First Semester Examination
2019/2020 Academic Session

December 2019 / January 2020

EPE441 – Nano and Micro Manufacturing Engineering
[Kejuruteraan Pembuatan Mikro dan Nano]

Duration : 2 hours
Masa : 2 jam

Please check that this examination paper consists of SEVEN [7] printed pages before you begin the examination.

[Sila pastikan bahawa kertas soalan ini mengandungi TUJUH [7] mukasurat bercetak sebelum anda memulakan peperiksaan.]

INSTRUCTIONS : Answer **ALL FOUR [4]** questions.
*[**ARAHAN** : Jawab **SEMUA EMPAT [4]** soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

…2/-

1. [a] In modeling atomic structures in Molecular Dynamics simulation, identifying potential between atoms and minimization process are two important parameters or steps.

Dalam memodelkan struktur atom dalam simulasi Molecular Dynamics, mengenal pasti potensi antara atom dan proses pengecilan adalah dua parameter atau langkah penting.

(i) Sketch a general pattern of Lennard-Jones Potential graph and describe the pattern.

Lakarkan corak umum Potensi Lennard-Jones dan terangkan corak tersebut.

(ii) Explain the minimization and sketch a general minimization graph.
Jelaskan pengecilan dan lakarkan graf pengecilan am tersebut.

(iii) How do you identify that the system is minimized?
Bagaimana anda mengenal pasti bahawa sistem diminimumkan?

(35 marks/*markah*)

[b] Scientific Fact: "The Eiffel Tower can be 150 mm taller during the summer" Discuss about this fact by describing on what happened in the material at atomic scale and how design engineer overcome the issue.

Fakta Saintifik: "Menara Eiffel boleh menjadi lebih tinggi 150 mm pada musim panas" Bincangkan fakta ini dengan menerangkan tentang apa yang berlaku didalam bahan pada skala atom dan bagaimana jurutera rekabentuk mengatasi isu tersebut..

(20 marks/*markah*)

[c] Researchers from Argonne National Laboratory have discovered that *Bacillus subtilis* bacteria have the ability to turn very small gears. These bacteria are aerobic, meaning that they need oxygen for growth and development. When placed in a solution with the micro-gears, the bacteria swim into the spokes of the gears and cause them to turn in a specific direction. It takes a few hundred bacteria working in unison to turn the gears. It was also discovered that the bacteria can turn gears that are connected at the spokes, similar to the gears of a clock. The researchers were able to control the speed at which the bacteria turned the gears by adjusting the amount of oxygen in the solution. Decreasing the amount of oxygen caused the

…3/-

bacteria to slow down. Removing the oxygen caused them to stop moving completely.

(Source: "Bacteria used to power simple machines: Organisms turn microgears in suspended solution by swimming." ScienceDaily, 17 December 2009. www.sciencedaily.com/releases/2009/12/091216121500.htm)

Based on these information, SUGGEST a possible bio-medical device that could utilize these bacteria as the prime mover (engine). Provide a sketch and describe how the device should works.

Penyelidik dari Makmal Kebangsaan Argonne mendapati bahawa bakteria Bacillus subtilis mempunyai keupayaan untuk memutarkan gear yang sangat kecil. Bakteria ini adalah aerobik, bermakna mereka memerlukan oksigen untuk pertumbuhan dan perkembangan. Apabila diletakkan dalam larutan dengan gear mikro, bakteria berenang ke dalam lekapan gigi gear dan menyebabkan mereka memusing kearah tertentu. Ia memerlukan beberapa ratus bakteria yang berfungsi serentak untuk memutar gear. Ia juga mendapati bakteria boleh memutar gigi gear yang bersambung, sama seperti gear jam. Penyelidik dapat mengawal kelajuan di mana bakteria memutar gear dengan bersesuaian dengan jumlah oksigen dalam larutan. Mengurangkan jumlah oksigen menyebabkan bakteria memperlahankan putaran. Mennyahkan oksigen menyebabkan mereka berhenti bergerak sepenuhnya.

(Source: "Bacteria digunakan untuk menggerakkan mesin sederhana: Organisma memutar gear mikro di dalam larutan tergantung dengan berenang." ScienceDaily, 17 Disember 2009. www.sciencedaily.com/releases/2009/12/091216121500.htm)

Berdasarkan maklumat ini, CADANGKAN satu peranti bio-perubatan yang sesuai yang mana boleh menggunakan bakteria ini sebagai penggerak utama (enjin). Sediakan lakaran dan huraikan bagaimana peranti tersebut berfungsi.

