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Optical properties of $In_xGa_{1-x}N$/GaN quantum-disks obtained by selective area sublimation

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Abstract

We study the cathodoluminescence (CL) and the photoluminescence (PL) properties of $In_xGa_{1-x}N$/GaN quantum disks (QDisks) included in nanowires obtained by selective area sublimation from an $In_xGa_{1-x}N$/GaN multiple quantum well using an *in situ* Si_xN_y nanomasking performed in a molecular beam epitaxy reactor. The NW density can be adjusted as a function of the Si_xN_y coverage. The mean NW diameter is found almost constant for NW density varying by two orders of magnitude. The light emission from the $In_xGa_{1-x}N$/GaN QDisks is blue-shifted compared to the quantum wells. The origin of this shift is discussed in terms of strain and lateral confinement effects in the QDisks. The CL and PL spectra reveal strongly reduced peak linewidths for experiments conducted on a few or single objects isolated by using sub-micrometer apertures in a metallic mask.

Keywords: A1. Sublimation, A1. Nanostructures, B1. Nitrides, B2. Semiconducting III-V materials

1. Introduction

Two main routes, corresponding to opposite approaches, are followed to fabricate semiconductor nanostructures. The first one, termed bottom-up, based on self-organized growth, is the most generally used to obtain quantum dots (QDs) [1] or nanowires (NWs) [2]. The second one, widely used in classical semiconductor technology, is a top-down approach for which nanostructures are made by shaping an epitaxial layer by wet or dry etching through a mask [3]. One of the main advantages of the self-organized approach of nanostructure growth is certainly its simplicity since it can be entirely performed into standard molecular beam epitaxy (MBE) [4,5,6] or metal-organic chemical vapor deposition (MOCVD) [7,8,9] reactors. However, this implies to develop a growth process specific of the intended nanostructures, generally very different to the one devoted to classical 2D epitaxial structures. In turn, top-down approaches [10,11] are performed on functional 2D epitaxial structures (i.e. designed for specific electronic or optoelectronic device applications), obtained by well-mastered MBE or MOCVD standard growth process, but at the expense of a series of complex *ex-situ* technological steps, and also, of nanostructure lateral size limitation.

In a previous paper, we have reported a new top-down approach of GaN nanostructure fabrication, making use of the congruent nature of GaN evaporation (sublimation) [12]. It consists of post-growth *in situ* partial Si_xN_y masking of GaN-based epitaxial layers, followed by high temperature annealing in vacuum in a MBE reactor to get GaN selective area sublimation (SAS). Using this top-down approach, NWs with nanometer scale diameter are obtained from GaN and $In_xGa_{1-x}N$/GaN multiple quantum well (MQW) epitaxial structures. Actually, preliminary results indicated that $In_xGa_{1-x}N$ quantum-disks (QDisks) are formed when SAS is performed on $In_xGa_{1-x}N$/GaN MQWs [12].

The aim of the present paper is to report new experimental data intended to get more insight into the properties of $In_xGa_{1-x}N$/GaN NWs and QDisks obtained by SAS.