Microfabrication technologies

Started on	Tuesday, 4 October 2022, 18:26
State	Finished
Completed on	Tuesday, 4 October 2022, 19:13
Time taken	46 mins 55 secs
Grade	**9.0** out of 10.0 (**90**%)

Question 1
Correct
Mark 1.0 out of 1.0
Flag question

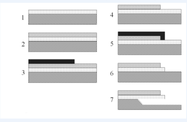
Why is the thermo-mechanical micro-actuator bending after the KOH release before actually applying any current for joule heating? Because of…

a. …the capillary forces created by the liquid KOH during the release step
b. …the repulsive electrostatic force between the cantilever and the silicon substrate
c. …the difference in residual stress between the chromium and SiO_2 layers ✓
d. …the electrical current going through the chromium track

Your answer is correct.
The initial bending of the cantilever is due to residual stresses resulting from the various fabrication steps. The origin of these stresses will be discussed in a subsequent video in this chapter. See the video about the thermo-mechanical micro-actuator between 09:48 and 11:54 for detailed explanation. Applying electrical current changes the radius of curvature of the micro-actuator but the initial upward bending already exists without any current. Capillary forces can be problematic in microfabrication, especially during drying steps. However in this specific case, capillary forces would tend to make the cantilever collapse on the wafer. They are not responsible for the initial upward bending. Finally, there exists no electrostatic force between the cantilever and the silicon substrate.
The correct answer is:
…the difference in residual stress between the chromium and SiO_2 layers

Question 2
Correct
Mark 1.0 out of 1.0
Flag question

For the following Process Flow of the Bimorph structure assign the correct steps to the corresponding number (the images show a cross section AFTER the process to assign have been concluded):



2 — Cr layer deposition ✓
7 — Silicon etch in KOH ✓
1 — Silicon oxidation ✓
5 — Lithography 2 (cantilever) ✓
4 — Cr etch and resist stripping ✓
3 — Lithography 1 (heater) ✓
6 — Silicon dioxide etch and resist stripping ✓

Your answer is correct.
The correct answer is:
2 → Cr layer deposition,
7 → Silicon etch in KOH,
1 → Silicon oxidation,
5 → Lithography 2 (cantilever),
4 → Cr etch and resist stripping,
3 → Lithography 1 (heater),
6 → Silicon dioxide etch and resist stripping

Question 3
Correct
Mark 1.0 out of 1.0
Flag question

Match the corresponding Contamination causes in microfabrication with their consequences:

Unwanted chemicals — Non-uniform processes ✓
Metallic ions — Semiconductor materials contamination ✓
Small particles — Failure of microstructures ✓

Your answer is correct.
Small particles effects: small feature size of microstructures makes them prone to failure, if microparticles are present during microfabrication.
Metallic ions effects: electrical properties of semiconductor circuits in a sensitive way depend on embedded impurities; Mobile Ion Contaminants (MICs) are metallic ions that are very mobile in semiconductor materials, are present in most chemicals, and can result in device failure long time after fabrication.
Unwanted chemicals effects: trace chemicals and process water can result in unwanted surface etching, creation of compounds that cannot be removed from the surface, or cause non-uniform processes
The correct answer is:
Unwanted chemicals → Non-uniform processes,
Metallic ions → Semiconductor materials contamination,
Small particles → Failure of microstructures

Question 4
Correct
Mark 1.0 out of 1.0
Flag question

To confine the acoustic waves generated at resonance, …

a. …FBAR-BAW use an underlying air gap, whereas BAW SMR use an underlying PDMS layer
b. …FBAR-BAW use a cavity etched through the entire wafer thickness, whereas BAW SMR use Bragg mirrors
c. …FBAR-BAW use an underlying air gap, whereas BAW SMR use Bragg mirrors ✓

Your answer is correct.
FBAR stands for thin-Film Bulk Acoustic Resonator. FBAR have an underlying air gap, which is actually a surface-micromachined local cavity whose height (gap) is in the order of few hundreds of nm (there is one cavity per resonator). This cavity confines the acoustic waves. SMR stands for Solidly-Mounted resonator. SMR are not free-standing structures, hence their name. The acoustic waves confinement is provided by underlying Bragg mirrors.
The correct answer is:
…FBAR-BAW use an underlying air gap, whereas BAW SMR use Bragg mirrors

Question 5
Incorrect
Mark 0.0 out of 1.0
Remove flag

The signal-to-noise-ratio (SNR) and sensitivity of capacitive accelerometers have been greatly enhanced over the past 20 years, mostly by... (More than one option could be correct.)

