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**ESP 5403 Nanomaterials for Energy Systems**

**Quiz-2/Solutions**

**06/11/2020**

**Marks 15 (Grade 15%)**

This is an open-book quiz. Please attempt all questions in this quiz. You are given 40 min. to complete the quiz.

Write your Metric Number and answers on the quiz question sheets and submit this document as a PDF file to LUMINUS at the end of the quiz.

Save PDF file starting with your Metric No.

**Matric No.**:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Dominated volume recombination in *p*-region of a monocrystalline Si-solar cell at high doping level is:

(a) Radiative recombination

(b) Auger recombination 

(c) Trap-assisted SRH recombination

(d) Surface recombination

Mention one subsequent effect during this recombination process.

2. During the analysis of I-V curve and its Fill Factor of a solar cell, we note that the main impact of high series resistance is to reduce the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ while the main impact of low shunt resistance is to reduce the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Provide reason why either OCV or short circuit current is affected substantially (as mentioned above) at high series resistance (1-2 sentences only):

3. Upon increasing the band gap of semiconductors, the conversion efficiency of solar cells made by such semiconductors increases steadily.

(a) True (b) False

Provide the reason (1-2 sentences only).

4. Consider a perovskite solar cell, in which a perovskite is sandwiched between TiO2 and Spiro-MeOTAD. Upon light illumination, electron-hole pair is formed in the perovskite. From thermodynamic point of view, the valance band maximum of perovskite is suitable for \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ separation and conduction band maximum is suitable for \_\_\_\_\_\_\_\_\_\_\_\_ separation.

Mention the reason why perovskites have high diffusion length (>1 micon) or high carrier

mobility.

5. The OCV of a Si solar cell is always smaller than its bandgap 1.12eV. Explain the

reason in 1-2 sentences.

6. In a practical Si solar cell the fill factor is always less than 1. Explain the reason in 1-2 sentences.

7. Mention one advantage and one disadvantage of using hole transport medium instead of liquid electrolyte in dye-sensitized solar cells.

8. Mention five predominant recombination processes in a perovskite solar cell (no need to draw figure, only mention between what and what).

9. Select the most fast process among the following in a dye-sensitized solar cell:

(a) Electron transport within TiO2

(b) Electron transfer from the LUMO of the dye molecule to the conduction band edge of TiO2

(c) Electron transfer from Fermi level of TiO2 to the HOMO level of dye molecule

(d) Electron transfer from Fermi level of TiO2 to the redox level of the electrolyte.

Give possible reason for this fast process just in one sentence.

10. The bandgap of quantum dots is always \_\_\_\_\_\_\_ than the band gap of corresponding bulk semiconductor. Explain the reason in 1-2 sentences.

11. Impedance measurement at different frequencies are referred to measure different processes within a dye sensitized solar cells as compared to DC measurement. Which process occur at very low frequency (say in mHz – 1Hz range). Provide your reason why this process is too slow.

12. In a dye sensitized solar cell device, micron sized TiO2 is used to as blocking layers. Provide one reason (1-2 sentence) for designing this blocking layers.

13. At room temperature in Si semiconductor, we expect certain amount of electrons in conduction band and same amount of holes in valance band. (i) Explain why you these carriers appear at room temperature in these bands and (ii) explain why notice same amount of electrons and holes occur.

14. In a fuel cell what is the driving force for the OCV? Provide your answer precisely in 2-3 sentences.

15. In semiconductors, with increasing doping level the Fermi level for electron \_\_\_\_\_\_\_\_\_\_\_\_ while the Fermi levels for holes \_\_\_\_\_\_\_\_\_\_\_\_\_\_. Provide your explanation, enter relevant equations if required.