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Double-Pulsed Growth of InN by RF-MBE

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The initial steps of three different methods for growth of InN were investigated. For this purpose, layers of approximately 15 nm thickness were grown by applying continuous, pulsed or double-pulsed source fluxes. The surface morphologies were investigated by atomic force microscopy and scanning electron microscopy. The structural properties were investigated by reflection high-energy electron diffraction and high-resolution x-ray diffraction. For the continuous and pulsed growth methods, fine-grained structures with grain sizes of approximately 80 nm and 120 nm are observed. In contrast, the double-pulsed growth method leads to surface morphologies made of atomically flat, nearly 2-μm-sized grains. Furthermore, XRD ω scans of the InN (0002) reflection show that the full-width at half-maximum (FWHM) values are smallest for this method. These results were used to develop a new growth method that enables growth of atomically flat InN surfaces without any evidence of metallic In within or on top of the layer.

Key words: Molecular-beam epitaxy, InN, XRD, AFM

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INTRODUCTION

In recent years indium nitride has attracted wide interest due to its outstanding electronic and optoelectronic properties such as high carrier mobility and low bandgap.[1,2] The latter enables a tunable bandgap of GaInN that ranges from the ultraviolet to the near infrared. However, growth of InN has turned out to be very difficult. This is mainly due to the very high equilibrium partial pressure of N above InN, which makes very low growth temperatures necessary.[1] It is well known that low growth temperatures lead to surface roughening and low crystalline quality due to low adatom mobilities.[3] To overcome these problems, several methods have been developed. The most important ones are so-called metal modulated epitaxy (MME)[4–6] and droplet elimination by radical ion beam irradiation (DERI).[7–9] In both methods the adatom mobility is increased due to a pulsed source flux. In MME the nitrogen flux is continuous whereas the In flux is pulsed, and in the DERI method an alternating flux (In and N) is used. Both methods lead to increased quality of III-nitride material. In this paper we compare the initial growth steps of three different methods for growth of InN.

EXPERIMENTAL PROCEDURES

All samples were grown on metalorganic vapor-phase epitaxy (MOVPE) GaN templates in a RIBER 32P MBE system equipped with a conventional effusion cell for In. An active nitrogen beam was generated by an ADDON radiofrequency (RF) plasma source. Thin layers of about 15 nm thickness were grown at 520°C using a conventional growth method, where all fluxes are continuous, a pulsed growth method, which is comparable to MME, or a double-pulsed growth method, which is comparable to DERI. However, in contrast to DERI, where In droplets are desired, our intention is to prevent accumulation of In into droplets by supplying no more than one monolayer per pulse. In

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