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“Photoluminescence Investigation of Bulk GaAsBi on GaAs”

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Outline

- Introduction
- Wafer Details
- GaAsBi HRXRD
- Power Dependent PL
- Temperature Dependent PL
- Room temperature FWHM
- Summary

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Introduction

- Bi-containing alloy for optoelectronics and spintronics devices.
- We want devices to be cheap, reliable, temperature insensitive etc.
- PL to assess GaAsBi quality.

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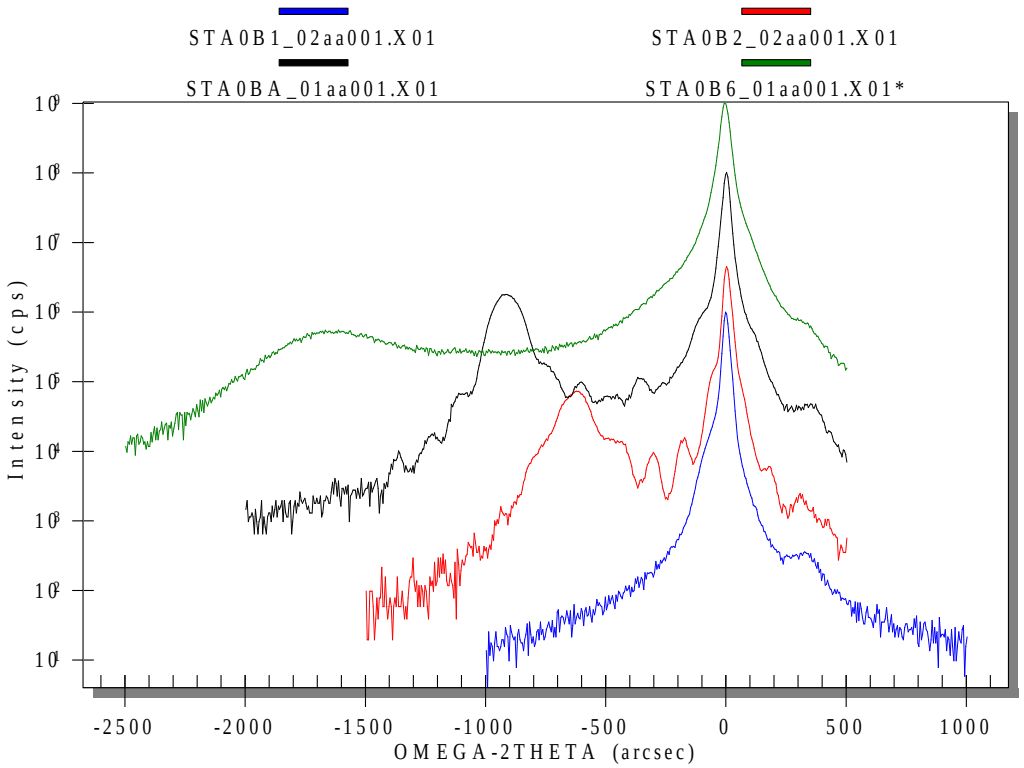
Wafer Details

- Omicron STM-MBE
- Wafer size: 3.5 x 5 mm
- Ga assisted oxide removal to avoid thick buffer.

Material	Thickness (nm)
GaAs cap	80
$GaAs_{1-x}Bi_x$	160
GaAs buffer	80
S.I or n+ (100) GaAs substrate	

