HIGH-DENSITY PLASMA DEPOSITED SILICON NITRIDE FILMS FOR COATING InGaAlAs HIGH-POWER LASERS

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For the deposition of silicon nitride (SiN) films high-density plasma such as electron cyclotron resonance (ECR) plasma or inductively coupled plasma (ICP) is being increasingly used. In the present paper, we will report on the application of ECR-plasma deposited SiN films with low stress as optical coatings for InGaAlAs high power lasers. Pre-cleaning of the surface to be coated and stable low stress in the SiN films have been found to be among the important requirements on coatings for these lasers.

Prior to deposition of the SiN films the laser facets were cleaned in an Ar-plasma in the same machine in which the deposition of the films occurred. To assess damage during cleaning, photo-luminescence measurements at 10 K using 1-mW Ar^+-laser excitation at 514.5 nm were used. Fig. 1 shows the photoluminescence spectra from GaAs in the GaAs/AlGaAs 4 QW´s structures before and after cleaning the sample in the Ar-plasma. QW´s were at different depths from the surface, with QW1 being the first from the top. Virtually no variation in PL intensities is observed following the cleaning procedure. From this behavior it can be concluded that negligible damage is introduced into the epitaxial layers during deposition of the film.

The stability of the film was assessed by measuring change in stress in the film with thermal cycling. Film stress was determined by measuring changes in curvature of a 2´´-wafer before and after deposition of the film. As can be seen in Fig. 2, at room temperature the stress in the film is slightly compressive. On heating to 400 °C it decreases almost linearly with temperature. On cooling from 400 °C to room temperature the stress change follows almost the same path as that of heating. Further, it was found that the stress remained unchanged even after boiling the film in water. From these results it can be induced that the film structure is stable.

Fig. 3 illustrates results of lifetime test of 2 mm long and 150 µm wide InGaAlAs broad-area high-power laser diodes with an emission wavelength of 880 nm. The emitting facet was coated with different types of SiN films. The heat-sink temperature, laser operation current and output power of the laser diodes during the tests were 50 °C, 3 A, and 2 W, respectively. As can be seen the lifetime is increased significantly when the emitting facet is coated with our stable low-stress SiN film.

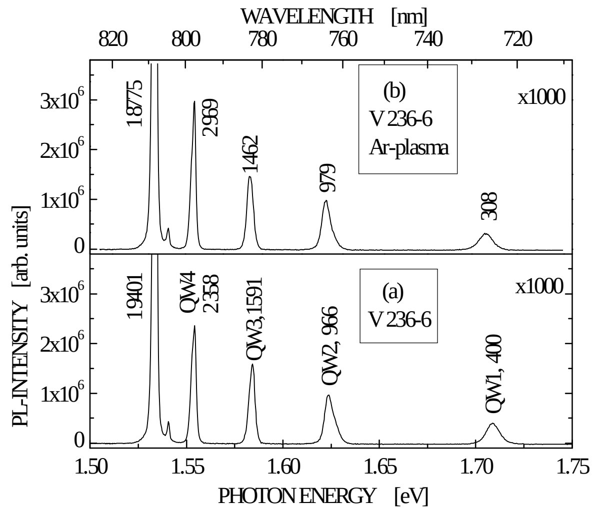

Fig.1. Photoluminescence spectra of a 4 QW´s GaAs/AlGaAs sample V236-6 before (a) and after (b) cleaning the sample in Ar–plasma of ECR-PECVD system.

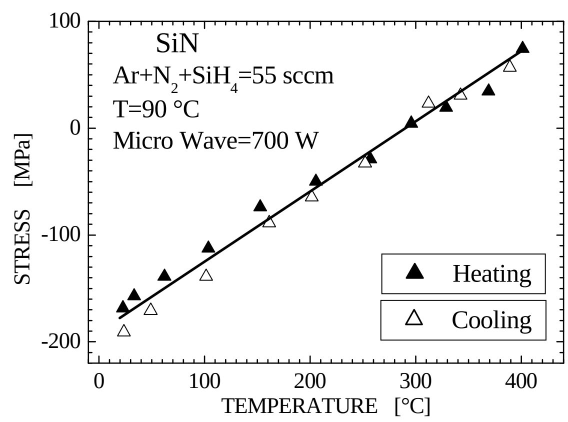

Fig. 2. Variation of stress in the optimized SiN film deposited on GaAs with temperature.

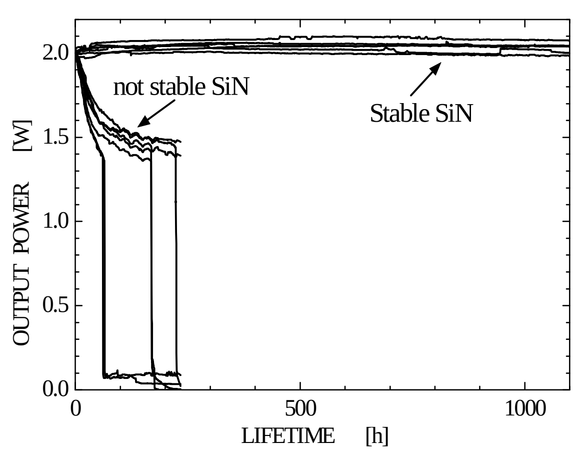

Fig. 3. Lifetime test of DQW InGaAs/AlGaAs laser diodes.