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BLUE PHOTOLUMINESCENCE IN GaAs(N) NANOWHISKERS

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GaAs(N) nanostructured thin films have been deposited using the radio frequency sputtering technique. Films are formed by filament-like nanocrystallites with a sharp grain size distribution. The mesured nanowhisker average diameter range about 3.9 to 4.1 nm. The film structure was cubic with a preferential (1,1,1) orientation. Particle size effects were observed in the photoluminescence emission spectra. The blue emission (λ=425-432 nm) was due to the quantum confinement effect with a effective band gap of 2.92 eV and a quantum yield of about 92% of efficiency.

1 Introduction

Semiconductor nanocrystalline films have been recently received considerable attention due to their novel properties and potential applications as linear or non-linear optical components [1,2]. In fact, quantum wires are being studied because of their potential applications in electronic and blue laser devices. Nanowhiskers have been obtained in GaAs, InAs, GaAlAs and others II-V semiconductor compounds, however, GaNAs nanowhiskers have only been reported by us until now [3].

In the present work, as the first step towar the goal of controlling nanowire-like thin film growth, the fabrication of $GaN_x As_{1-x}$ nanowhiskers with X in the range of 0.0050, prepared by rf magnetron sputtering technique on glass substrates is reported.

2 Experimental

The GaAs(N) nanowhisker thin films were grown in an rf magnetron sputtering system, using a water-cooled cathode with a commercial GaAs monocrystalline (1,1,0) wafer as target. Different samples were grown at susbtrate temperatures

(Ts) in the range of room temperature to 300°C (RT, 100, 150, 200 and 300°C) with a constant growing time of 120 minutes and maintaining a growth radio frequency power of 100 Watts with an Argon-Nitrogen (50/50) gas pressure of 10 mTorr. Sample thickness was measured using a Dektak Sloan profile analyzer. The thickness varied from 3.2 μm for Ts at RT down to 1.8 μm at 300°C. The crystalline structure- Cubic (1,1,1) orientation- was obtained from X-ray diffraction pattern employing an X-ray Siemens D5000 diffractometer (CuKα line). Surface morphology and average grain size of whiskers were analyzed by using atomic force microscopy images (Park Scientific Instruments). For the atomic concentration of elements in the layers, electron and wavelength dispersion spectroscopy measurements were done in a Leica-Cambridge 440 SEM-EDS-WDS system, respectively. The average atomic nitrogen content was about 0.5±0.15 per cent. Photoluminescence emission was carried out at RT in a Perkin Elmer LS50B system, using an excitation wavelength of 275, 300 and 325 nm, respectively.

3 Results and Discussions

Surface morphology of two samples grown at different substrate temperature is shown in Fig. 1(a, b). The film surface shows a well resolved fibrous structure, which is normally termed whiskers- structure. The diameter of whiskers is normally measured at the middle point of the full length for each whisker [4]. In our case, the diameter of the whisker was measured by AFM technique i.e., only the upper-top can be measured due to the cantilever can not penetrate deep into the surface sample to avoid damage it. The whiskers shown in Fig. 1, have typical diameter ranging between 40 and 45 Å. The surface morphology exhibit a high density of whisker-like features that are almost normal to the surface.

Typical room temperature photoluminescence spectra recorded from the investigated structures by exciting above the GaAs band gap are shown in Fig. 2, illustrating their dependence on growth temperature. It is clear that all spectra contain two PL bands: a dominant emission band peaked at a wavelength of 425 nm, that is due to the GaAs(N) alloy band gap (Eg = 2.92 eV) and a relatively weak PL band peaked at around 834 nm, due to the matrix intrinsic GaAs (Eg = 1.49 eV) small bottom layer onto the substrate glass. In addition, the dominant PL emission band peaked in the blue spectral region is the result of the quantum confinement effect, caused by the nanostructuration of the whisker grains [5]. The fact that the PL peak energy remains the same for all samples indicate that the effective grain size is almost equal for all samples, result that confirmed the result obtained from the AFM measurements. However, the quantum yield for the PL peaks, increases as increases the nanowhisker density, i.e., as increases the

