# Magneto-Photoluminescence Measurements of Dilute $GaAs_{1-x}N_x$

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## Introduction

GaAs exhibits unusual behavior upon the addition of dilute concentrations of N, including a strong drop in the bandgap energy, a sharp reduction in electron mobility and a large rise in the electron effective mass. Nitrogen is known to introduce a resonant level in the GaAs conduction band that modifies the electronic structure. However, bound states associated with N pairs and clusters are also thought to play a role in the transition of this material from isoelectronically-doped GaAs:N to a $GaAs_{1-x}N_x$ alloy. We demonstrate that localized N cluster states undergo an Anderson transition into an extended band of N-supercluster states at 0.23% N and form an associated mobility edge [1]. We additionally demonstrate that high magnetic fields can be used to tune the overlap of the N cluster states and reverse the Anderson transition [2].

## Experimental

Photoluminescence (PL) measurements on $GaAs_{1-x}N_x$ (0 to 0.5% N) samples were performed at the Los Alamos NHMFL with the 60 T Long-Pulse Magnet. Evolution of the PL from extended states as a function of magnetic field was probed at 115 K using a diode-pumped solid-state laser (515 nm), while the behavior of the localized N-cluster states was evaluated at 1.6 K.

## Results and Discussion

Measurements performed at 115 K confirm that the bound N cluster states in samples with N concentrations less than 0.23% show no magneto-dispersion and are localized. The highest energy N cluster states in samples with higher N concentrations, on the other hand, exhibit a magneto-dispersion, suggesting that they form an infinite delocalized supercluster (**Figure 1**) [1]. Furthermore, the application of very high magnetic fields ejects resonant N cluster states from the conduction band as it moves to higher energies [2]. Reduction of the exciton Bohr radius causes further fragmentation of the cluster states, producing sharp peaks in the PL spectra, as shown in **Figure 2**. The ability to controllably adjust the overlap of impurity states via a magnetic field presents a powerful avenue for investigating percolation-induced phenomena in a wide range of materials.

## Acknowledgements

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[1] Fluegel, B., *et al.*, Phys. Rev. B, **86**, 205203 (2012).
[2] Alberi, K., *et al.*, submitted to Phys. Rev. Lett, (2012).

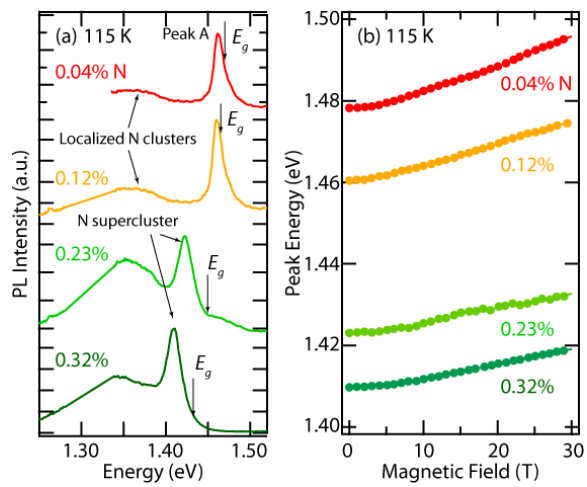


**Figure 1.** (a) 0 T spectra of select $GaAs_{1-x}N_x$ samples. The bandgaps, $E_g$, as measured by electroreflectance, are marked with arrows. The PL peaks in samples with 0.23% and 0.32% N correspond to N superclusters (b) PL peak energy as a function of applied magnetic field. The dispersion of the N supercluster peaks suggests that these states are delocalized.

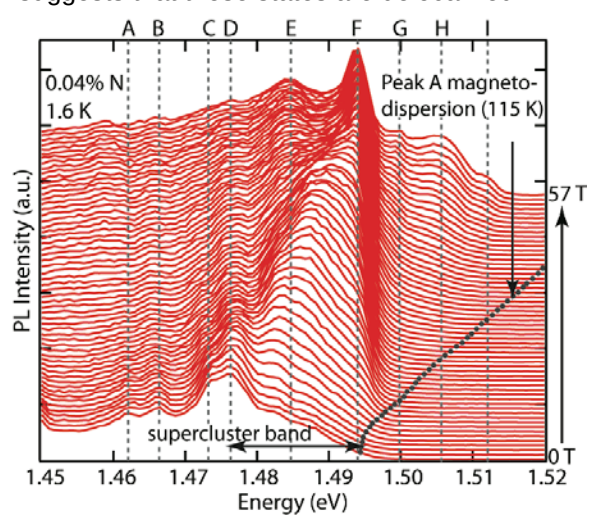


**Figure 2.** Magneto-PL spectra of the $GaAs_{1-x}N_x$ sample with 0.04% N. The magneto-dispersion of peak A in Fig. 1 (measured at 115 K and shifted in energy to account for the temperature difference) is marked by black dots.