The effect of Si site-switching in GaAs on electrical properties and potential fluctuation

H. G. Svavarsson, J. T. Gudmundsson, G. I. Gudjonsson and H. P. Gislason[1]

Science Institute,

University of Iceland,

Dunhaga 3,

IS-107 Reykjavík,

Iceland,

[1]**haflidi@hi.is**

Introduction

We report on Hall and conductivity measurements and 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 converted to n-type by thermal annealing under As pressure ($\sim$ 1 atm) at 840°C
- Annealing at temperature close to the transition temperatures resulted in a change in the compensation ratio and conduction mechanism
- The compensation ratio was monitored through the shift rate of the PL bands with increased excitation intensity
- Comparison was made with Si-doped GaAs layers grown at 840°C LPE

Experiment

- The Hall concentration and conductivity were measured in the temperature range 50–300 K
- Photoluminescence measurements were performed at 14 K using a closed-cycle He cryostat. The 5320 Å line of a Verdi Nd:YVO4 laser was used as 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
- Two series of samples, one grown to have low Si concentration and another with high Si concentration were studied

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

Experiment

- Samples used in the investigation
  Their Hall concentration and Hall mobility

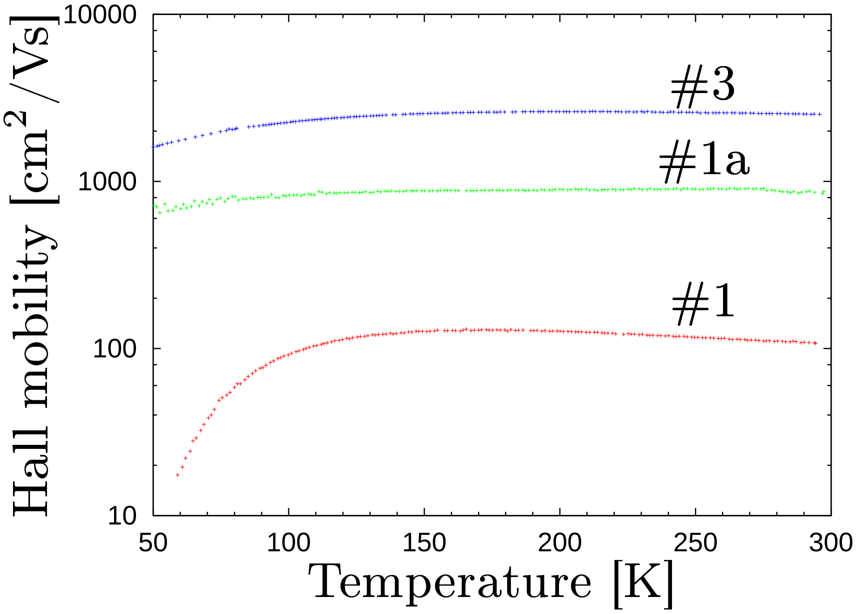
- Low silicon concentration

Sample	Carrier conc. $[\mathrm{cm}^{-3}]$	Shift [meV/dec.]	Mobility $[\mathrm{cm}^2/\mathrm{Vs}]$
#1	$p = 1.6 \times 10^{17}$	6	110
#1a	$n = 3.9 \times 10^{17}$	2-5	880
#3	$p = 1.4 \times 10^{16}$	8	2500

