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Blue-Green Stimulated Emission in Lattice-Matched ZnHgSSe/ZnSSe Double Heterostructures by Optical Pumping

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A ZnHgSSe wide bandgap quaternary alloy is a class of novel materials which can be used as an active layer in ZnSe-based lasers with totally lattice-matched to both cladding layers and substrates (e.g., ZnHgSSe/ZnSSe/GaAs (100) or ZnHgSSe/ZnMgSSe/GaAs (100) DH's). We believe that introduction of lattice-matched materials system is one of the most effective solution to the problem of the slow degradation encountered in the lattice-mismatched ZnCdSe/ZnSSe/ZnMgSSe lasers. In this paper, we report the fabrication of lattice-matched DH laser structures by using the ZnHgSSe/ZnSSe system, and demonstrate for the first time the occurrence of blue-green stimulated emission by optical pumping.

Samples were grown by molecular beam epitaxy (MBE) on GaAs (100) substrates. Source materials were elemental Zn, Hg, and Se, and a compound ZnS. A typical DH structure consists of, from the top, a $ZnS_{0.08}Se_{0.92}$ upper cladding layer (100 nm, T_{sub}=200℃), a $Zn_{0.988}Hg_{0.012}S_{0.10}Se_{0.90}$ active layer (200 nm, T_{sub}=190℃), a $ZnS_{0.07}Se_{0.93}$ lower cladding layer (1 μm, T_{sub}=280℃), a ZnSe buffer layer (30 nm, T_{sub}=280℃), and an n-type GaAs (100) substrate. A substrate temperature (T_{sub}) for the growth of the active layer was set to be relatively low to promote the incorporation of Hg in the active layer. Interdiffusion of Hg across the heterointerface was not significant, as confirmed by the secondary ion mass spectroscopy (SIMS) depth profile analysis (Fig.1).

Fig.2 shows a photoluminescence (PL) spectrum at 20 K of a DH sample. A 325 nm-line of a He-Cd laser was used for excitation. Two different emission bands were observed ; a broad emission band (2.4~2.6 eV) due to a ZnHgSSe active layer, and a weak emission band (~2.86 eV) originated from an upper ZnSSe cladding layer. A strong PL emission from the ZnHgSSe layer relative to the emission from the ZnSSe layer indicates that carriers can be accumulated effectively in the active layer.

Fig.3 shows the emission spectra at 77K taken from a cleaved edge of a striped DH sample under various excitation intensities. The length of the cavity was 1.1 mm. The excitation source was a pulsed THG-YAG laser (355 nm) whose pulse width and repetition rate were 20 ns and 10 Hz , respectively. We have observed the spectral narrowing with a peak position of 510.5 nm when the excitation power reaches at around $90kW/cm^2$. This threshold value is somewhat higher than the values reported earlier for ZnCdSe-based lasers. Further increasing the power, the emission intensity increases superlinearly.

Fig.4 shows the polarization dependence of the light output intensity for TE and TM modes. As seen clearly, the intensity of the TE mode is ten times higher than that of the TM mode. In total, we have demonstrated the occurrence of stimulated emission in blue-green wavelengths region for a lattice-matched ZnHgSSe/ZnSSe DH.

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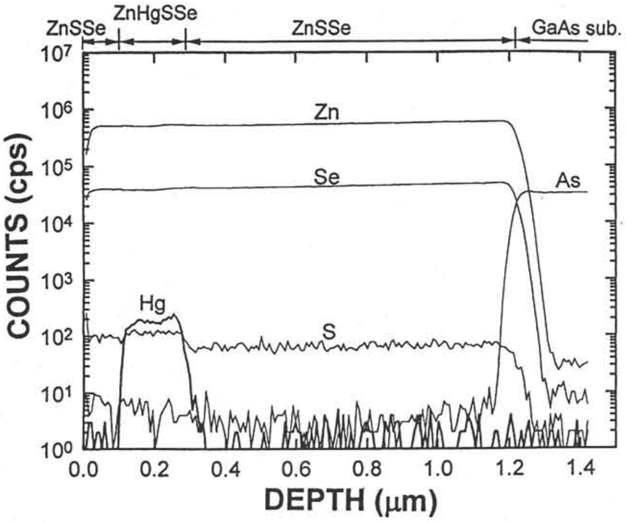

Fig.1 SIMS depth profile of a DH sample used for photopumping experiments.

