# Potential fluctuations and siteswitching in Si-doped GaAs studied by photoluminescence

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# Introduction

We report on a photoluminescence (PL) study of highly compensated Si doped GaAs:

- Si-doped GaAs layers were grown $p-$type at 700°C by liquid phase epitaxy (LPE) and subsequently converted to n-type by thermal annealing at temperatures above a transition temperature of about 840°C
- Annealing at temperature close to the transition temperature resulted in change in the compensation ratio as well as the conduction mechanism
- The change in compensation was verified by a change in the shift of PL bands with increased excitation intensity

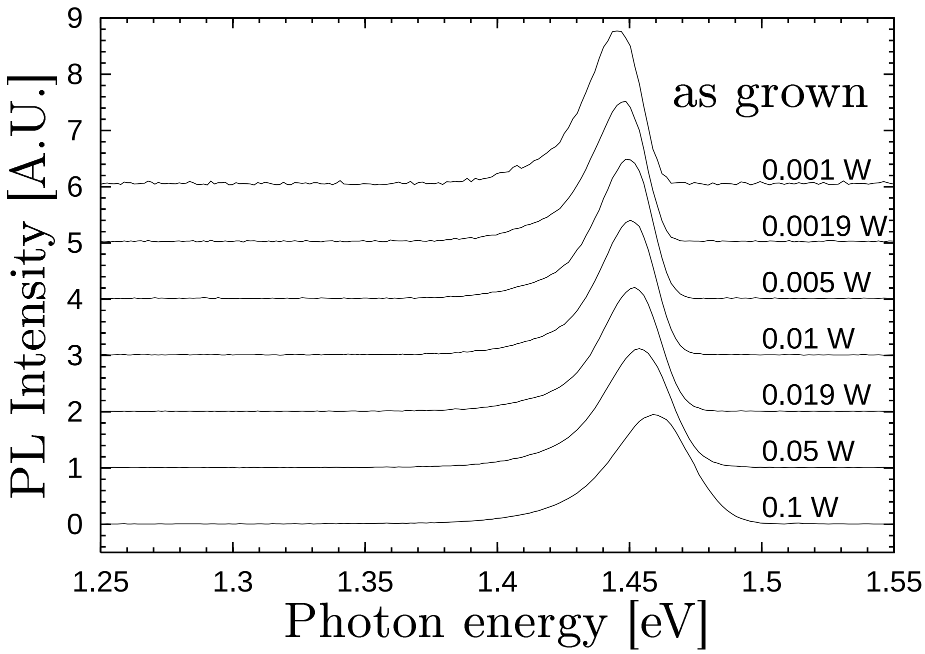
# Experiment

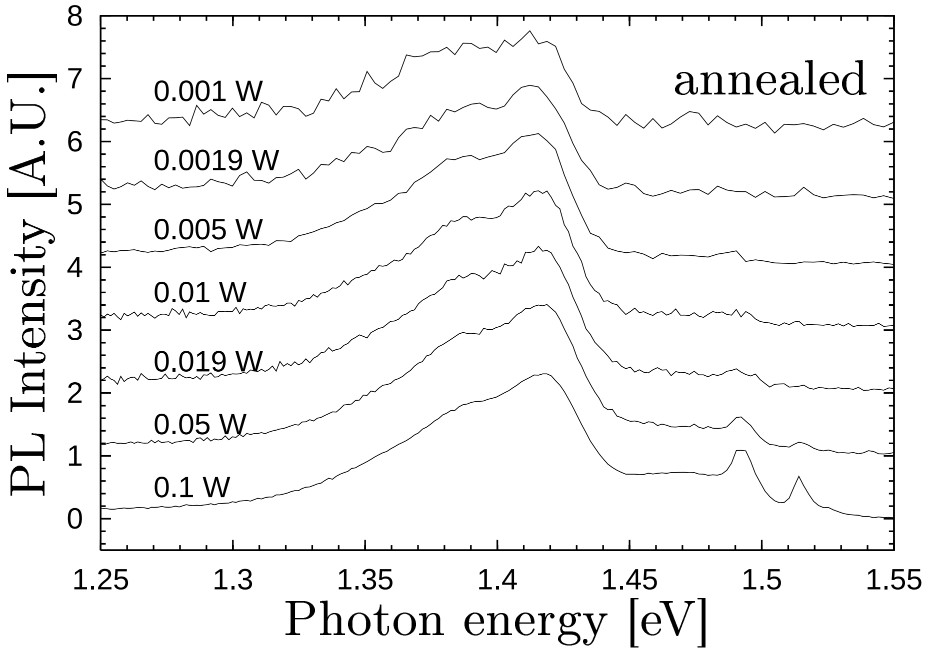
- Photoluminescence (PL) measurements were performed at 14 K using a closed-cycle He cryostat. The 532 Å line of a Verdi Nd:YVO4 laser was used as an excitation source
- The excitation intensity was varied over several decades and the PL signal was detected via a double 0.85 m Spex 1404 grating monochromator using a cooled Ge detector
- The majority charge carrier type and the free carrier concentration at room temperature were obtained by Hall measurements
- Two $p-$type samples, one grown to have low Si concentration and another with high Si concentration were studied

