Investigations the Optical Properties of InN Thin Film

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ARTICLE INFO
Submission date:8/11/2016
Acceptance date:7/12/2016
Publication date:14/10/2018

Abstract

In the present work the optical properties have been investigated for the composite semiconductor material is Indium Nitrite (InN). In this study the multiphoton absorption phenomenon for the photon have been depended. The absorption spectrum for the Indium nitrite (InN) was recorded by using 5000 Varian UV-VIB-NIR Cary spectroscopy. The thickness of the thin film was calculated to be 3.5µm.

Keywords: optical spectrum, InN, semiconductor, thin films

1- Introduction

The absorption is a process takes place in the optical medium when a light passes through it. However, this process includes many mechanisms depending on the type of the medium. An interesting absorption mechanism can occur under the condition of high intensity light propagating through an optical medium that is multiphoton absorption phenomenon; it is very useful in many applications. Amorphous solid or a crystalline is a semiconductor whose electrical conductivity is typically between an insulator and a metal. The absorption process was defined as the raising an atom from the lower state to the upper state by absorbing a photon or it is a transition induced by the photon [1]. An interesting absorption process that is called multiphoton absorption, when a number (≥ 2) of photons are absorbed, accompanied by the transition of an absorbing molecule from a lower state to a higher state. Due to its potential applications Recently, InN has attracted considerable attention [2].

On the other hand, the seemingly conflicting results of various investigations. The most important observations which were repeated of an effective band gap of about 0.7 eV by optical techniques [2]. The smaller band gap value extends the possible emission range of optoelectronic devices based on group-III nitrides from the deep-uv (AIN) down to the near-IR region (InN). The applications of InN are suggested, because of its superior transport properties [3]. Moreover, a large saturation velocity and an extremely high drift velocity (at room temperature) make InN a promising material for high- speed and high-frequency electronic devices.

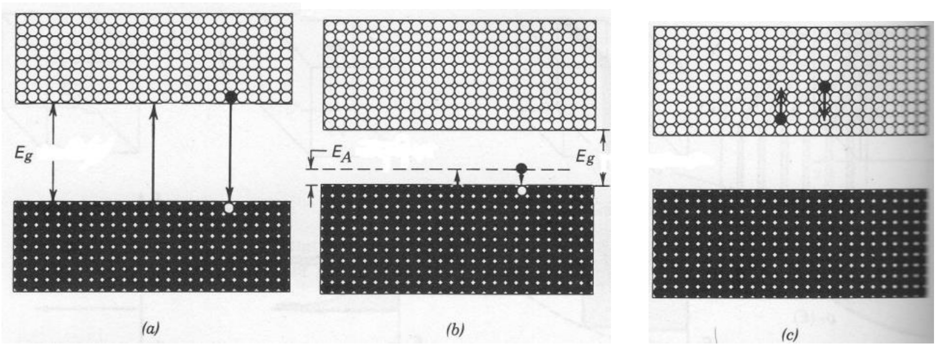
1- 1 **Absorption Theory in Semiconductor**

Mechanisms of absorption

The mechanisms of the absorption processes in semiconductor can be classified into.

A. Band-to-Band (Interband) Transitions. Creating an electron –hole pair caused by an absorbed photon in an electron in the valence band making an upward transition to the conduction band, see Fig (1-a).

B. Impurity-to-Band Transitions. Fig (1-b) shows the process of absorption a photon which can cause in a transition between a donor (or acceptor level and band in a doped semiconductor.
C. Free-Carrier (Interband) transitions. An absorbed photon can impart its energy to an electron in a given band, causing it to move higher within that band as illustrate in Fig (1-c).
D.



"Fig.(1) examples of absorption of photons in a semiconductor. (a)Band- to - Band transitions. (b)the absorption of photons results in a valance- band to excerptor level transitions. (c) A free- carrier transitions within the conduction band [4]"

2- Theory

When the light pass through the material the attenuation of a light can be describe by the following expression [5].

$$\frac{dI(z)}{dz} = -\alpha I(z) - \beta I^2(z) - \gamma I^3(z) - \eta I^4(z)..... \quad (1)$$

Where I(z) is the intensity of the incident light beam propagating along the z-axis and α, β, γ, and η are the one-, two-, three-, and four- photon absorption coefficients of the transmitting medium, respectively. The value of α describes the linear absorption, and β describes the two photon absorption value. Equation (1) can be re-write by simplified form.

$$\frac{dI(z)}{dI(z)} = -\alpha I(z) - \beta I^2(z) \quad (2)$$

Rearranging equation (2)

$$\frac{dI(z)}{I(\alpha + \beta I)} = -dz$$

By using integration by partial we can get the value of I (z) as a function to α, β, and I_0 , where

$$\int_{I_0}^{I} \frac{dI(z)}{I(\alpha + \beta I)} = \int_{I0}^{I} \frac{A}{I} dI(z) + \int_{I0}^{I} \frac{B}{(\alpha + \beta I)} d(z) = \int_{0}^{z} - dz$$