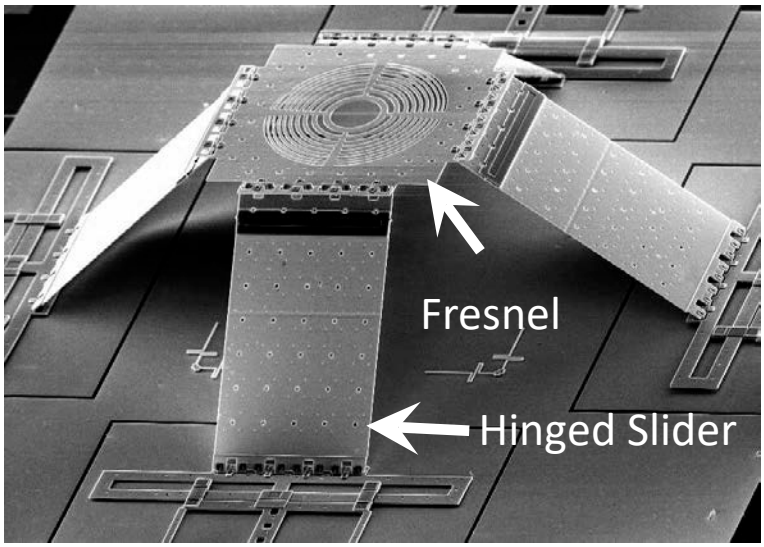
(45 marks/*markah*)

2. [a] Figure 2[a] shows a micro Fresnel lens which is supported with four hinged sliders made of polysilicon. It was fabricated using semiconductor microfabrication technology. Construct a complete fabrication process flow complete with process details for producing the Hinged Sliders of micro Fresnel lens.

Rajah 2[a] menunjukkan kanta Fresnel skala mikro yang dibina menggunakan teknologi mikrofabrikasi semikonduktor. Bina aliran proses

…4/-

fabrikasi yang lengkap dengan butiran proses untuk menghasilkan komponen Engsel Gelunsur bagi kanta Fresnel ini.



(source : http://nanophotonics.eecs.berkeley.edu)

Figure 2[a]
Rajah 2[a]

(55 marks/*markah*)

[b] As a process development engineer in MEOMS Sdn. Bhd, you are requested to develop the process involved in creating a two-dimensional multilevel microstructure on silicon substrate as shown in Figure 2[b]. Construct the process flow diagram together with brief explanation for each process step.

Sebagai seorang jurutera pembangunan proses di MEOMS Sdn. Bhd, anda diminta untuk membangunkan proses yang terlibat dalam membina struktur mikro dua-dimensi pelbagai peringkat diatas substrat silicon seperti yang ditunjukkan dalam Rajah S2 [b]. Susunaturkan gambarajah aliran proses bersama penjelasan ringkas untuk setiap langkah proses.

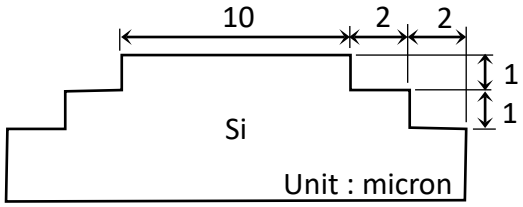


Figure 2[b]
Rajah 2[b]

(45 marks/*markah*)

…5/-

3. [a] You are an engineer at a vacuum system manufacturing company. Your client is asking for a design of thermal evaporator system with a vacuum chamber that provides an ultrahigh vacuum condition (10^{-12} to 10^{-9} Torr). On your component shelf, there are turbomolecular pump, diffusion pump, scroll pump, rotary vane pump, valves and fittings. Select the appropriate components and design a vacuum system to meet your client requirement. Sketch the vacuum system and justify the selection of the components.

Anda adalah seorang jurutera di sebuah syarikat membuat sistem vakum. Pelanggan anda meminta untuk dibuat sistem pemeluapan thermal dengan ruang vakum yang menyediakan keadaan vakum ultrahigh (10^{-12} kepada 10^{-9} Torr). Di atas rak komponen anda, ada pam turbomolecular, pam resapan, pam tatal, pam ram berputar, injap dan kelengkapan pemasangan. Pilih komponen yang sesuai dan reka bentuk sistem vakum untuk memenuhi keperluan pelanggan anda. Lakarkan sistem vakum dan kewajaran pemilihan komponen-komponen tersebut.

(40 marks/*markah***)**

[b] Figure 3[b] shows high resolution microscopy image of GaN [211] with the electron diffraction pattern recorded simultaneously (insert bottom right).