$$\frac{[\mathrm{Si}]_{\mathrm{high}}}{[\mathrm{Si}]_{\mathrm{low}}} \approx 20$$

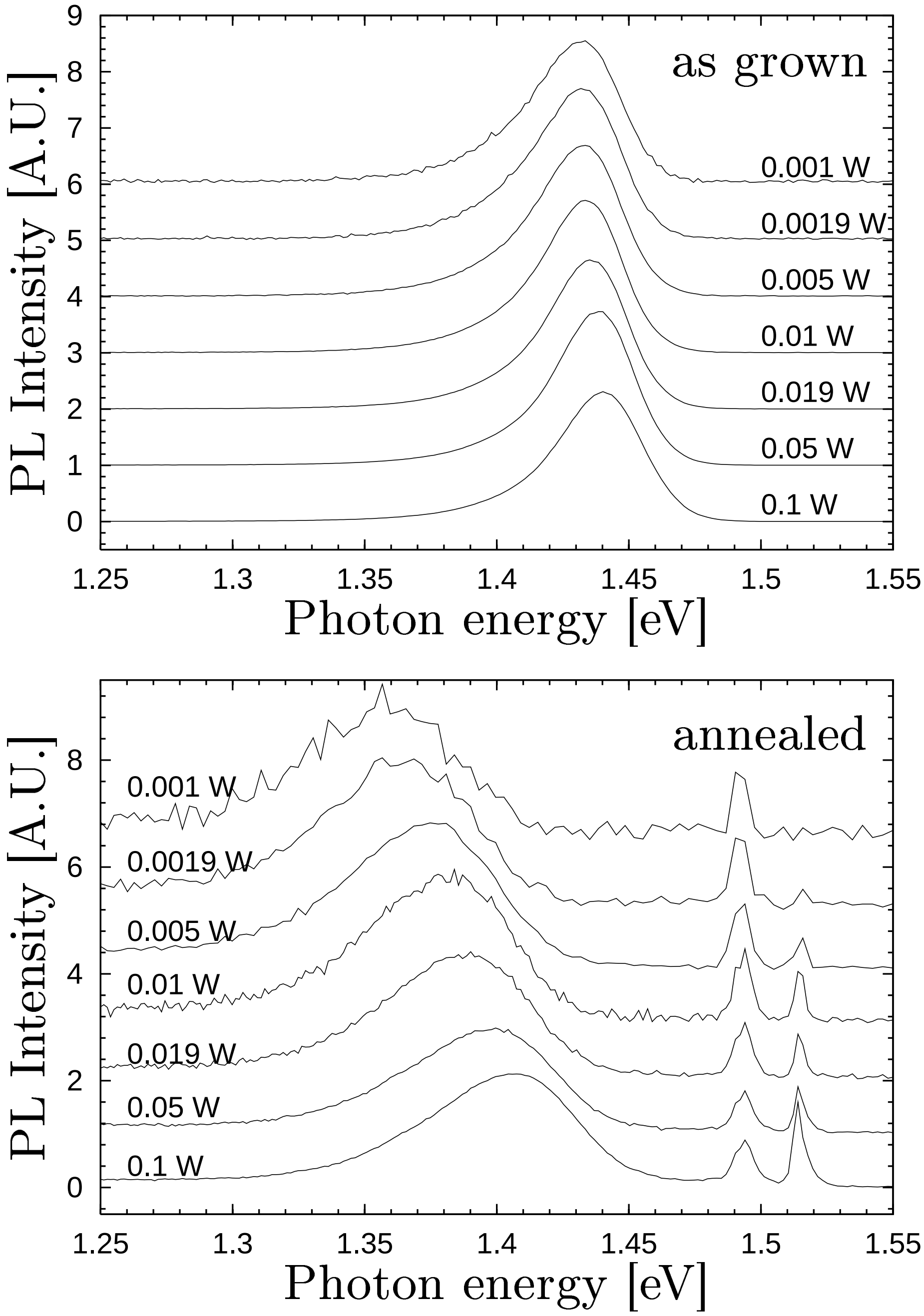
- The as-grown LPE samples were baked in quartz ampoules at 840°C under As pressure ($\sim$ 1 atm) for 24 h with subsequent quenching in liquid nitrogen
- By annealing $p-$type samples at temperatures around the transition temperature, they are converted to n-type
- List of samples used in the investigation and their Hall concentration

