Fabrication of Group III-Nitride Waveguides by Inductively Coupled Plasma Etching

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Precise fabrication of waveguides with abrupt ridges and smooth sidewalls are desired for novel optoelectronic devices such as intersubband all optical switches [1]. However, as it is generally known, etching of III-nitride materials is not easy because they are chemically and physically stable. Reactive Ion Etching (RIE) technique have conventionally been used for the etching to date, but this often results in poor etching profiles and low etching rates, particularly for structures with large aspect ratio. In comparison, Inductively Coupled Plasma (ICP) dry etching technique is promising because it realizes a high plasma density, and conditions of the plasma density and ion energy are independently controlled. Chemical reaction of chlorine with III-nitrides also enhances the etching rate. Hence, abrupt ridges and smooth side walls as well as a high etching rate can be achieved.

In this study, we demonstrate fabrication of high-mesa waveguides using ICP dry etching technique for structures consisting of $Al_{0.1}Ga_{0.9}N$ cladding layers and a AlN/GaN multiple quantum well core layer. Mixture of Cl_2 and Ar was used as the etching gases under a total flow rate of 10 cc/min. A gas mixing ratio and a pressure of the ICP chamber were first controlled for optimization, then ICP power and bias power of a substrate holder were separately adjusted to achieve abrupt ridges and smooth sidewalls. Figure 1 shows an example of the fabricated waveguides where a sufficiently high aspect ratio for a high-mesa waveguide (4 μm in width and 4.6 μm in height) is demonstrated. High etching rate (220 nm/min) and excellent reproducibility was confirmed. A series of the waveguides with a width ranging from 2 to 20 μm and a length of 1mm were fabricated and the propagation of light at 1.55 μm was observed for a width as narrow as 3 μm.

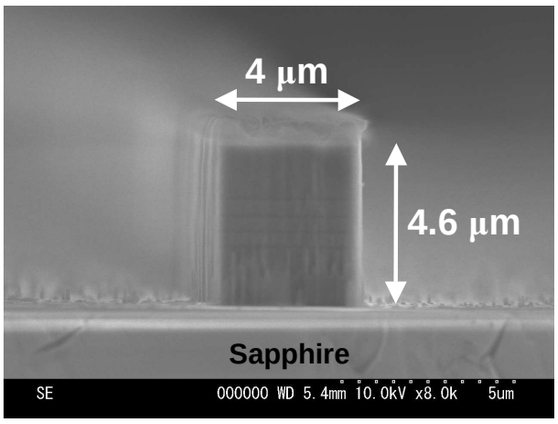

Fig.1 Cross-sectional SEM image of a waveguide fabricated by ICP etching.

Reference: [1] N. Suzuki and N. Iizuka, Jpn. J. Appl. Phys. **36**, L1006 (1997).