Magneto-Photoluminescence Measurements of $Al_xGa_{1-x}As$ Near the Direct-Indirect Crossover

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Introduction

$Al_xGa_{1-x}As$ is an important semiconductor alloy for a variety of technological applications. The potential to substantially manipulate its optical and electronic properties by tuning the composition around the direct-indirect bandgap transition is attractive for designing new heterostructures with enhanced functionality. In order to probe these effects continuously through the transition, we measured the diamagnetic shift of the photoluminescence (PL) peaks in several $Al_xGa_{1-x}As$ samples above and below the transition composition. Our results show that the alloy bandgap can be switched from direct to indirect under the application of a magnetic field.

Experimental

Photoluminescence (PL) measurements on $Al_xGa_{1-x}As$ ($0.33 < x < 0.41$) samples were performed at the Los Alamos NHMFL with the 60 T Long-Pulse Magnet. Evolution of the PL peaks as a function of magnetic field was probed at 1.6 K using a diode-pumped solid-state laser (515 nm).

Results and Discussion

The diamagnetic shift of the PL peaks in a sub-set of $Al_xGa_{1-x}As$ samples is shown in Fig. 1. Since the low temperature, direct-indirect bandgap transition occurs at $x = 0.384$, samples with compositions of $x \leq 0.376$ are direct gap at zero field, while those with compositions of $x \geq 0.387$ are indirect gap [1]. The strong and weak diamagnetic shifts of the PL peaks are consistent with these assignments. However, the diamagnetic shift of the sample with $x = 0.376$ abruptly changes between the two behaviors at magnetic fields above 40T. This result indicates that the magnetic field has moved the direct Γ conduction band edge above the indirect X band edge, effectively inducing a direct to indirect bandgap transition.

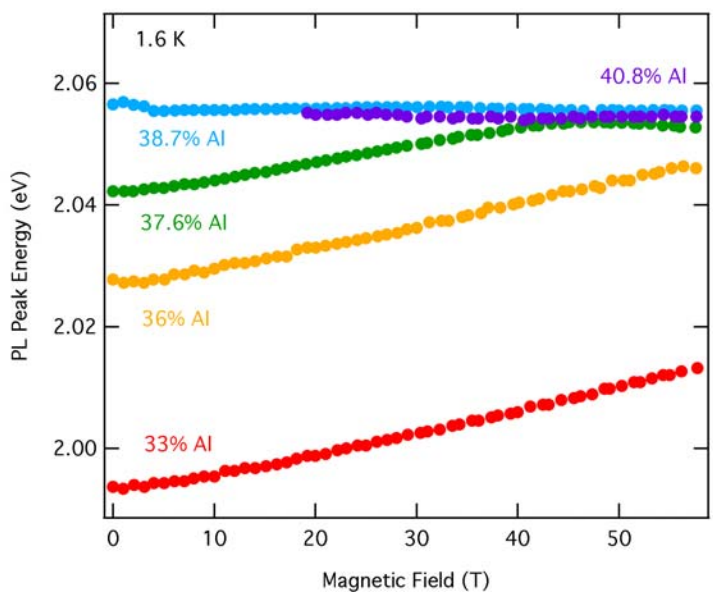

FIG. 1. Diamagnetic shift of $Al_xGa_{1-x}As$ samples with compositions $0.33 < x < 0.41$.

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References

[1] Beaton, D.A. *et. al.*, Appl. Phys. Express, **6**, 071201 (2013)