| Sample | Material | $n/p$ [cm$^{-3}$] |
|---|---|---|
| 1 | As-grown | $p = 1.6 \times 10^{17}$ |
| 1a | Annealed | $n = 3.9 \times 10^{17}$ |
| 2 | As-grown | $p = 2.0 \times 10^{18}$ |
| 2a | Annealed | $n = 1.9 \times 10^{17}$ |

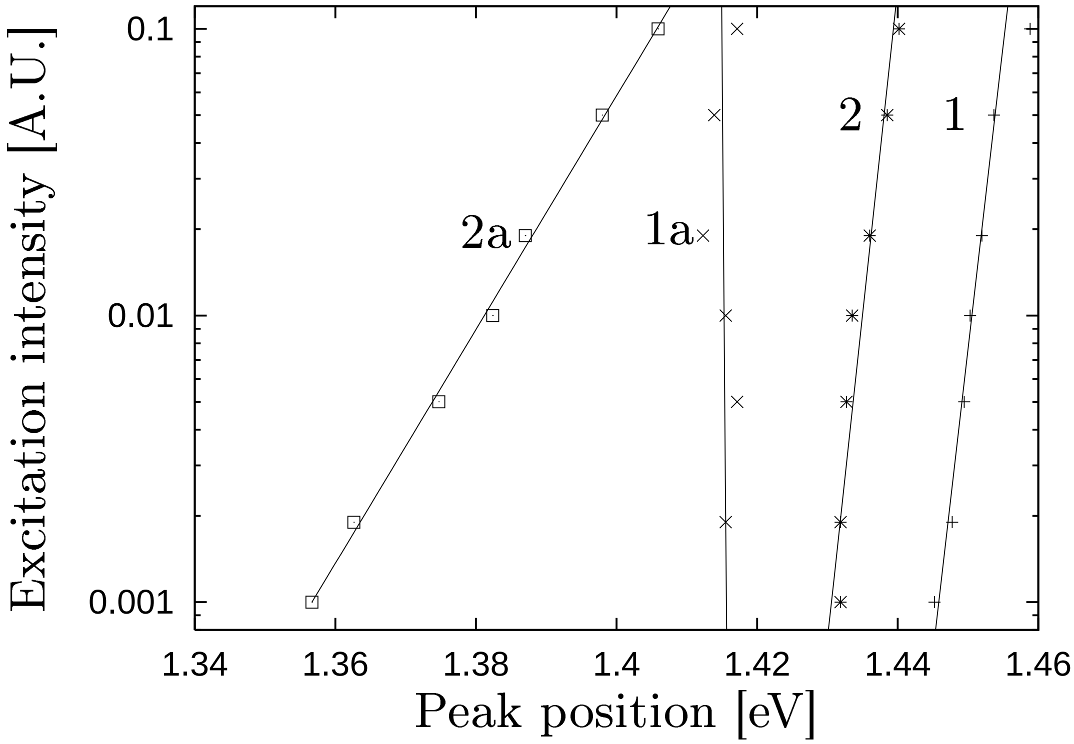



- Normalized photoluminescence spectra measured at 14 K for LPE grown GaAs with low Si concentration (sample 1)




- Normalized photoluminescence spectra measured at 14 K for LPE grown GaAs with high Si concentration (sample 2)




- PL peak position for different excitation intensity for the four samples
- The slope of each curve represents the shift rate with excitation intensity

| Sample | Material | PL peak shift |
|---|---|---|
| 1 | As grown | 5 meV/decade |
| 1a | Annealed | $\sim$ 0 meV/decade |
| 2 | As grown | 4 meV/decade |
| 2a | Annealed | 24 meV/decade |

# Conclusion

We studied the siteswitching of Si in GaAs by photoluminescence

- The conduction type of as-grown p-type samples is converted to n-type by annealing
- We have correlated the observation of potential fluctuations with possible site switching of Si from As sites to Ga sites
- A large shift of PL bands with increased excitation intensity was observed in highly Si doped GaAs sample after annealing

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