Where the value of A, B can be calculated
A=1/α and B=-β/α

By some algebra methods we can get value.

$$I(z) = \frac{I_0 \alpha e^{-\alpha z}}{\alpha + \beta I_0 (1 - e^{-\alpha z})} \qquad (3)$$

The total amount of light absorb in the case of a thin film, both the top and bottom surfaces of the thin film depend upon the sum of these two absorption processes. Furthermore, these two absorptions may add together constructively or destructively depending upon their phase relationship. This phenomenon is due to the wave nature of light, with the phase relationship determined by the difference in optical path lengths of the two absorptions. The resulting absorption pattern (absorption fringes) can be used to determined the thickness of the film using the following expression:

$$t = \frac{m}{2n(v_1 - v_2)} \qquad (4)$$

Where **t** is the thickness of the film, m is the number of absorption fringes in the wave number region, n is the refractive index of the thin film, $(v_1 - v_2)$ is the wave number region [6].

3- Results and Discussion

Absorption spectrum for the thin film InN

In this section we will discuss the linear absorption spectra for the InN semiconductor over the range 200-2000 nm "using a Cary 5000 UV-Vis-NIR spectrophotometer. Base on absorbance fringes observed, the thickness of the film was calculated".

Fig (2-a) shows the absolute absorption spectrum of the InN thin film.The absorption pattern due to the thin film is obviously evident over the entire wavelength range scanned with the fringe spacing increasing with wavelength.

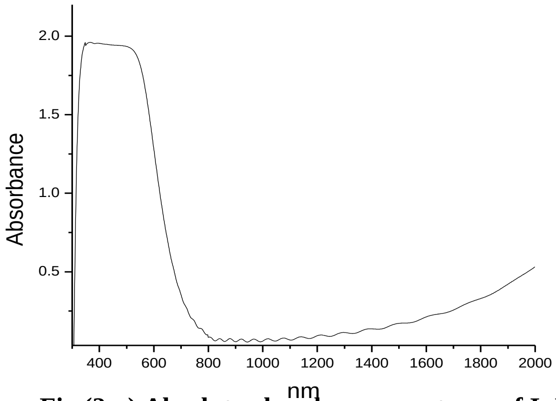


Fig (2-a) Absolute absorbance spectrum of InN As a function of wavelength.

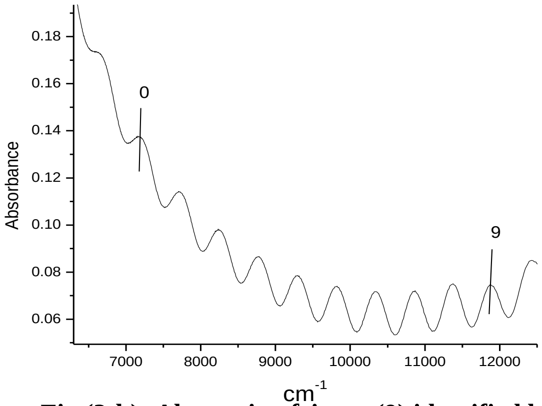


Fig (2-b): Absorption fringes (9) identified between
$v_1 = 7199.209 cm^{-1}$ and $v_2 = 11879.3 cm^{-1}$

Fig (2-b) illustrates the number of absorption fringes which are 9 fringes, the refractive index for InN is 2.745, and the wave number region from $v_1 = 7199.209 cm^{-1}$ to $v_2 = 11879.3 cm^{-1}$. The thickness of the thin film was calculated using equation 4, and its value t=3.5µm.

Conclusion

The absorption spectrum for the thin film InN showing that the thin film has higher absorbance in range VIB (400-700 nm) spectra region. While the minmum absorbance happen at NIR (Near Infrared Region), this is because the smaller band gap value extends the possible emission range of optoelectronic devices based on group-III nitrides from the deep-uv (AIN) down to the near- IR region.Therefore, the thin film of InN can be considered as a good sensors in the VIB region. The thickness of the film was measured to be 3.5µm.

CONFLICT OF INTERESTS.
There are non-conflicts of interest.

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الخلاصة

تم في هذا البحث دراسة الخواص البصرية لمادة مركبة شبه موصلة هي نترات النيديوم. اعتمدت هذه الدراسة على ظاهرة الامتصاص المضاعف للفوتون باستخدام جهاز مطياف Varian UV/VIB/NIR Cary لقياس طيف الامتصاص لهذه المادة . كما وتم حساب سمك الغشاء الرقيق وقيمته ٣,٥ مايكرومتر.

الكلمات الدالة: الطيف البصري, نترات النيديوم, اشباه الموصلات, الاغشية الرقيقة