

<b>Started on</b>	Thursday, 9 November 2023, 09:15
<b>State</b>	Finished
<b>Completed on</b>	Thursday, 9 November 2023, 09:38
<b>Time taken</b>	23 mins 32 secs

**Question 1**

Complete

Marked out of 3.00

This question is related PVD.

**In a so-called lift-off process, a thin gold (Au) film is deposited by PVD on a patterned resist layer.**

*Select the correct sentence. (Only one option is correct and only one option can be selected)*

- ☐ Sputtering is better suited than thermal evaporation for an application such as lift-off.
- ☐ Using a rotating planetary system is required in order to have good step coverage.
- ☐ An e-beam evaporator should be used because the boiling point of gold is too high for a resistive-heating evaporator.
- ☒ An evaporator with a large source-substrate distance should be used for line of sight deposition.

**Question 2**

Complete

Marked out of 3.00

This questions concerns Photolithography.

Consider a photolithography exposure + development process. Which of these statements is TRUE? (only one answer possible)

- ☐ a. Doubling the dose when exposing with a mask, will double the feature size for isolated lines, i.e. isolated line width is linear with dose.
- ☒ b. The developed patterns can have imperfections due to light wavelike nature.
- ☐ c. The photoresist developed thickness is a linearly increasing function of the local accumulated dose.
- ☐ d. Mask-to-developed-resist pattern transfer is optimal for a dose equal to the thickness-development dose threshold.

**Question 3**

Complete

Marked out of 2.00

This question is related to PVD.

**Physical vapour deposition (PVD) exists in various variations and allows for addressing a multitude of applications.**

*Drag the corresponding missing words into the corresponding spots in the following phrases. (There is only one possible combination).*

- With , substrate cooling is required.
- can only be used to deposit electrically conductive materials.
- With  the deposited material has poor step coverage.
- With , the target wear is not uniform.

**Question 4**

Complete

Marked out of 2.00

This questions concerns PVD / Evaporation

Consider a metallic thin film deposited by evaporation (PVD) on a circular wafer substrate. Which of the following statements is the most accurate about the thickness uniformity over the whole wafer? (only one answer possible)

- ☐ a. The uniformity improves as the substrate is bigger and closer the source.
- ☐ b. The uniformity improves as the substrate is bigger and farther from the source.
- ☒ c. The uniformity improves as the substrate is smaller and farther from the source.
- ☐ d. The uniformity is nearly perfect (variations < 0.1%) due to the directional nature of the technique.

**Question 5**

Complete

Marked out of 1.00

Lithography normally uses a binary mode of illumination (either light or no light). Grayscale lithography is a variation where 3D structures can be obtained in resist.

*Decide if the following sentence is true or false.*

**In order to obtain 3 different heights in the patterned photo-resist structure after development, lithography can be performed both by direct write laser and using a photomask.**

Select one:

- ☒ True
- ☐ False

**Question 6**

Complete

Marked out of 3.00

This question is related to Lithography.

**The image below shows a schematic drawing of a typical process flow for a photolithographic process.**

Drag and drop the text items to the right side of the corresponding image to name each step. Be aware of the distractors.

(There is only one possible combination).

