in a suitable form factor to facilitate intraocular implantation. (A) to use (B) using (C) use (D) uses

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38. [ ] The proposed pressure sensor ----- a flexible diaphragm chamber integrated with parallel metal plates as an integrated capacitor and metal wires as a dual-layer planar inductor to create the resonant circuit that communicates with the external reader. (A) comprises (B) are comprised (C) comprising (D) is comprised
39. [ ] Some MEMS devices, such as resonant transducers and thermal imagers, ----- a vacuum environment for maximum performance. (A) needing (B) needs (C) have needed (D) need
40. [ ] These MEMS devices take advantage ----- several beneficial effects that are provided by the reduced gaseous molecular density at vacuum pressures. (A) to (B) with (C) non (D) of
41. [ ] Creating wafer-level MEMS vacuum packages is a challenge ----- their small scale. (A) because (B) because of (C) however (D) although
42. [ ] Various types of wafer bonding ----- to create wafer-level vacuum packages. (A) use (B) used (C) have been used (D) has used
43. [ ] Anodic, Fusion, and Eutectic bonding can all create the high-quality robust hermetic seals that are required for MEMS vacuum packaging; ----- , they are all processed at temperatures that may preclude the use of some temperature sensitive materials. (A) since (B) although (C) because (D) however
44. [ ] Because the fabrication steps for the MEMS resonators never exceeds 450 degree C, the process is amenable to ----- MEMS-last monolithic integration with the 0.35μm CMOS technology node, but also next generation CMOS with gate lengths 65nm and smaller that uses advanced low-k dielectric material to lower interconnect capacitance. (A) not only (B) only (C) only as (D) the
45. [ ] The motion of the comb-drive actuators can be observed under the microscope by ----- the proof mass or fingers of the actuator structures. (A) watch (B) watching (C) watched (D) to watch
46. [ ] Silicon nitride etching follows the same sequence of operations ----- etching. (A) as silicon dioxide (B) that silicon dioxide (C) where silicon dioxide (D) silicon dioxide

47. [ ] Because of the thermomechanical mismatch between different deposited layers, the layered system is generally ----- residual stresses which, in turn, can result in degradation of the functionality and reliability of the system. (A) subject with (B) subjected to (C) subjecting with (D) subjective into
48. [ ] MEMS components via micromachining technologies ----- discrete devices with bulky size and costly fabrication. (A) took the place of (B) took placing (C) took place of (D) took place
49. [ ] The MEMS conference will ----- in Hsinchu from Wednesday to Friday next week. (A) take a place (B) take the place (C) take places (D) take place
50. [ ] The ----- the pressure applied, the larger the deformation of the MEMS-fabricated membranes. (A) higher (B) high (C) highest (D) height

Part III. Answer problems 51-60 based on the following description on micromachining technologies. You will have 3 points in each correct answer. There is no penalty for problems in this part so try your best to mark the correct answers.

Introduction to the micromachining technologies

Micro-Electro-Mechanical Systems are miniaturized, multifunctional microsystems consisting of sensors, actuators, and electronics. They are built using various micromachining processes which become an enabling technology that allows formation of physical, as well as electronics, devices. Micromachining uses many of the standard IC (integrated circuit) fabrication techniques. Current micromachining technologies can be divided into four categories, including (i) the bulk micromachining technology; (ii) the surface micromachining technology; (iii) the metal electroplating or LIGA; and (iv) the 3-D machining technology.

Bulk micromachining defines structures by selectively etching a substrate, thus producing micro structures inside the substrate. Usually, silicon (Si) wafers are used as substrates for bulk micromachining, as they can be anisotropically wet etched, forming highly regular structures. Typically the microstructure is fabricated by

removing part of the starting silicon (Si) material. The microstructure is often made of single-crystal Si (SCS). This is perhaps one of the most important advantages of bulk micromachining because SCS has very good uniform, and reproducible material properties. Both wet and deep dry etching techniques can be used. High aspect-ratio structures (i.e., large height-to-width ratio) are more easily formed in bulk silicon because the starting wafer is usually several hundred microns in thickness.

