

Started on Thursday, 9 November 2023, 09:15**State** Finished**Completed on** Thursday, 9 November 2023, 10:07**Time taken** 52 mins 23 secs**Question 1**

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.

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

Question 2

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 μm and a DOF larger than 0.7 μm 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.

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

Question 3

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

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

Question 5

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)

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

Question 6

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. The developed patterns can have imperfections due to light wavelike nature.
- ☐ b. Mask-to-developed-resist pattern transfer is optimal for a dose equal to the thickness-development dose threshold.
- ☐ c. 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.
- ☐ d. The photoresist developed thickness is a linearly increasing function of the local accumulated dose.

Question 7

Complete

Marked out of 2.00

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 tip of Schottky field emitters are coated with ZrO_2 to reduce the working function.
- ☒ 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.

Question 8

Complete

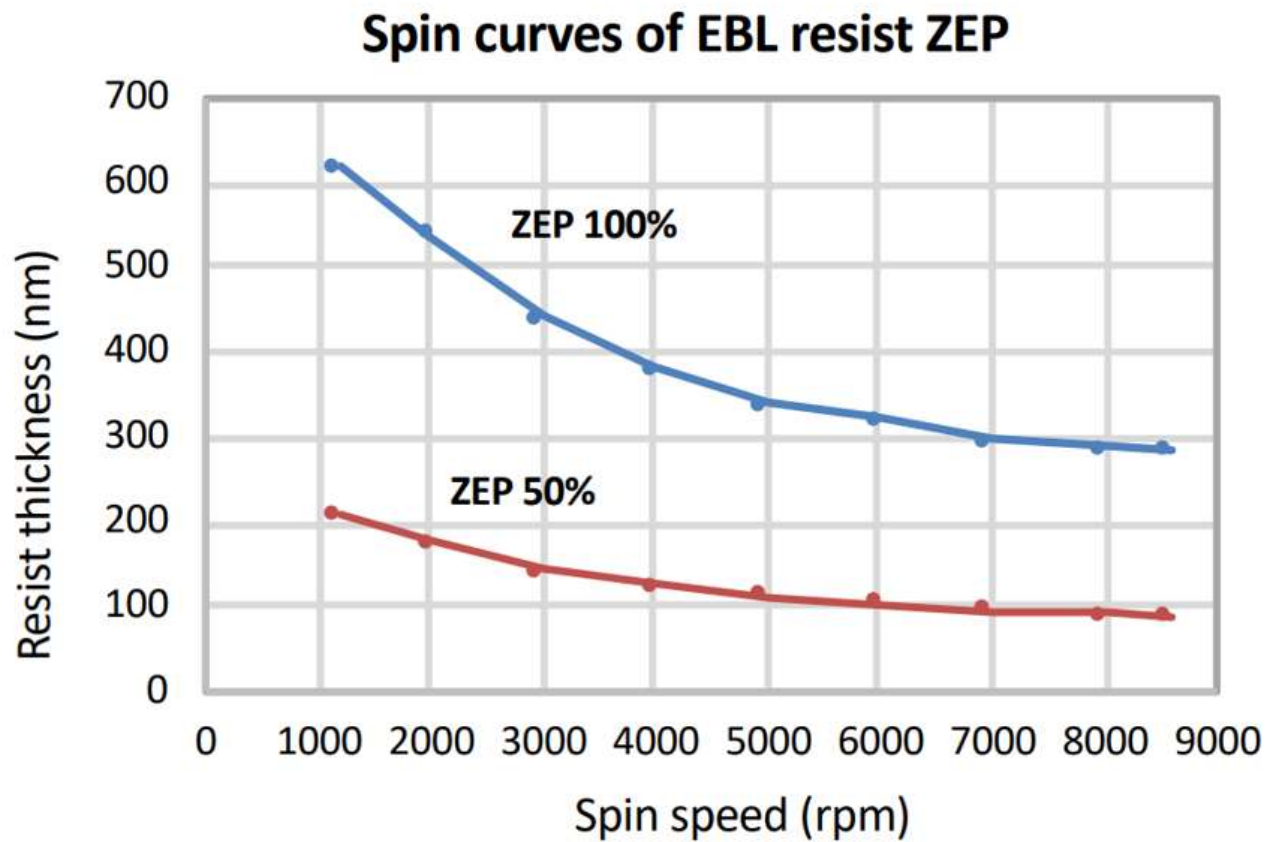
Marked out of 2.00

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.