Wafer / substrate

Photoresist

Wafer / substrate

Photomask

Photoresist

Wafer / substrate

Photoresist

Wafer / substrate

Photoresist

Wafer / substrate

Wafer / substrate

Substrate preparation

Resist coating

Exposure

Development

Etching

Resist stripping

Si SiO<sub>2</sub> Photoresist

Metal evaporation

Ion implantation

Lift-off

**Question 7**

Complete

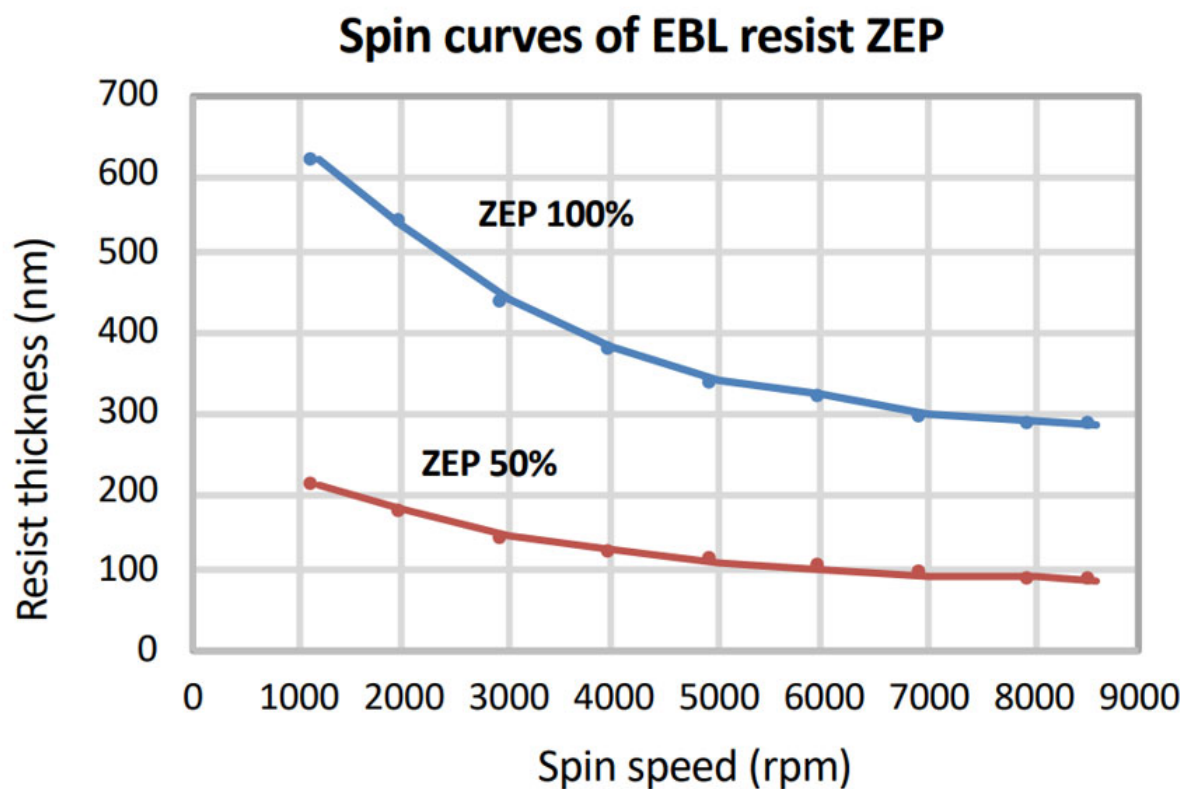
Marked out of 2.00

This question is related to Lithography.

The spin curve for photoresists shows the relationship between spin speed and resist thickness.

Two typical spin curves for the EBL resist ZEP in two variations are shown below. According to this graphic, in order to obtain a resist thickness of 300 nm the chosen resist should be  and the spin speed should be around  rpm.

Drag the correct option to the corresponding blanc in the text. There is only one possible combination.



<input type="text" value="5000"/>	<input type="text" value="2000"/>	<input type="text" value="ZEP 50%"/>	<input type="text" value="6000"/>
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**Question 8**

Complete

Marked out of 3.00

This question is related to Lithography.

**Which of the following statements about photolithography and electron-beam lithography, is/are correct?**

*More than one option can be selected and more than one option could be correct.*

- ☒ Electron-beam writing can generate smaller features than UV photolithography
- ☐ UV lithography can be performed without a photomask as a serial writing method using a laser
- ☒ Electron-beam lithography can be used without an electron-mask as a serial beam writing method
- ☐ Photolithography can generate smaller features than electron-beam writing
- ☒ UV photolithography can be used to expose a full wafer through a photomask

**Question 9**

Complete

Marked out of 1.00

This question is related to PVD.

**You need to deposit by DC sputtering a 355 Å thick layer of gold (Au) on a silicon substrate. The sputter equipment is set to have a deposition rate of 9 Å/sec for gold. How long (in sec.) does it take to deposit your Au thin film?**

*Write your answer in the box below.*

Answer:

**Question 10**

Complete

Marked out of 1.00

This question is related to PVD

**After the deposition of a thin gold (Au) film directly onto a glass wafer by using an e-beam evaporator, the subsequent tape pull-test is not successful (i.e. the gold delaminates). What could you do to overcome this problem and improve the adhesion of the gold layer?**

*More than one option can be selected and more than one option could be correct.*

- ☐ Use a planetary substrate holder.
- ☒ Use a sputter tool instead of a thermal evaporator to deposit the gold film.
- ☒ Deposit a Cr adhesion layer before the gold film deposition.
- ☐ Add a Pt adhesion layer before the gold evaporation.

**Question 11**

Complete

Marked out of 2.00

This question is related to PVD.

**PVD can be used to deposit uniform thin films of a variety of materials. The most prominent methods are evaporation and sputtering. What is the advantage of sputtering over evaporation?**

*(Only one option is correct and only one option can be selected)*

- ☐ Higher film purity can be achieved with sputtering.
- ☐ Stencil lithography is better suited for use in a sputter tool.
- ☒ Sputtering eases the deposition of refractory materials such as Hafnium carbide (HfC).
- ☐ With sputtering the substrate is less prone to damage.

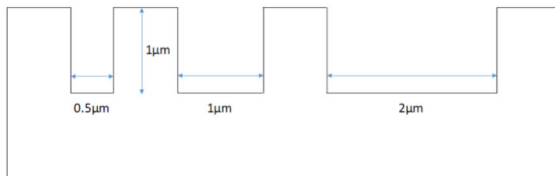
**Question 12**

Complete

Marked out of 3.00

This question is related to PVD.

**$\text{Al}_2\text{O}_3$  is sputtered with a deposition rate of 17 Angstrom/s onto the substrate cross-section shown below.**



**What of the following schematics would be the deposited film profile after 4 minutes deposition time?**

*(Only one option is correct and only one option can be selected)*

- ☐
- ☐
- ☒
- ☐

**Question 13**

Complete

Marked out of 2.00

This question is related to Lithography.