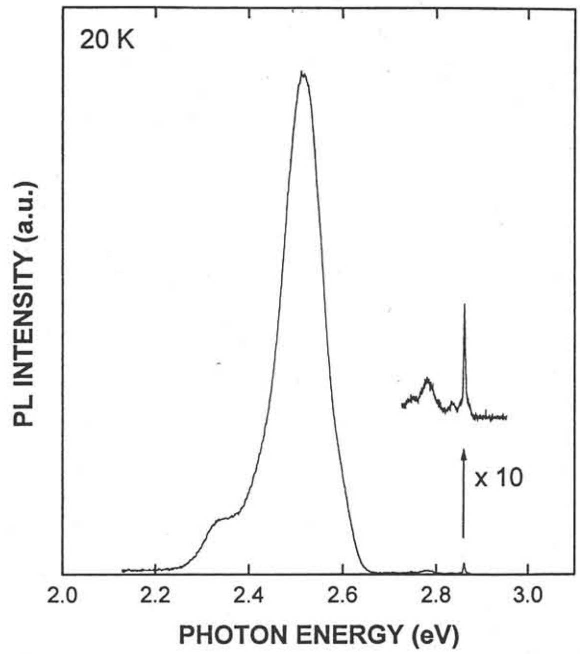

Fig.2 PL spectrum of a DH sample at 20K. A shoulder around 2.3 eV is due to the optical interference effect.

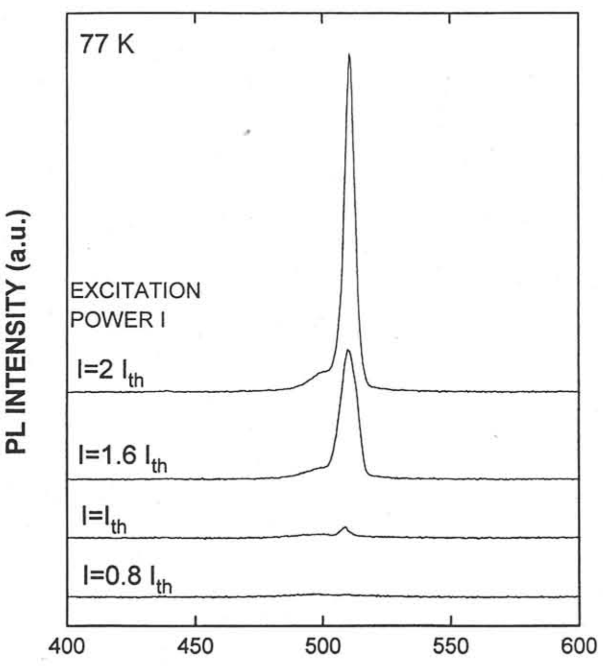

Fig.3 Emission spectra of a DH sample under various excitation intensities.

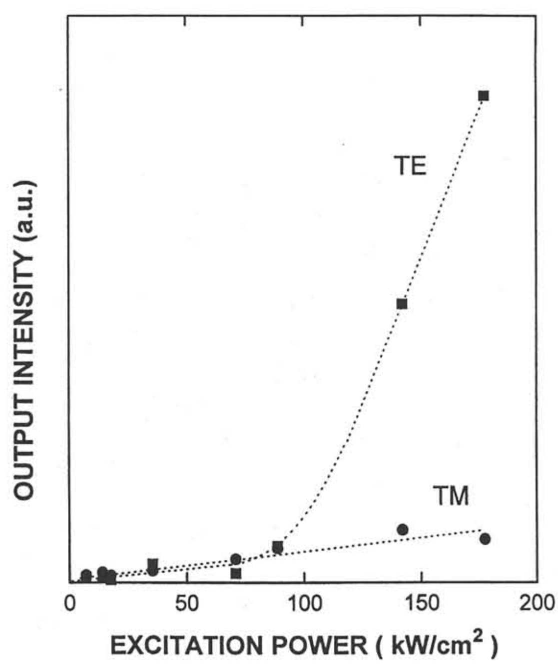

Fig.4 Polarization dependence of the light output for TE and TM modes.