# InP-based InAs/InGaAs quantum well lasers at 2 μm

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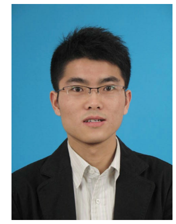
## BIOGRAPHY



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## TECHNICAL ABSTRACT

Mid-infrared lasers with emission wavelength around 2 μm are very useful for molecular spectroscopy and trace-gas sensing. Traditionally such semiconductor lasers are developed in InGaAsSb/AlGaAsSb material system on GaSb substrate [1]. On the other side, $In_xGa_{1-x}As/In_{0.53}Ga_{0.47}As$ (x>0.53) quantum well (QW) structure on InP substrate is an alternative approach to demonstrate lasers in this spectral range. It is promising to achieve superior performances owing to the superior quality of InP substrate as well as the more mature growth and processing technology [2]. In this work, we report the demonstration of InP based InAs/InGaAs quantum well lasers emitting at 2 μm, where a double QW structure composed of compressive InAs /$In_{0.53}Ga_{0.47}As$ DA triangular well and tensile $In_{0.43}Ga_{0.57}As$ barrier is used as the active region. The spectral and optoelectronic features of the laser are characterized in detail.

The laser sample was grown in a VG Semicon V80H gas source molecular beam epitaxy (GSMBE) system on (100) InP epi-ready substrates. After growth, the wafer was processed into ridge waveguide laser by standard lithography and wet chemical etching process. Fig. 1 shows the lasing spectra of a 6-μm-wide and 800-μm-long laser at temperature from 99 K to 107 K in a step of 2 K. The laser was operated at a driving current of 250 mA in pulsed mode with a pulse width of 500 ns and a repetition frequency of 100 KHz. It can be seen that the lasing wavelength blue shifted from 1.940 μm at 99 K to 1.926 μm at 107 K. This phenomenon may results from the reduced slope of maximum gain function *G(E)* due to the relatively high inter absorption and weak optical confinement in the laser structure [3]. In order to investigate the spectral characteristics and tunability more clearly, the lasing spectra of the same laser was observed in the same driving current at temperature from 101 K to 103 K in a step of 0.5 K as shown in Fig. 2. From 101 K to 103 K, the lower energy lasing mode (mode 1) red shifted continuously from 1936.084 nm to 1936.210 nm and the higher energy lasing mode (mode 2) red shifted continuously from 1935.366 nm to 1935.509 nm, respectively. For the same lasing mode, the average wavelength shift as a function of temperature $\Delta\lambda/\Delta T$ was about 0.067 nm/K, which was attributed to the refractive index change with the temperature. Fig. 3 shows the current-power (I-P) and current-voltage (I-V) characteristics of the laser under continuous-wave (CW) driving conditions from 80 K to 105 K. The threshold current was 57 mA at 80 K, corresponding to a threshold current density of 1.19 $kA/cm^2$. The maximum output power was 4.18 mW at 80 K. At 100 K, the turn-on voltage of the laser was about 1 V and a differential resistance of about 5.4 Ω was obtained.

**References:**

[1] J. G. Kim, L. Shterengas, R. U. Martinelli, G. L. Belenky, D. Z. Garbuzov and W. K. Chan, Appl. Phys. Lett. **81**, 3146 (2002).
[2] T. Sato, M. Mitsuhara, T. Watanabe and Y. Kondo, Appl. Phys. Lett. **87**, 211903 (2005).
[3] F. Klopf, S. Deubert, J. P. Reithmaier and A. Forchel, Appl. Phys. Lett. **81**, 217 (2002).

**Keywords:** InP-based, GSMBE, quantum well lasers, strained compensated

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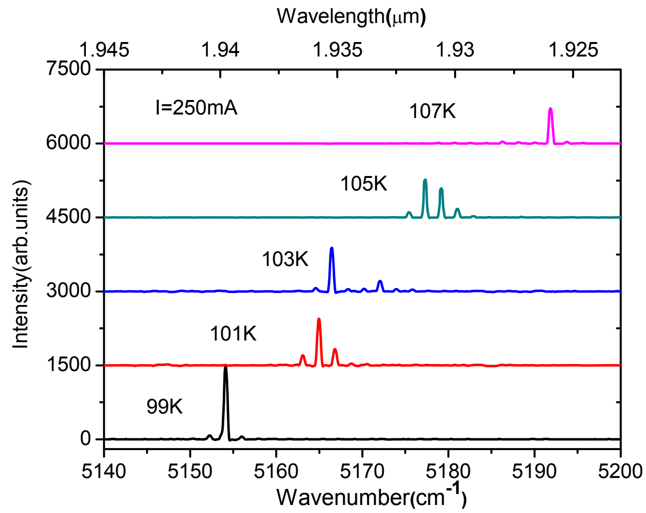


Fig. 1. Lasing spectra of the laser at temperature from 99 K to 107 K

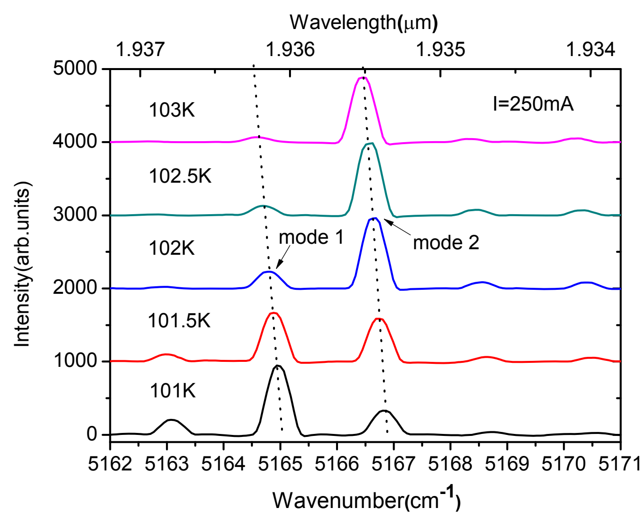


Fig. 2. Lasing spectra of the laser at temperature from 101 K to 103 K

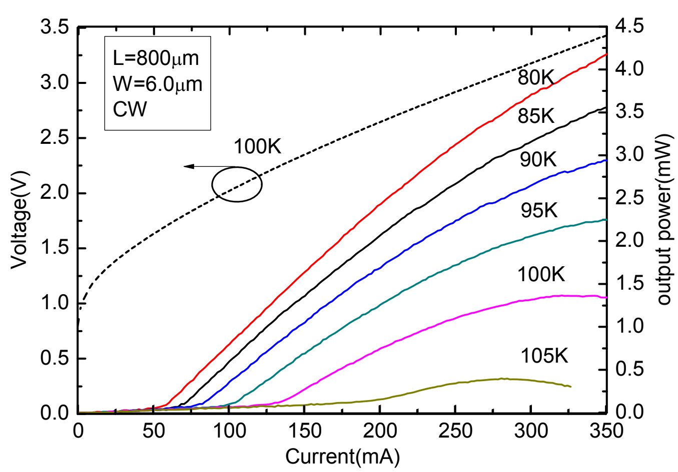


Fig.3. I-P and I-V characteristics of the laser