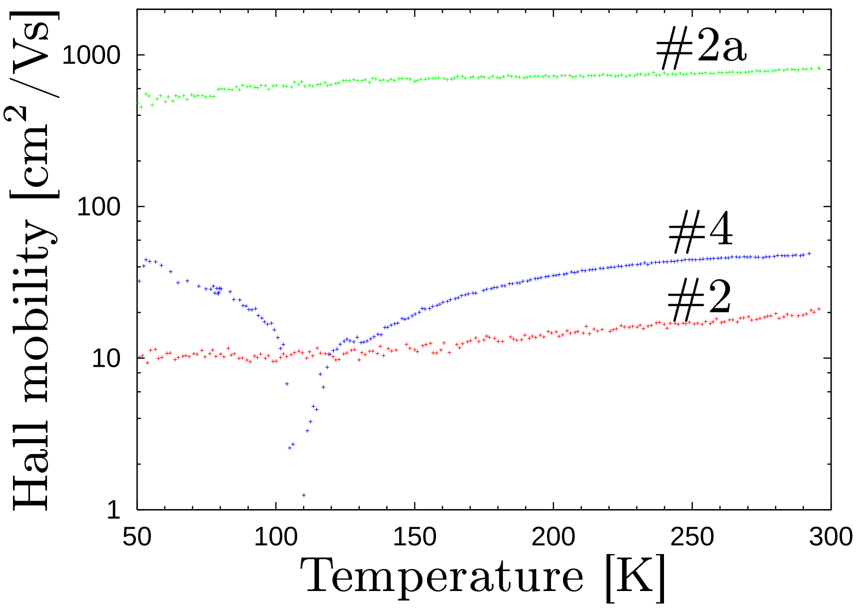
- High silicon concentration

Sample	Carrier conc. $[\mathrm{cm}^{-3}]$	Shift [meV/dec.]	Mobility $[\mathrm{cm}^2/\mathrm{Vs}]$
#2	$p = 2.0 \times 10^{18}$	5	20
#2a	$n = 1.9 \times 10^{17}$	24	820
#4	$n = 3.9 \times 10^{17}$	8	50