**Consider a photolithography process that uses a UV wavelength of 405 nm and in which the process parameters  $k_1$  and  $k_2$  are both equal to 0.5. A resolution smaller than  $1\ \mu\text{m}$  and a DOF larger than  $0.7\ \mu\text{m}$  are desired. The numerical aperture of the system can be chosen to satisfy the specifications.**

**Which of the following values of NA are compatible with the desired resolution and DOF?**

*More than one option can be selected and more than one option could be correct.*

- ☒ 0.25
- ☐ 0.85
- ☐ 1.05
- ☐ 1.25
- ☐ 0.65
- ☒ 0.45

**Question 14**

Complete

Marked out of 2.00

This question is related to PVD.

**When depositing thin film by PVD techniques, it is important to measure the film thickness *in-situ* during the process. How do modern evaporation equipment perform this real-time monitoring?**

*(Only one option is correct and only one option can be selected)*

- ☐ By using a profilometer to scan the substrate's surface.
- ☒ By measuring the changes in the oscillation frequency of a quartz crystal resonator.
- ☐ By using an ellipsometry system to measure the changes in the light reflected from the substrate's surface.
- ☐ By measuring the change of the substrate's mass through a weight sensor under it.

**Question 15**

Complete

Marked out of 1.00

This question is related to Lithography.

**Lithography using photons is limited by optical diffraction which is a function of the wavelength used. Lithography using electrons is not affected by electron diffraction (but by scattering) at the resolution we are currently capable of patterning (nanometer scale). Nevertheless it is of interest to know the equivalent wavelength of electrons.**

**The De-Broglie wavelength of an electron accelerated to 100 kV is around 4 .**

*Drag the corresponding unit symbol in front of the magnitude. Only one option is correct*

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This question is related to Lithography.

**Which of the following statements are true considering the properties of electron guns?**

*More than one option can be selected and more than one option could be correct.*

- ☒ The purpose of a suppressor in an electron gun is to limit the emission of electrons to the tip apex region.
- ☐ The more anodes in an electron gun, the better the resolution.
- ☒ The tip of Schottky field emitters are coated with  $\text{ZrO}_2$  to reduce the working function.

**Question 17**

Complete

Marked out of 3.00

This question concerns PVD / Evaporation

The typical pumping time of an evaporation chamber can be estimated following this train of thought:

- ☐ a. The mean free path is chosen equal to the substrate-source distance, and this imposes the maximum pressure accepted, which requires a minimum pumping time related to the chamber volume and residual leakage.
- ☐ b. To ensure the required purity, the mean free path required is a constant (typically 20 m), which fixes a maximum pressure admissible requires a minimum pumping time related to the chamber volume and residual leakage.
- ☐ c. The pumping time needs to be of at least 10 hours to ensure that the vacuum is as good as it can get for a standard pumping chamber.
- ☒ d. The mean free path is chosen much greater than the source-substrate distance; this imposes a maximum pressure admissible, which requires a minimum pumping time related to the chamber volume and residual leakage.

**Question 18**

Complete

Marked out of 2.00

This question concerns Photolithography.

When photoresists is applied on the wafer by spin coating... (Select the only statement that is TRUE).

- ☐ a. The thickness obtained is only dependent on the type of resist (density, viscosity, etc.).
- ☐ b. Increasing rotation speed leads to a thicker photoresist thin film.
- ☒ c. The more viscous the resin, the higher the rotation speed required to achieve a given thickness.
- ☐ d. Regardless of the resist you use, there is a unique function where `image001.png` that can be used to predict the resist thickness.

**Question 19**

Complete

Marked out of 1.00

This question is about Lithography.

**In UV-lithography we typically use a photomask, which is made of a transparent glass plate coated with a structured chromium film. What is the process flow to fabricate such a mask, assuming that the chromium layer is already added on the glass plate?**

*(Only one option is correct and only one option can be selected)*

- ☐ Development, etching, resist coating, resist stripping, laser writing, drying
- ☐ Laser writing, resist coating, development, etching, resist stripping, drying
- ☐ Laser writing, etching, resist coating, development, resist stripping, drying
- ☐ Resist coating, development, laser writing, etching, resist stripping, drying
- ☒ Resist coating, laser writing, development, etching, resist stripping, drying

**Question 20**

Complete

Marked out of 2.00

This question is related to PVD

**The pressure in the chamber during deposition is higher for sputtering than for evaporation. What is the reason for this?**

*(Only one option is correct and only one option can be selected)*

- ☐ The magnetic field used with magnetron sputtering limits the vacuum level.
- ☐ Sputter chambers are larger than evaporation chambers and it is thus not possible to reach ultra-high vacuum.
- ☒ Plasma cannot be created at very low pressures.
- ☐ Sputtered atoms must undergo more collisions in order to have a better step coverage.

◀ [Wrap-up Lithography and Dry etching](#)

Jump to...

Your place in the class during the exam ▶