Question 9

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)

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

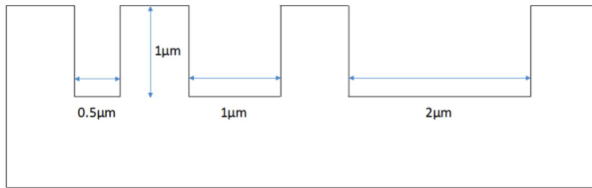
Question 10

Complete

Marked out of 3.00

This question is related to PVD.

Al_2O_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 11

Complete

Marked out of 1.00

This question is related to PVD.

You need to deposit by DC sputtering a 311 Å thick layer of gold (Au) on a silicon substrate. The sputter equipment is set to have a deposition rate of 8 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 12

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 13

Complete

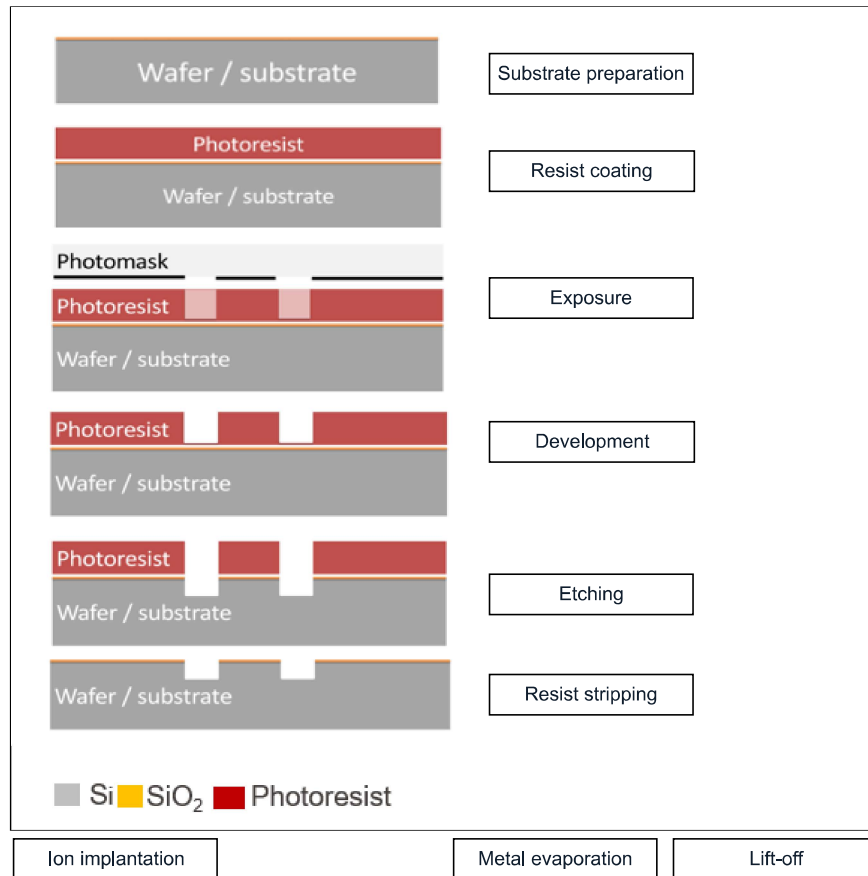
Marked out of 3.00

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).

**Question 14**

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)

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

Question 15

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 16

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 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.
- ☐ 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 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.
- ☐ d. 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.

Question 17

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)

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

Question 18

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

Question 19

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.

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


Question 20

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

◀ Graded quiz 2 (PVD and Lithography)

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Your place in the class during the exam ▶

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