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Study on etch process of GaSb-based VCSEL

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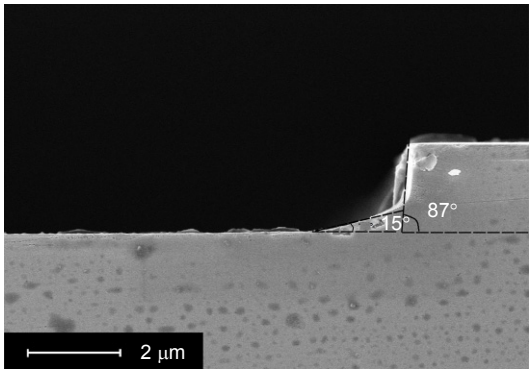

Corrosion surface of sample with H_3PO_4:H_2O_2:$C_4H_6O_6$:H_2O=1:1:0.6:10.

Abstract: 2 μm~5 μm mid-infrared vertical cavity surface emitting laser (VCSEL), featured with advantages of low power consumption, small divergence angle, no astigmatism circular spot, high modulation bandwidth, wavelength stability, low production cost, and high density ultra-small dimensional packaging, is an ideal light source for the molecular spectrum measurement, biochemical testing, laser radar, thermal imaging and medical diagnosis. For example, in the TDLAS (tunable laser diode absorption spectroscopy test) system for monitoring polluting gases CO, CH_4, NH_3 and HF, the use of VCSEL as a light source will greatly reduce the complexity and the cost for no beam shaping and easily coupled packaging, and shrink the size of the system. Furthermore, its modulation rate can reach several tens of Gbit/s, so it is considered to be the best alternative device of distributed feedback (DFB) laser in the future. As the GaSb material can cover the entire mid-infrared band, it is the best material system for the development of 2 μm~5 μm mid-infrared VCSEL.

GaSb-based VCSEL has become a hot concern over the world because of its promising application. However the immaturity of its fabrication processes seriously hinders its development. E.g., owing to its easily oxidized properties that make etching GaSb not a easy thing, etch process is one of the most key technologies in preparing a GaSb-based VCSEL.

In the previous etching experiments, only the effect of hydrofluoric acid plus tartaric acid etching solution on the corrosion rate was explored, but the surface morphology of the substrate and the undercutting effect was not well analyzed. Etching characteristics of GaSb is investigated in detail by use of phosphoric acid plus tartaric acid solution. In order to compare them, we chose concentration ratio of H_3PO_4:H_2O_2:$C_4H_6O_6$:H_2O as 1 mL: 1 mL: 0.3 g: 10 mL, 1 mL: 1 mL: 1 g: 10 mL, and 1 mL: 1 mL: 0.6g: 10 mL, respectively. In order to prevent the corrosion rate of the viscous reaction product formed on the GaSb surface during the etching process, the sample is continuously immersed in the etching solution by a magnetic stirrer to assist in obtaining a constant etching rate.

The experimental results were characterized through scanning electron microscopy (SEM) and so on, and the testing results were compared and analyzed. Etched GaSb in the third group solution (H_3PO_4:H_2O_2:$C_4H_6O_6$:H_2O=1:1:0.6:10) shows very good morphology: undercutting effect was eliminated and a vertical side wall was obtained with no lateral etching. Etching rate is 0.62 μm/min. The perfect etch behavior of GaSb provides a good preliminary experimental basis for laser preparation.

Keywords: Gallium antimonide; VCSEL; etching rate; surface morphology; tartaric acid

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