midterm 2

18:49 Vendredi 3 novembre 79%

Time taken 20 mins 33 secs
Marks 17.50/18.00
Grade **9.72** out of 10.00 (**97%**)

Question **1**
Partially correct
Mark 0.50 out of 1.00

Resolution enhancement in electron

The resolution in EBL is limited by forward scattering of the electrons and it can be improved by using a [thinner] ✔ resist and by [increasing the size of the electron source] ✖ .

thicker | decreasing the acceleration voltage | increasing the acceleration voltage

Your answer is partially correct.

You have correctly selected 1.

When hitting the resist, the electron beam broadens because of forward scattering. The thinner the resist layer, the smaller the impact of this broadening in the final structures. On the contrary, the acceleration voltage needs to be increased to decrease the forward scattering.

The correct answer is:

Resolution enhancement in electron beam lithography (EBL)

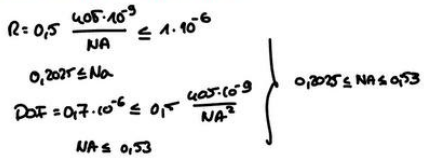
The resolution in EBL is limited by forward scattering of the electrons and it can be improved by using a [thinner] resist and by [increasing the acceleration voltage].

Question **2**
Correct
Mark 1.00 out of 1.00

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? (hint: 2 values are correct).

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



Your answer is correct.

The expression of the resolution is $R=k_1 \lambda/NA$ and the expression for the depth of field is $DOF=k_2 \lambda/NA^2$. By imposing that R needs to be lower than 1 μm and the DOF larger than 0.7 μm one can find a range of acceptable values for NA: 0.2<NA<0.53. Therefore just 0.25 and 0.45 are acceptable answers.

The correct answers are:
0.25,
0.45

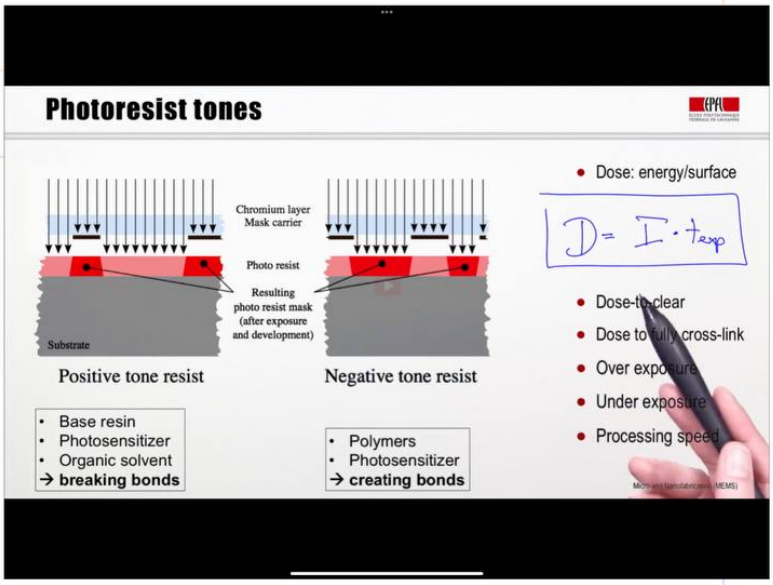
2 – 7

Question **3**

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

ure.

dose of 77 mJ/cm^2



relating power and energy E=Pt.

Partially correct
Mark 0.75 out of 1.00

lithography, is/are correct?

Multiple answers are possible.

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

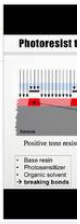
Your answer is correct.

Electron-beam lithography is an inherently serial writing method. The beam has to scan the sample to locally expose the electron-sensitive resist.. Photolith… to serial writing. Serial photolithography can be achieved with direct laser writers and photomask are used to expose the whole mask design on the photore… called a flood exposure. Finally, contrary to photolithography, electron-lithography is not limited by diffraction. With electron-beam tools, higher resolutions …

The correct answers are:
UV photolithography can be used to expose a full wafer through a photomask ,

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



Question **13**
Correct
Mark 1.00 out of 1.00

Photolithography processes rely strongly on the relation of light intensity and resist dose and exposure.

A UV lamp can deliver a power of 7 mW/cm^2 to a wafer. Calculate the exposure time in s needed to expose the wafer with a dose of 77 mJ/cm^2

Answer: 11 ✔

$$\frac{77}{7} = 11 = \frac{D}{I}$$

The correct exposure time to deliver a certain dose given the value of the lamp power can be found by inverting the formula relating power and energy E=P…

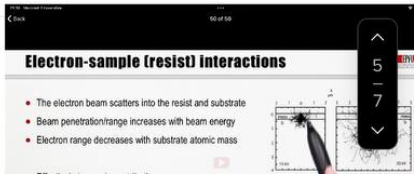
The correct answer is: 11.00

Question **14**
Correct
Mark 1.00 out of 1.00

Resolution in EBL is limited by forward scattering of the electrons in the resist.

Which of the following measures favour higher resolution?

- Increase the size of the electron source
- Apply lower electron-beam accelerating voltage



...d material has poor step coverage.

...ear is not uniform.

	Evaporation		Sputtering		
	Resistive	E-beam	DC	RF	Magnetron
Rate [Å/s]	0.1 - 20	10 - 100	1 - 100	1 - 100	1 - 200
Thickness range [nm]	10 - 2000	10 - 2000	10 - 6000	10 - 6000	10 - 6000
Material	Metals	Metals, oxides	Metals, alloys	Metals, alloys, dielectrics, compounds	Metals, alloys, dielectrics, compounds
Purity	+	+ +	- -	- -	-
Step coverage	-	-	+	+	+
Adhesion	-	-	+	+	+
Large area uniformity	-	-	+	+	+
Pressure [Torr]	10^{-6} - 10^{-7}	10^{-6} - 10^{-7}	10^{-1} - 10^{-2}	10^{-1} - 10^{-2}	10^{-3}
Substrate temp. [°C]	20 - 400	20 - 400	20 - 400	20 - 400	20 - 400
Other	Lift-off	Lift-off	Substrate cleaning & activation	Substrate cleaning & activation	Substrate cleaning & activation