a. …using combs ✓
b. …packaging them in vacuum ✗
c. …implementing thin gaps
d. …highly doping the Si

Your answer is incorrect.
SNR and sensitivity are proportional to the readout capacitance. Using combs enables to drastically increase the readout capacitance by increasing the capacitive readout area without increasing the inertial mass size. Implementing thing gaps enables to drastically increase the readout capacitance, which is inversely proportional to the capacitive gap. Si must be conductive enough, i.e. it needs to be doped. But highly doping does not provide any benefit. Finally, accelerometers have to avoid any oscillations, hence they need to be damped, i.e. operation in vacuum has to be avoided.
The correct answers are:
…using combs,
…implementing thin gaps

Question 6
Correct
Mark 1.0 out of 1.0
Flag question

For cleanroom use water has to be de-ionised to give a very high resistivity, 18 [M] ✓ Ω cm in VLSI areas

G k m T

Your answer is correct.
The correct answer is:
For cleanroom use water has to be de-ionised to give a very high resistivity, 18 [M]Ω cm in VLSI areas

Question 7
Correct
Mark 1.0 out of 1.0
Flag question

Packaging is an important part of modern MEMS microphones as they are often exposed to adverse environment. A MEMS microphone package contains the MEMS microphone die itself as well as the ASIC die. What other functions does the package fulfill? More than one option could be correct.

a. The package protects the 2 dies ✓
b. The package provides electromagnetic shielding ✓
c. The package is under vacuum
d. The package affects the acoustic performance ✓

Your answer is correct.
The package physically protects the dies and their bonding wires. It also prevents them from direct contact with external environment. There is a metallic layer in the inner part of the lid that acts as cap of the package, in order to provide some electromagnetic shielding. It also plays a great role on the acoustic performance as the back-volume is part of the SNR calculation. It is of course not in vacuum since both membranes have holes, i.e. the back-volume is at ambient pressure.
The correct answers are:
The package protects the 2 dies,
The package affects the acoustic performance,
The package provides electromagnetic shielding

Question 8
Correct
Mark 1.0 out of 1.0
Remove flag

Let us assume we have a 148 µm wide x 510 µm long pattern in a SiO_2 layer on top of a silicon wafer. What is the required etching time in minutes to release such a pattern in KOH in order to create a cantilever? We assume the wafer orientation is (100), the same as in the bi-morph example, and that the patterns are oriented at 45° from the flat as in the bi-morph example.

Answer: 222 ✓

The etching rate of silicon (100) plans is about 20 µm/h. To release the cantilever from the silicon wafer, 148*0.5 µm silicon must be under etched from each side of the cantilever. This represents an etching time of 148*0.5/20 h or 148*0.5/20*60 minutes. See the video about the thermo-mechanical micro-actuator between 09:47 and 11:53 for detailed explanation.
The correct answer is: 222.00

Question 9
Correct
Mark 1.0 out of 1.0
Flag question

Bulk acoustic wave (BAW) resonators are the key element of modern GHz-range ladder filters that are used today in smartphones etc. They are basically…

a. …band-pass filters ✓
b. …low-pass filters
c. …high-pass filters

Your answer is correct.
Ladder filters are band-pass filters used to select a particular band of the GHz telecom frequency spectrum.
The correct answer is:
…band-pass filters

Question 10
Correct
Mark 1.0 out of 1.0
Flag question

What is the purpose of the chromium layer in the thermo-mechanical micro-actuator? More than one option could be correct.

a. To be electrically conductive ✓
b. To give a metallic appearance to the wafer
c. To ensure a good adhesion of the photoresist
d. To have a different thermal expansion coefficient compared to SiO_2 ✓

Your answer is correct.
The purpose of the chromium layer is to be electrically conductive in order to apply a current through the patterned chromium tracks. It is this current which heats up and actuates the thermo-mechanical micro-actuator. Chromium is also chosen because of its large difference of coefficient of thermal expansion with SiO_2. Indeed, the radius of curvature of the bi-morph cantilever is proportional to this difference. See the video about the thermo-mechanical micro-actuator between 00:54 and 02:25 as well as between 04:25 and 05:47 for detailed explanation. The metallic appearance that chromium gives to the wafer is not a required property in the case of the thermo-mechanical micro-actuator. The device would work perfectly well without it. Finally, chromium doesn't help the photoresist adhesion.
The correct answers are:
To be electrically conductive,
To have a different thermal expansion coefficient compared to SiO_2

Finish review

Quiz navigation

Emilie Grace Grandjean

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