First Semester Examination
2023/2024 Academic Session

Februari 2024

EPE 441 – Micro and Nano-Manufacturing Engineering
(Kejuruteraan Pembuatan Mikro dan Nano)

Duration: 3 hours
(Masa: 3 jam)

Please check that this examination paper consists of FIVE (5) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA (5) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions : Answer **ALL FIVE (5)** questions.

*[**Arahan** : Jawab **LIMA (5)** soalan]*

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1. [a] In modelling atoms or molecules using molecular dynamics, determining the potential of forcefield between atoms are crucial for a realistic result. The potential can be divided into pair body or many body potentials and some of the basic pair potential is Lennard-Jones Potentials.

(i) Sketch and briefly interpret the general pattern of Lennard-Jones Potential graph.

(30 marks)

(ii) Discuss why for Lennard-Jones potential, the cutoff radius $r_c=2.5\sigma$ assumed to be good value for cutoff value for neighbor list.

(20 marks)

[b] In molecular dynamics, there are step for structure conditioning to ensure the system is ready for real dynamics simulations. The processes for conditioning are energy minimization, temperature equilibrium and pressure equilibrium.

```
compute eng all pe/atom
compute eatoms all reduce sum c_eng
thermo 10
thermo_style custom step pe c_eatoms
min_style cg
minimize 0 0 500 1000
```

Block of coding above is to conduct energy minimization style cg that based on Polak-Ribiere version of the conjugate gradient (cg) algorithm.

(i) Interpret each line of the LAMMPS coding above.

(15 marks)

(ii) Discuss the energy minimization and draw a general minimization graph

(15 marks)

(iii) Discuss how the system is considered as energy minimized.

(20 marks)

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2. [a] A stent is a small, expandable tube used to open narrowed or blocked arteries to restore blood flow. The properties of stents are crucial for their effectiveness and safety in various medical applications. Select ONE (1) smart material to be used for the stent and give THREE (3) justifications for your material selection.

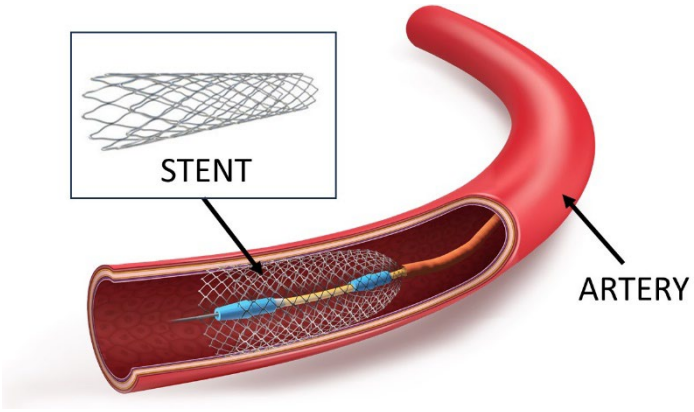

Figure 2[a]

(40 marks)

[b] You need to design a novel vacuum process for the fabrication of microscale devices with a specific emphasis on achieving precise control over nanostructures. Give THREE(3) criteria that need to be considered based on the principles of micro and nano engineering, and justify each of them.

(60 marks)

3. [a] In Figure 3[a], the SEM image presents a side view of MEMS resonators fabricated on a silicon substrate. Construct a complete process flow for fabricating these micro-pillar structures. Include a corresponding sketch to illustrate the key stages of the process.

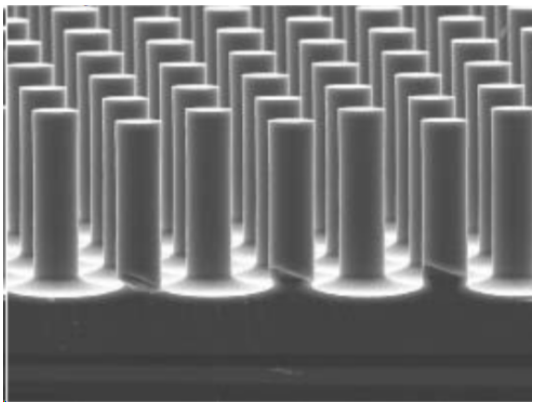

Figure 3[a]

(60 marks)

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[b] Foreign particles on the substrate surface can interfere with the photolithography process, leading to defects. Propose TWO effective strategies for minimizing or preventing such contamination in a cleanroom environment.

(40 marks)

4. [a] We are reaching a critical point where technology will enable us to build complex molecular machines. Molecular assemblers and disassemblers could be developed from this technology, which would have great potential for both good and bad. The two greatest threats from development of nanotechnology are catastrophic accidents and misuse. (Source : www.scu.edu/ethics/focus-areas/technology-ethics/resources/the-ethics-of-nanotechnology/)

Discuss about ethical issues from the development of nanotechnology. Suggest THREE (3) possible actions and consequences.

(50 marks)

[b] Figure 4[b] shows images of invisible effects of metamaterials (negative refractive index materials). Discuss about the ethical issues of this development and suggest THREE (3) potential remedies or controls.

Figure 4[b]

(50 marks)

5. [a] The Star - Saturday 14 Oct 2023 – "Focus on energy transition, digital and high-technology industries" –

Quality investments in high value-added industries will be propelled by the strategies and measures under the National Energy Transition Roadmap (NETR), New Industrial Master Plan 2030 (NIMP 2030) and the Mid-Term Review (MTR) of the 12th Malaysia Plan (12MP) as guided by the Madani Economy framework. This is especially in energy transition, digital and

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high-technology industries that will ultimately create more high-income employment opportunities towards sustainable economic growth, according to Bank Negara in its Economic Outlook 2024 Report. Without swift and effective reforms in investment-related policies, Malaysia is far from achieving its aspiration to be in the top 30 largest economies. Notwithstanding the ongoing economic recovery post-pandemic, Bank Negara said several challenges persist in balancing the private consumption and investment that necessitate a renewed focus on investment-related policies. Therefore, Malaysia needs to prioritize investment in innovative and advanced technology to achieve higher productivity and sustainable economic growth.

The central bank said the revival of private investment and foreign direct investment (FDI) is crucial in driving towards higher productivity.

Available Online: https://www.thestar.com.my/business/business-news/2023/10/14/focus-on-energy-transition-digital-and-high-technology-industries

Comment on the above news focused on energy transition, digital and high-technology industries. What would be the nanotechnology roles on moving forward?

(50 marks)

[b] Nanotechnology and nanomanufacturing have led to numerous innovations that could easily feature in everyday automotive, textiles and fluid products (coating and skincare). Discuss more details and provide THREE (3) examples focused on one of those category.

(50 marks)

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