Dependence on the atmosphere of preparation of the luminescence of spark processed porous GaAs

M. Rojas-López, M. A. Vidal, and H. Navarro-Contreras[a)]
Instituto de Investigación en Comunicación Optica (ICO), Universidad Autónoma de San Luis Potosí, Av. Karakorum #1470, Col. Lomas Altas 4a. sección, CP. 78100, San Luis Potosí, S. L. P., México

J. M. Gracia-Jiménez, E. Gómez, and R. Silva-González
Instituto de Física ''Luis Rivera Terrazas,'' Benemérita Universidad Autónoma de Puebla, Apdo. Postal J-48, Puebla, Pue., C.P. 72570, México

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We report on the preparation of photoluminescent porous GaAs by the application of high voltage spark discharges in atmospheres of pure oxygen, pure nitrogen, and in mixed N_2:O_2 ratios of 4:1 and 1:4. The spark-processed porous (spp) samples were characterized by the observation of their visible photoluminescence (PL) when illuminated with UV monochromatic radiation. Some differences are observed in the initial PL spectra of the spp-GaAs according to the atmosphere of preparation under similar sparking and time conditions. The PL consists of two dominant bands, a yellow-green band between ~2.2 and 2.6 eV and a blue-violet band, centered at 3.1 eV. Comparison with Raman and PL results from As_2O_3 and As_2O_5 indicates that the PL in the spp-GaAs is produced by the formation of these compounds by exposure to oxygen during the preparation. This is reinforced by energy dispersive x-ray spectroscopy measurements that indicate that the spp-GaAs is always oxidized, even when prepared under a nitrogen flow. The blue-UV emission at 3.1 eV suggests that we cannot rule out confinement as a contributing mechanism for this PL. Raman spectra indicate that for samples prepared in pure nitrogen, the resulting material consists of amorphous As and GaAs, and the cubic form of As_2O_3, arsenolite. PL and Raman indicate that there exists an increasing degree of amorphization of the resultant material with the introduction of nitrogen in the preparation atmosphere.
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I. INTRODUCTION

In recent years, porous materials have attracted considerable interest due to the discovery that porous Si (p-Si) photoluminesces[1] in the visible and by the fact that this phenomenon may be produced by confined electrons in nanometric sized granules or pillars in the p-Si.[2] Spark processing (SP) is a useful alternative to prepare new photoluminescent semiconductor porous materials.[3] SP has some potentially desirable features compared to the electrochemical etching method that has been extensively used in silicon,[1–3] such as: (a) it is a nonwet approach that could be used to prepare optoelectronic devices, (b) the luminescent area affected can be chosen at will, (c) the emission can be tuned in some materials by changing the parameters of preparation (wafer-tip separation, substrate temperature, ambient gas, pressure, spark frequency, current, voltage and exposed time, etc.), (d) the same equipment and procedures can be used for the preparation of any type of semiconductor material.

The list of materials spark processed, whose luminescent properties have been observed as reported in the literature are: Si, Ge, GaAs, Sb, Bi, Sn, As, and Te[4] and to this list, it recently was included the semiconductors CdTe, GaSb, InSb, and InP.[5,6]

There have been several reports on the light emission properties of porous GaAs prepared by this method,[7,8] as well as from electrochemically etched porous GaAs (eep-GaAs).[9] The spark-processed porous GaAs (spp-GaAs) prepared at low-frequency sparking shows reproducible photoluminescence (PL) in two main bands: a yellow-green band at 2.5 eV and a blue-violet band, centered at 3.1 eV.[8] In the same work, the PL is attributed to luminescence from oxygen compounds and x-ray photoelectron spectroscopy XPS spectra reveals the presence of As_2O_3, As_2O_5, and traces of either Ga_2O or Ga_2O_3, but no direct assignment of the PL to any of these oxides is made. In Ref. 9, the PL in eep-GaAs appears in two bands centered at 2.02 and 2.26 eV. The latter is directly correlated to similar emissions from solid As_2O_3 and As_2O_5. No identification is offered for the 2.02 eV emission. The 3.1 eV band is not present in the spectra of eep-GaAs published in that work.[9]

In this work, we report the preparation by spark processing of porous GaAs (spp-GaAs) at low-frequency sparking in pure and mixed atmospheres in N_2/O_2 ratios of 1:0, 4:1, 1:4, and 0:1, and the characterization of its PL at room temperature. We present the results of a study of the chemical composition of the spp-GaAs surface using Raman spectroscopy and energy dispersive x-ray spectroscopy (EDS). These confirm the presence of both type of arsenic oxides, As_2O_3 and As_2O_5, and that they play a fundamental role as source of

a)Electronic mail: hnavarro@cactus.iico.uaslp.mx

