<u>Course "Large-area electronics: Devices"</u>

Multiple choice test, spring 2022.

Cross the correct answer. More than one answer may be correct!

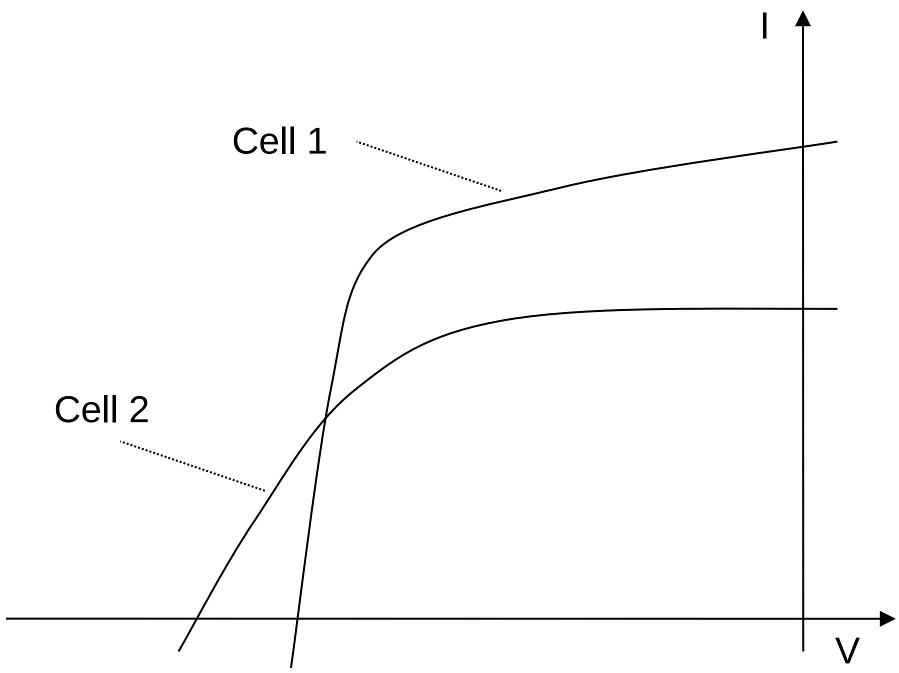
1. Cite 4 different applications of amorphous silicon:

TFT / Flat panel displays
Solar cells
Drums for xerography
Detectors

2. Are the following affirmations regarding the spectral conversion efficiency correct or wrong?

It is always higher than the maximal conversion efficiency of a cell	✓ correct	O wrong
It can be increased by stacking different gap materials	✓ correct	O wrong
It is always lower for fluorescent light than for AM1.5	O correct	✓ wrong

3. Examine the two I(V) characteristics below.



Compare the following characteristics by choosing the appropriate relationships.

Cell 1		Cell 2
I_{sc} (1)	>	I_{sc} (2)
V_{oc} (1)	<	V_{oc} (2)
FF (1)	>	FF (2)
η (1)	>	η (2)
Serial resistance 1	<	Serial resistance 2

4. Which structure exhibits the maximal spectral conversion efficiency under AM1.5 illumination (taking into account the direction of the incoming light, indicated by the arrow and the order of the layer stacking)?

O Light → a-Si:H
O Light → a-Si:H / a-Si:H
O Light → a-SiC:H
✓ Light → a-Si:H / c-Si

5. **How much energy per year should be produced by a 1 kW PV system located in Neuchâtel (with optimal orientation) ?**
   ✓ ≈ 1000 kWh
   O ≈ 2000 kWh
   O ≈ 5000 kWh
   O ≈ 15000 kWh

6. **If you increase the bandgap of the intrinsic layer (e.g. by alloying with C) of an a-Si:H cell, how do you expect the following cell characteristics to be ?**

Short circuit current	✓ Lower	O Higher
Open circuit voltage	O Lower	✓ Higher
Dark current	✓ Lower	O Higher
Infrared light absorption	✓ Lower	O Higher

7. **Why do we need a p-i-n structure (instead of a p-n) for a-Si:H cells ?**
   O because carriers cannot be transported by diffusion
   ✓ because the lifetime in the doped layers is too low
   O because carriers are only absorbed in the depletion region
   O because we need light-trapping (rough layers and interfaces)

8. **From which side should the light enter an a-Si:H solar cell for maximum efficiency?**
   O n-side
   ✓ p-side
   O It does not make a difference

9. **What is the typical total thickness of an a-Si:H single junction cell (total thickness of the active layer and doped layers)?**
   O 100 nm
   ✓ 300 nm
   O 1 µm
   O 3 µm

