Nanoparticle from the relevant spectrum biology essay

Science, Biology

Photoluminescence AnalysisResearch MethodsMSc Micro Electronics & Nano TechnologySubmitted toDr. Shashi PaulStudent Name: Febin PaulP Number : P12212927

Q1. Calculate the peak energy (in eV) for each nanoparticle from the relevant spectrum.

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Fig. 1

The spectrum of the light being incidented on the nanoparticles lead to certain amount of absorption. But at some typical frequency, an unprecedented absorption is observed. This frequency is typical of the size of the nanoparticles. As the size reduces, the frequency of maximum absorption also reduces. The energy of photon absorbed can be found out by the equation below. E= hc/λFrequency of maximum absorption and the energy of the corresponding photon for different sized nanoparticles is as given below: Wavelength of absorption (nm)380400420440460480Energy corresponding to the absorbed frequency (eV)3. 273. 112. 962. 822. 702. 59As we can see that the energy of the photon absorbed reduces with different samples. These values of absorbed energy is corresponding to the bandgap value. The difference in the bandgap with reduction of size is given by a formula. Thus if we have the difference in bandgap, this formula will give us the value of the size of the particle. Where, h is Planck’s constantR is the radius of the particleand are the effective masses of the electron and holee is the electronic chargeis relative dielectric constant of the semiconductor and is the permittivity of free space. Now we know, from the question, that the bandgap of CdS is 2. 45 eV. Thus from the values in the table we get the value of difference in the energy bandgap. So we have a new table. Wavelength of absorption (nm)380400420440460480Energy corresponding to the absorbed frequency (eV)3. 273. 112. 962. 822. 72. 59

8. 19E-016. 56E-015. 08E-013. 74E-012. 51E-011. 38E-01

Q2. Show how the shift in band-gap relates to the size of nanoparticle.

We have the value of. Putting this value in the above equation, we get the size of the nanoparticle. where, h (Planck's constant)= 4. 135667516(91)×10−15 eV·s(effective masses of the electron)= 4. 33E-30 kg(effective masses of the hole)= 2. 00E-27 kg

e (Electronic charge)= 1. 60217646 × 10-19 coulombs

(Relative dielectric constant of the CdS)= 8. 9(Permittivity of free space)= 8. 854 187 817... x 10-12 (F·m−1)Now, substituting all the values of the constant in the equation all solving it, we get,= 3. 79 x 10-37 /R2- 4. 65 x 10-29 /RNow, if you substitute the numerators as A and B, we get,= A /R2 - B /RThe equation can be rearranged to the form below, A- BR= R2R2+ B R= AThis is the final equation. This is a form of quadratic equation. When we solve this equation, and substitute the values for we get the two roots. But only the root within the range of our estimate will be chosen and the other will be discarded. The roots for any given quadratic equation is found out using the given equation. After solving the equation for the radius of nanoparticles we get the following results.

CdS

R (radius)

D (diameter)

3801. 72 x 10-93. 44 x 10-94001. 9 x 10-93. 8x 10-94202. 19 x 10-94. 38x 10-94402. 55 x 10-95. 1x 10-94603. 18x 10-96. 36x 10-94803. 90 x 10-97. 8x 10-9

Q3. Calculate the Tauc gap for each nanoparticle and calculate the diameter of the nanoparticle.

662593_2. jpgIn Tauc's relation the bandgap of a material is given by a formula. The formula is as given below.

(αhν) n = A (hν-Eg)

In the formula above, the value of (αhν)n is ½ for direct transition. Now if we plot the graph of the energy absorbed, of the different sized nanoparticles against (αhν)n, we get the value of bandgap. If we extrapolate the graph below at the x- axis, then the intercept at the x- axis will represent the bandgap of the nanoparticle. An example of how this is done is given below. Thus performing the same operations for all the sizes of nanoparticles. We get the following table below.

Wave Length (nm)

Band Gap (ev)

(ev)

R(radius) (m)

D(diameter)(m)

3803. 190. 741. 8 x 10-93. 6 x 10-94003. 060. 71. 94 x 10-94. 98 x 10-94202. 940. 492. 3 x 10-94. 6 x 10-94402. 850. 42. 4 x 10-94. 8 x 10-94602. 860. 412. 46 x 10-94. 92 x 10-94802. 850. 42. 40 x 10-94. 80 x 10-9

Q4. Statistically analyse the data on the nanoparticles’ size that you have calculated from the data measured using the two different techniques.

Below is the graph representing the plot of the change in bandgap with change in the size of particle for both the method. We observe from the plot that the bandgap seems to increase with the decrease in the size of the nanoparticles. This happens due to the confinement effect, evident in nanoparticles. We have calculated the standard deviation for both the method. We observe that the deviation is very less for the Tauc’s method. The photoluminescence Method induces great errors in the result, especially when the particle size is big. So it’s better to analyse the experiment using the Tauc’s Method,