Hall mobility

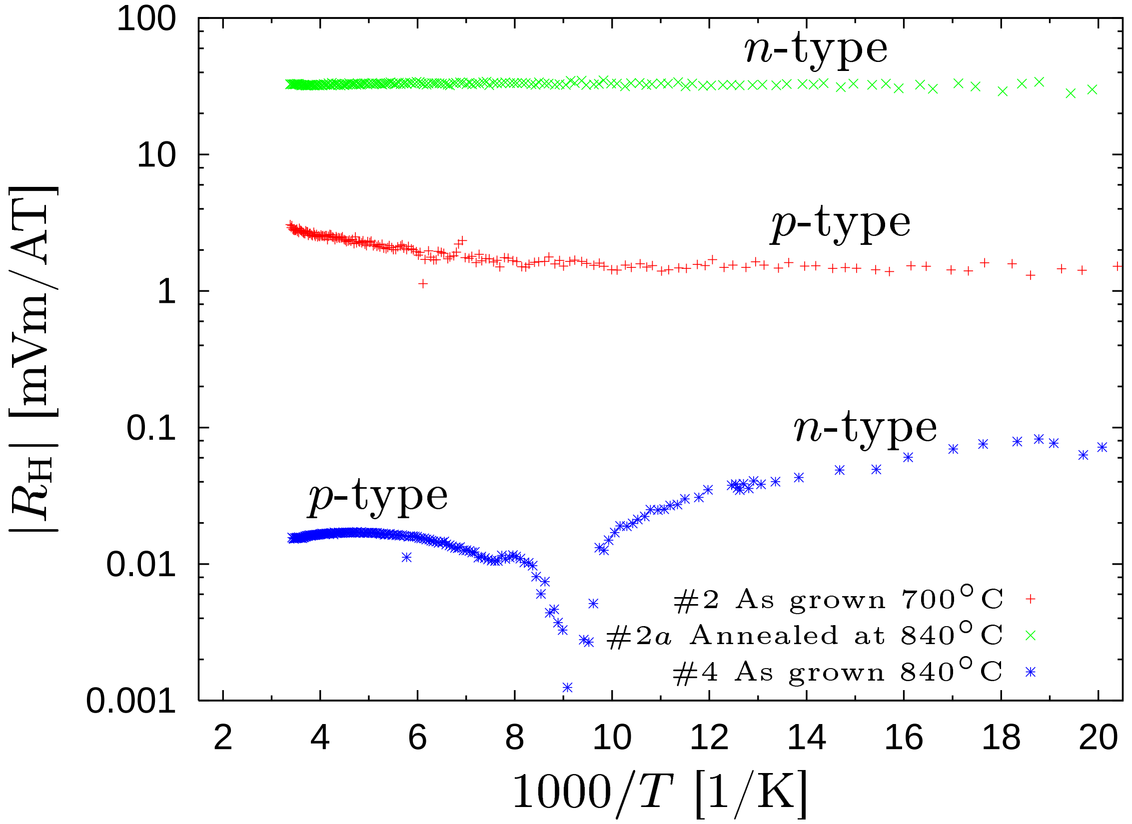


- The Hall mobility – low Si-concentration



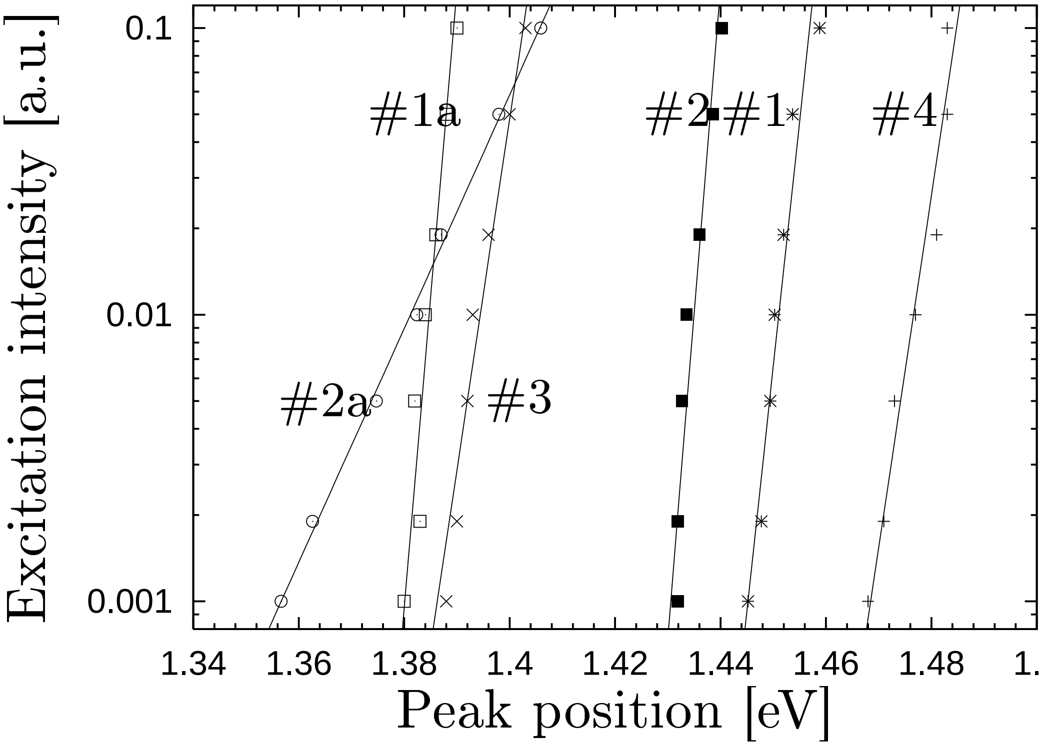
- The Hall mobility – high Si-concentration

Hall coefficient



- Sample #2, grown at 700°C, is p-type and after annealing it becomes n-type with roughly an order of magnitude higher Hall mobility (sample #2a)
- The highly doped sample #4 grown at 840°C, exhibits p-type behavior at elevated temperatures but n-type behavior below 105 K

Photoluminescence



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

Conclusion

We studied the site-switching of Si in GaAs by photoluminescence and Hall measurements

- The conduction type of as-grown p-type samples is converted to n-type by annealing accompanied with a large increase of the Hall mobility
- Higher Si-concentration raises the p/n transition temperature
- We correlated the observation of potential fluctuations with a possible site-switching of Si from As sites to Ga sites

This research was supported by the Icelandic Research Council and the University Research Fund.