10. **What are the characteristics of an a-Si:H single-junction cell which may be affected significantly by the Steabler-Wronski effect?**
    ✓ I_{sc}
    O V_{oc}
    ✓ FF
    O the serial resistance
    ✓ the internal electric field profile

11. **Single junction a-Si:H cells exhibit a light-induced degradation with time. What are the possible measures to reduce the efficiency drop ?**
    O Increase the cell thickness
    ✓ Go to tandem or triple-junction configurations
    ✓ Increase the internal electric field
    O Reduce the light absorption in the doped layers
    O Increase the doped layer thickness

12. **Mention other materials used for solar cell technologies other than a-Si:H, as well as one advantage and one disadvantage**

Materials	**Advantage**	**Disadvantage**
CIGS	**Efficiency**	**Cost; availability of In**
CdTe	**Efficiency, easy process**	**Cd (toxic), availability Te**
Organics	**Easy processing, cheap**	**Low mobility, stability**
Pb halide perovskites	**Easy processing, efficiency**	**Stability, contain Pb**

13. **Solar cell efficiencies are usually determined at 25° and AM1.5 illumination. How the efficiency is going to change if you increase the light illumination (assuming that the serial resistance is negligeable)?**
    O will decrease   O will stay constant   ✓ will increase
    How the efficiency is going to change if you increase the temperature?
    ✓ will decrease   O will stay constant   O will increase

14. At which polarization are photodiodes operated?

O no polarization (short-circuit conditions)
O forward polarisation
✓ reverse polarization

15. Imagine that you have one a-Si:H based PV system and one c-Si based PV system (with the same nominal power) to be installed in a sunny place in Southern Europe which one would you select (taking into account only the performance aspects) and why?

✓ a-Si based O c-Si based

Reason: Lower thermal coefficient of efficiency -> higher energy output

16. Why do we use rough or textured TCO in a-Si:H based solar cells ?

O to increase the V_{oc}
✓ to increase I_{sc}
O to improve the serial resistance
✓ to permit the reduction of the cell thickness (better stability with same output current)

17. What is the most important material charateristics for best photoconductor?

O highest mobility
O highest lifetime
✓ highest mobility-lifetime product

18. For xerography applications, independently of any other material characteristics, which material would you select as photoconductor (outer part of the photoconductor drum)?

✓ 2 eV gap semiconductori
O 1.5 eV gap semiconductor

19. For xerography applications what type of semiconductor could be used ?

✓ Semiconductor with reasonable hole mobility and very low electron mobility
✓ Semiconductor with very low hole mobility and reasonable electron mobility
✓ Semiconductor with both reasonable hole mobility and electron mobility

20. Why are p-type a-Si:H TFT of no practical use ?

O too defective material
O too low band mobility of holes
✓ too low effective mobility of holes
✓ too wide valence band tail

21. What are the advantages of using LTPS instead of a-Si:H for TFT

✓ full CMOS capability
O better threshold voltage uniformity
O lower cost
✓ higher mobility

22. What are be the advantages of using metal oxide instead of a-Si:H for TFT

O full CMOS capability
O better threshold voltage uniformity
O lower cost
✓ higher mobility

23. Compare tow optimized AMOLED displays (same size and same pixel number), one with a-Si:H TFTs and one with LTPS TFTs

✓ Width of the channel of the OLED driver LTPS TFT will be smaller (than the a-Si:H one)
✓ Area of the OLED driver LTPS TFT will be smaller (than the a-Si:H one)
O Threshold voltage uniformity better for the OLED driver LTPS TFT

24. How many electron hole pairs a high energy particle will generated when interacting with a 50 µm thick Si diode ?

O 200
✓ 4000
O 10000

25. What is the typical thickness of photodiode used in a a-Si:H based flat panel imager ?

O 250 nm
✓ 1000 nm
O 5000 nm

26. What are the motivation to use lead halide perovskite instead of c-Si for particle detection?

✓ Thin-film
O High density material
✓ Material with high element with high atomic number.

27. For radiography applications, what are the differences between flat panel imagers based on a-Si:H and the ones based on a-Se?

	a-Si:H	a-Se
Detection scheme	Indirect (scintillator)	direct
Photodetection device	photodiode	photoconductor
Semiconductor layer thickness	thin (≤1 µm)	thick (≥50 µm)
Leakage current	small (blocking contacts)	larger (photoconductor)
X-rays detection/application	bones, non destructive tests	soft tissues, mammography
May use AM from AMLCD	O	✓