

## Course "Large-area electronics: Materials"

Multiple choice test, spring 2022.

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

1. **What type of order is prevalent in amorphous semiconductors?**
  - ☐ Static short range order
  - ☐ Long range order
  - ☐ Translational invariance
2. **In an amorphous semiconductor, is the atomic network totally random?**
  - ☐ Yes
  - ☐ No
3. **How does doping allow to vary dark conductivity of a-Si:H?**
  - ☐ by varying the average state of charge of dangling bonds
  - ☐ doping does not occur in a-Si:H due to network flexibility
  - ☐ by decreasing the activation energy down to a few hundreds of meV
4. **At room temperature, electronic charge transport in a-Si:H is similar to that of**
  - ☐ c-Si
  - ☐ polymers and amorphous insulators
5. **At low temperature, electronic charge transport in a-Si:H is similar to that of**
  - ☐ c-Si
  - ☐ an insulator
6. **Dangling bonds are the main electronic defects in a-Si:H**
  - ☐ yes
  - ☐ No
7. **If the defect density is very high, what are the possible consequences on the material quality?**
  - ☐ reduced electronic transport quality
  - ☐ reduced  $\mu\tau$ -product
  - ☐ increased recombination rate
8. **Why has a-Si:H a higher absorption coefficient than c-Si in the visible range of wavelength?**
  - ☐ because it is non-direct gap material.
  - ☐ because it contains hydrogen.
  - ☐ because c-Si is an indirect bandgap material.
9. **What is the role of Hydrogen in a-Si:H?**
  - ☐ It passivates dangling bonds.
  - ☐ It makes a-Si:H a direct bandgap material.
  - ☐ It reduces the defect density.
10. **The residual absorption (shoulder) in a-Si:H at low photon energy relates to:**
  - ☐ density of recombination centers
  - ☐ density of dangling bonds
  - ☐ bandtails
11. **Can the extrapolated optical gap be taken as a useful value for the bandgap of a-Si:H?**
  - ☐ yes
  - ☐ no
12. **Would this be also the case for a degenerated transparent conductive oxide (TCO)?**
  - ☐ yes

☐ no

13. **In order to increase the conductivity of a TCO layer without degrading its optical properties, which layer properties have to be enhanced?**  
☐ the free carrier mobility  
☐ the free carrier density  
☐ the sheet thickness
14. **After a few hours of illumination, defect related absorption of a-Si:H is increased. To which effect does this observation relate?**  
☐ Hall effect  
☐ Staebler-Wronski effect
15. **After very long exposure of a-Si:H layers to sun light (months), what happens?**  
☐ the defect-density reaches a quasi-stable value  
☐ the defect density increases exponentially
16. **What is approximately the defect density in device grade hydrogenated amorphous silicon?**  
☐  $10^{19} \text{ cm}^{-3}$   
☐  $10^{22} \text{ cm}^{-3}$   
☐  $10^{16} \text{ cm}^{-3}$
17. **Doping leads to an increasing dangling bond density in a-Si:H.**  
☐ yes  
☐ no
18. **How is a glass defined with respect to an amorphous material?**  
☐ A glass is an amorphous material obtained by rapid cooling from the liquid phase  
☐ A glass is not amorphous.  
☐ A glass is a highly viscous material with a continuous variation of specific heat with respect to temperature
19. **Does carrier lifetime increase with increasing dangling bond density?**  
☐ yes.  
☐ no.
20. **By measuring the activation energy of the dark conductivity above room temperature in a-Si:H, one can evaluate:**  
☐ whether it is doped or intrinsic.  
☐ if variable range hopping is the dominant transport mechanism.
21. **Why is it impossible to push the Fermi level closer than  $\sim 0.2 \text{ eV}$  to the conduction band edge of a-Si:H with Phosphorus doping**  
☐ because of the presence of bandtails states in the gap  
☐ because of the presence of hydrogen
22. **The main recombination mechanism in a-Si:H at room temperature occurs by successive trapping of an electron/hole pair on a dangling bond**  
☐ yes  
☐ no
23. **Does the simplest Shockley-Read recombination model generally apply to a-Si:H?**  
☐ Yes  
☐ No
24. **Do all localized states in the gap play the role of recombination centers?**  
☐ yes  
☐ no

25. **The slope of the exponential decrease of the absorption yields information on**  
O the dangling bond density  
O the bandtail states density
26. **Which states are acting as traps in a-Si:H?**  
O Bandtail states  
O Dangling bonds
27. **Why does a-Si:H remain a semiconductor even if it has lost crystallinity?**  
O Because short range order is sufficient to maintain an optical gap  
O Because Si is a metal  
O Because crystallinity is not required to observe a gap
28. **The Urbach energy of the valence band tail in a-Si:H is typically 50 meV. The Urbach energy of the conduction band is:**  
O higher  
O equal  
O lower
29. **Which type of hydrogen bonding is favorable in a-Si:H?**  
O SiH  
O SiH<sub>2</sub>  
O SiH<sub>3</sub>
30. **Does photoconductivity decrease with increasing dangling bond density?**  
O yes  
O no
31. **Which particles are present in a plasma?**  
O photons  
O ions  
O electrons  
O neutral atoms/molecules
32. **What happen to an (isolated) surface exposed to a plasma?**  
O it charges positively  
O it charges negatively  
O nothing happens
33. **Which one is higher in the plasma used for PE-CVD?**  
O electron temperature  
O ion temperature  
O neutral species temperature