Surface micromachining was coined by Phil Barth (at Stanford at that time) in 1985 to emphasize the process is performed on top of the wafer surface, as compared to that performed below the wafer surface (i.e., bulk micromachining). This technology utilizes thin films deposited on top of the Si rather than micromachining the silicon wafer itself to build MEMS. Some of the thin films are used to build the "microstructure", and some are used as a "sacrificial" layer that is later etched to "release" the microstructure. Because there is a wide range of materials that can be used for either of these areas, it is easier to build fairly complex mechanisms with a relatively straightforward process by depositing multiple layers on top of one another. Thin films can be deposited with great control over their thickness so surface micromachining can be used to build very fine and intricate mechanisms. Because the MEMS device is built on top of the wafer, it is sometimes easier to integrate MEMS with microelectronics. One of the main problems with surface micromachining is that the thin films used usually have a thickness limited to a few microns, so building high aspect-ratio, 3D structures is not easy. Since deposited thin films are used, it is sometimes difficult to control and reproduce material properties so greater care has to be taken in processing.

LIGA is a German acronym for Lithographie, Galvanoformung, Abformung (Lithography, Electroplating, and Molding) that describes a fabrication technology used to create high-aspect-ratio (i.e., height-to-width ratio) microstructures. It is a microfabrication process based on template-guided electroplating, which is capable of yielding micro structures with extremely high aspect ratios (at least 100:1) thanks to the use of extremely well-collimated synchrotron radiation (x-rays) to expose the

template layer with nearly perfectly straight sidewalls. However, the use of synchrotron radiation is very costly, therefore impeding the deployment of the LIGA technology for commercialization.

Finally, the 3-D machining technology includes micro-milling, electrical discharge machining (EDM), laser machining, etc. Unlike the abovementioned micromachining technologies which use planar photolithographic approach (i.e., parallel process with high throughput) to fabricate MEMS devices, the 3-D machining technology relies on standard precision machining which has a serial process feature with low throughput. As a result, it is not the main stream of the current MEMS fabrication processes due to the difficulty of mass production.

51. [ ] What is the most commonly used substrate for the bulk micromachining technology? (A) Silicon wafer (B) GaAs wafer (C) Quartz substrate (D) Glass wafer
52. [ ] Which micromachining technology would offer the uniform and reproducible material properties of its fabricated MEMS devices? (A) Bulk micromachining technology (B) Surface micromachining technology (C) metal electroplating or LIGA (D) 3-D machining technology
53. [ ] Micromachining technologies mainly stem from -----. (A) 3D printing (B) polymer synthesis (C) IC fabrication (D) LED fabrication
54. [ ] ----- can fabricate micro devices with very narrow lateral dimensions but very thick structures. (A) Surface micromachining technology (B) Metal electroplating or LIGA (C) IC fabrication (D) III-V compound semiconductor process
55. [ ] The MEMS devices fabricated using ----- are much easier to be integrated with microelectronics. (A) the bulk micromachining technology (B) the surface micromachining technology (C) the metal electroplating or LIGA (D) the 3-D machining technology
56. [ ] What is the most costly micromachining process used to build microstructures? (A) Bulk micromachining technology (B) Surface micromachining technology (C) Metal electroplating or LIGA (D) IC fabrication

57. [ ] ----- is very difficult to provide volume (or mass) production for MEMS components due to its non-planar microfabrication characteristic. (A) Bulk micromachining technology (B) Surface micromachining technology (C) Metal electroplating or LIGA (D) 3-D machining technology

58. [ ] Devices made by the surface micromachining technology often have their structural thickness on the order of -----. (A) 1nm – 10nm (B) 100nm - 1μm (C) 1μm – 10μm (D) 10μm - 100μm

59. [ ] Which micromachining technology can build fairly complicated 3-D microstructures with low cost? (A) Bulk micromachining technology (B) Surface micromachining technology (C) Metal electroplating or LIGA (D) 3-D machining technology

60. [ ] Which micromachining technology is very similar to the conventional IC (semiconductor) fabrication? (A) Bulk micromachining technology (B) Surface micromachining technology (C) Metal electroplating or LIGA (D) 3-D machining technology