

## Pressure-tuned resonance Raman scattering and photoluminescence studies on MBE grown bulk GaAs at the $E_0$ gap

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MS received 12 March 1990; revised 6 June 1990

**Abstract.** Hydrostatic pressure has been used to tune in resonance Raman scattering (RRS) in bulk GaAs. Using a diamond anvil cell, both the photoluminescence peak (PL) and the 2 LO and LO-phonon Raman scattered intensities have been monitored, to establish RRS conditions. When the  $E_0$  gap of GaAs matches  $\hbar\omega_S$  or  $\hbar\omega_L$ , the 2 LO and LO-phonon intensity, respectively, exhibit resonance Raman scattering maxima, at pressures determined by  $\hbar\omega_L$ . With 647.1 nm radiation ( $\hbar\omega_L = 1.916$  eV), a sharp and narrow resonance peak at 3.75 GPa is observed for the 2 LO-phonon. At this pressure the 2 LO-phonon goes through its maximum intensity, and falls right on top of the PL peak, revealing that  $\hbar\omega_S(2\text{ LO}) = E_0$ . This is the condition for “outgoing” resonance. Experiments with other excitation energies ( $\hbar\omega_L$ ) show, that the 2 LO resonance peak-pressure moves to higher pressure with increasing  $\hbar\omega_L$ , and the shift follows precisely the  $E_0$  gap. Thus, the 2 LO RRS is an excellent probe to follow the  $E_0$  gap, far beyond the  $\Gamma$ -X cross-over point. A brief discussion of the theoretical expression for resonance Raman cross section is given, and from this the possibility of a double resonance condition for the observed 2 LO resonance is suggested. The LO-phonon resonance occurs at a pressure when  $\hbar\omega_L \approx E_0$ , but the pressure-induced transparency of the GaAs masks the true resonance profile.

**Keywords.** Pressure-tuning; resonance Raman scattering; semiconductors.

**PACS Nos** 62.50; 78.30; 78.55

### 1. Introduction

In resonance Raman scattering (RRS) experiments (Cardona 1982) it is customary to vary the Raman excitation frequency ( $\hbar\omega_L$ ) while the electronic gap energies of the system under study is kept constant. However, it is possible to pressure-tune the electronic gap energies of the material into resonance with a fixed Raman excitation frequency ( $\hbar\omega_L$ ), and observe RRS (Trömmner *et al* 1976; Trömmner and Cardona 1978; Yu and Welber 1978; Holtz *et al* 1989; Aoki *et al* 1984). This method is particularly suited for zinc-blende type semiconductors, since their direct gaps ( $E_0$ ) have large pressure coefficients ( $\sim 100$  meV/GPa). Although GaAs is one of the most extensively studied semiconductors from the point of view of RRS, pressure-induced RRS experiments in bulk GaAs have received cursory attention only.

While carrying out pressure-induced RRS experiments in InGaAs/AlGaAs strained layer multiple quantum well (MQW) structures on GaAs substrates, we encountered a serious interference problem, both in Raman scattering and in photoluminescence