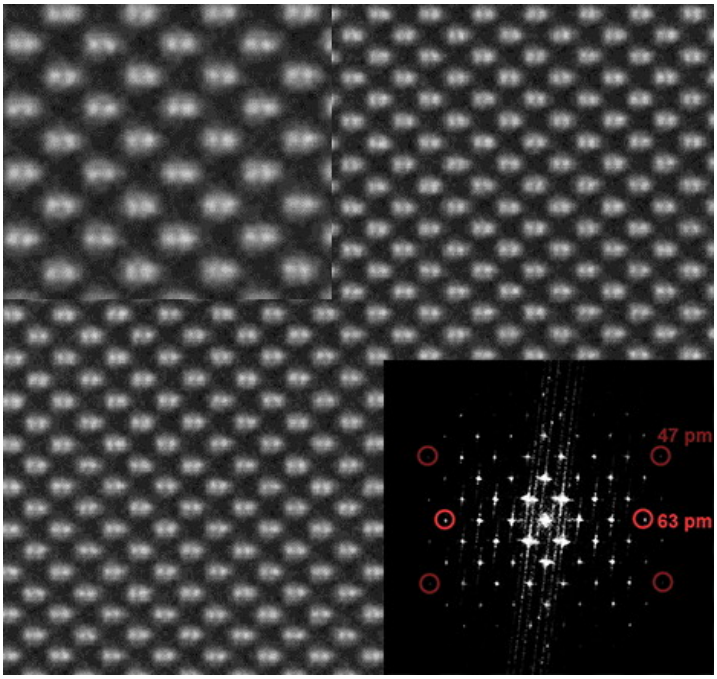
Rajah 3[b] menunjukkan imej mikroskopi resolusi tinggi GaN [211] dengan corak difraksi elektron direkod secara serentak (masukan bahagian bawah kanan).

(i) Identify the tool used in imaging this sample.
Kenal pasti alat yang digunakan dalam pengimejan sampel ini.

(ii) How does the system works?
Bagaimana sistem itu berfungsi?

(iii) Describe the sample preparation method.
Huraikan kaedah penyediaan sampel.

…6/-



(Source: ThermoFisher Scientific www.fei.com)

Figure 3[b]
Rajah 3[b]

(40 marks/*markah*)

[c] Explain the roles of nanotechnology in future Green Technology. Give an example of application in a sustainable International Space Station (ISS).

Terangkan peranan teknologi nano di masa hadapan Teknologi Hijau. Beri satu contoh penggunaan kelestarian di Stesen Angkasa Antarabangsa(ISS).

(20 marks/*markah*)

4. [a] Nanotechnology is the branch of engineering that deals with the design and manufacture of extremely small electronic components and mechanical devices built at the molecular level. Describe briefly any FIVE(5) potential dangers of nanotechnology and state the FIVE(5) ethical issues that affect workers in jobs involving nanomaterials.

Nanotekologi ialah cabang kejuruteraan yang terlibat dengan mereka bentuk dan membuat komponen elektronik dan peranti mekanik yang sangat kecil. Terangkan secara ringkas mana-mana LIMA(5) bahaya potensi pada nanotekologi dan nyatakan LIMA(5) isu etika yang mempengaruhi pekerja-pekerja dalam perkerjaan yang melibatkan bahan nano.

…7/-

(40 marks/*markah*)

[b] Sketch the basic layout of the white light interferometers based on the following types of optical configurations (i) Michelson, (ii) Mirau. Label all the main elements in your sketch. Using your sketches explain the basic principle behind the scanning white light interferometer. Compare the Michelson configuration with the Mirau configuration in terms of the features, advantages and disadvantages.

Lakarkan susunatur asas bagi interferometer cahaya putih berasaskan jenis-jenis konfigurasi berikut: (i) Michelson, (ii) Mirau. Labelkan kesemua elemen utama dalam lakaran anda. Dengan menggunakan lakaran anda terangkan prinsip asas di belakang interferometer cahaya putih. Bandingkan konfigurasi Michelson dan konfigurasi Mirau dalam sebutan ciri, kelebihan dan kelemahan

(40 marks/*markah*)

[c] State any TWO(2) advantages of the atomic force microscope (AFM) compared to the white light interferometer for 3-D surface profiling. State THREE(3) advantages and THREE(3) disadvantages of the contact mode compared to the non-contact mode of AFM operation

Nyatakan mana-mana DUA(2) kelebihan mikroskop daya atomik (AFM) dibandingkan dengan interferometer cahaya putih bagi memprofil permukaan 3-D. Nyatakan TIGA(3) kelebihan dan TIGA (3) kelemahan kaedah sentuh berbanding dengan kaedah tak-sentuh bagi mod operasi AFM

(20 marks/*markah*)

- oooOooo -