

Raman study of luminescent spark processed porous GaAs

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We have analyzed spark-processed porous GaAs (spp-GaAs) samples prepared by the application of high-voltage discharges at low repetition rates (20 Hz) in different ambients, ranging from pure nitrogen to pure oxygen flow, using a microRaman probe and a scanning electron microscope in combination with an energy dispersive spectroscopy system (SEM-EDS). We found that for samples prepared in pure nitrogen, the resulting material is basically amorphous material, with amorphous-GaAs with some cubic phase of As_2O_3 also present. For samples prepared under even a low concentration of oxygen, 20:1, we find that the cubic phase of As_2O_3 is substituted by the monoclinic phase of As_2O_3 "claudetite." SEM micrographs show the resultant morphologies obtained that exhibit a porous, granular, agglomerated granular appearance. EDS and Raman suggest that the claudetite phase of As_2O_3 and As_2O_5 play a contributing role in the green-blue photoluminescence emitted by spp-GaAs. © 2001 American Vacuum Society.

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I. INTRODUCTION

In recent years, porous materials have attracted considerable interest because of the discovery that porous Si (p-Si) photoluminesces¹ in the visible spectrum and because this phenomenon may be produced by confined electrons in nanometer-sized granules or pillars in the p-Si.² Spark processing (SP) is a useful alternative for preparing 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 For example, (a) it is a non-wet 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 exposure time) and, (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 and reported in the literature are: Si, Ge, GaAs, Sb, Bi, Sn, As, and Te,⁴ to this list, the semiconductors CdTe, GaSb, InSb, and InP have recently been included.^{5,6}

Recently, several reports have been published on the light-emission properties of porous GaAs prepared by the spark process,⁷⁻⁹ as well as of the electrochemically etched porous GaAs (eep-GaAs).¹⁰ The spark-processed porous

GaAs (spp-GaAs) prepared at low-frequency sparking shows reproducible photoluminescence (PL) in two main bands: a green-blue band between ~ 2.2 to 2.6 eV and a blue-violet band centered at 3.1 eV.^{8,9} In both works, the green-blue PL is attributed to luminescence from oxygen compounds; x-ray photoluminescent spectroscopy (XPS) spectra reveal the presence of As_2O_3 , As_2O_5 , and Ga_2O_3 ; and the assignment of the PL to the arsenic oxides is made.⁹ This assignment is confirmed by some preliminary Raman work included in that work. However, it is not dismissed that the blue-violet emission at 3.1 eV may be due to confinement effects. In Ref. 10, the PL in eep-GaAs that appears in two bands centered at 2.02 and 2.26 eV is directly correlated to similar emissions from As_2O_3 and As_2O_5 , respectively.

In this work, we present a more comprehensive Raman scattering and scanning electron microscope in combination with an energy dispersive spectroscopy system (SEM-EDS) study that reconfirms the presence of both types of arsenic oxides (As_2O_3 and As_2O_5) in all samples under study, and the fundamental role that they play as the source of the green-blue PL in air-processed spp-GaAs. Additionally, we obtain results that suggest that in nitrogen-prepared (spp-GaAs), the emissions centered at 2.45–2.55 and at 3.1 eV seem to have their source in material now in an amorphous states as suggested by Raman spectra. As_2O_3 , also detected in the Raman experiments in the N-spp-GaAs, appears to be formed during the spark processing by incorporation of some oxygen residual in the sample preparation chamber.

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