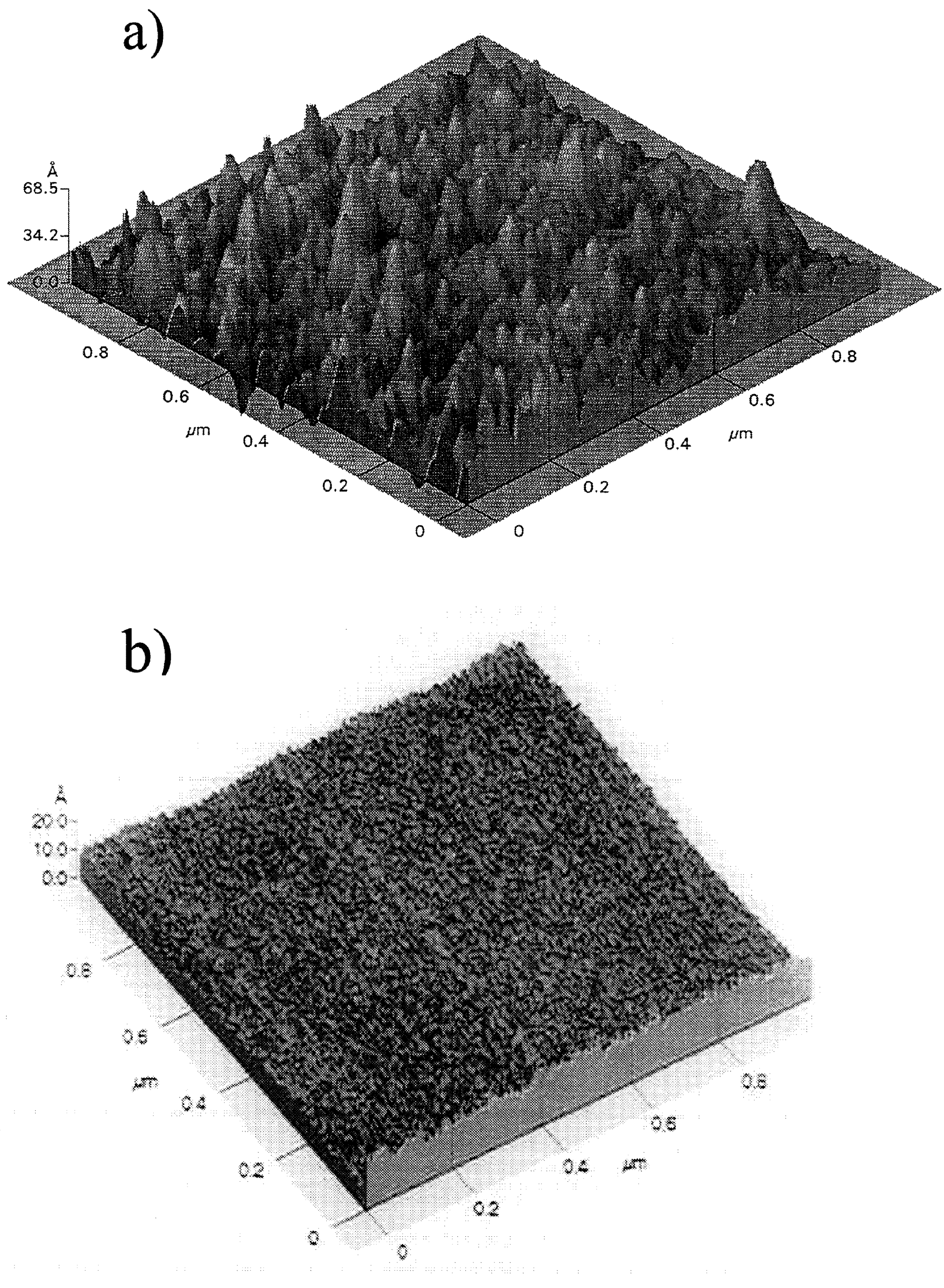

Figure 1. Surface morphology for the samples deposited at : a) Ts = 100°C and b) Ts = 300°C. Note the large increases in whiskers number i.e., whiskers density.

substrate temperature. In table I are summarized the calculated quantum yield and band gap of the samples.

In Fig. 3 (a), is indicated the lamp intensity spectra used as exciting beam for obtain the quantum yield of the samples and in Fig.3 (b), are shown the effects that different exciting wave lengths have on the PL spectra of the samples .

As can be seen, the PL emission spectra at the different wavelengths are almost equal to the spectra of Fig.2, showing that the samples do not have inclusion or segregated phases indicating a high material quality.

Table I Calculated and measured values.

λ_i (nm) Exitation	λ_e (nm) Emission	I_i (a.u.) Exitation	I_e (a.u.) Emission	Quantum Yield (%)	Grain Size (Å)	Band Gap (eV)
275	425.41	101.04	91.78	90.8	39.1	2.915
300	425.01	177.13	161.69	91.3	39.3	2.917
325	433.00	64.29	59.83	93.1	40.1	2.871

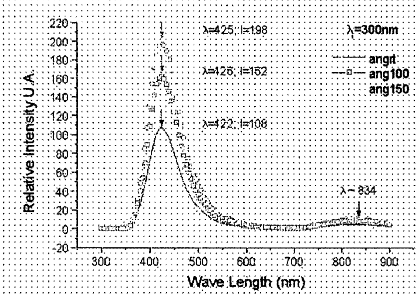

Figure 2. Emission luminescent in function of substrate temperature.

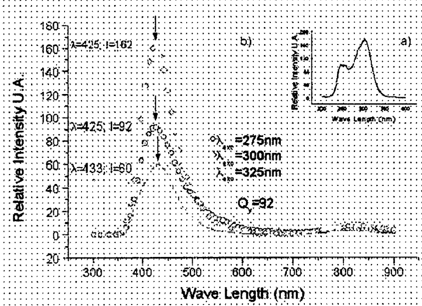

Figure 3. a) Excitation spectra. b) Emission luminescent for 3 different wavelengths.

4 Conclusions

Blue photoluminescence in GaAs(N) nanostructured films have been reported for the first time by us. Results evidenced a material with band gap of 2.92 eV of high quality and efficiency of light emission that are of particular importance in the development of optoelectronic devices.

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