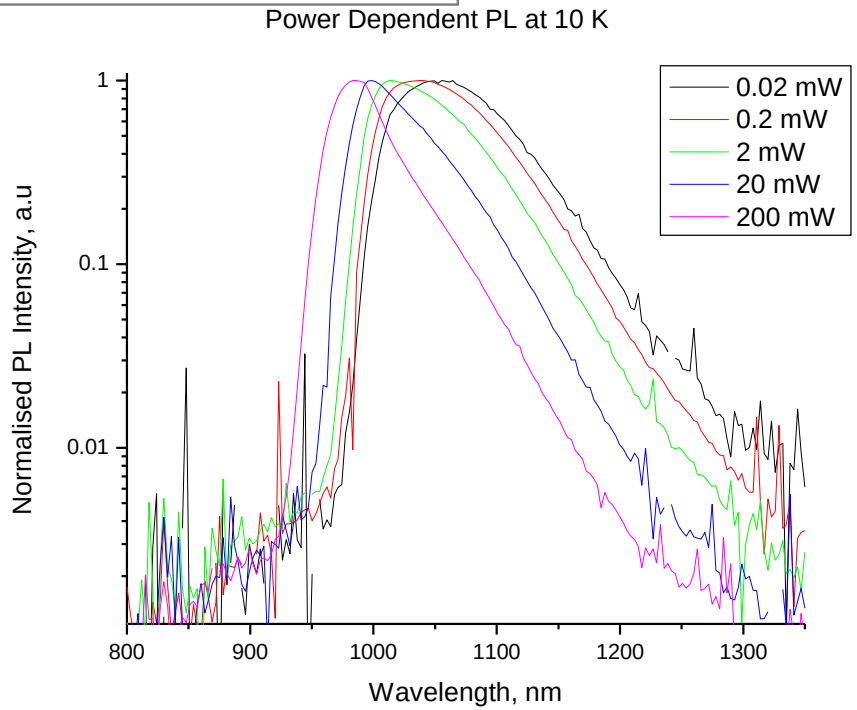
GaAsBi HRXRD

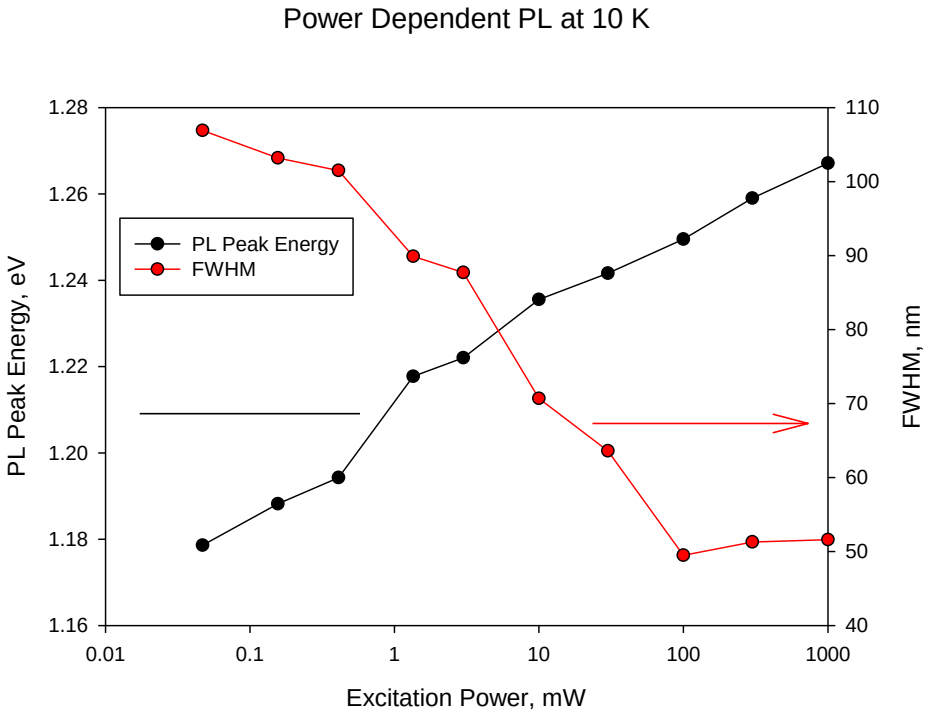


Sample	Bi content
B1	0
B2	0.022
BA	0.032
B6	0.058

- [Bi] = 0 – 0.058
- Fringes clearly observed for [Bi] = 0.032
- No traces of Bi on non-Bi wafers grown afterwards.

Power dependent PL





- At RT, PL peak energy is independent of the excitation power.
- PL peak energy is blue-shifted with increasing power at 10 K.
- FWHM reduces as power is increased at 10 K.

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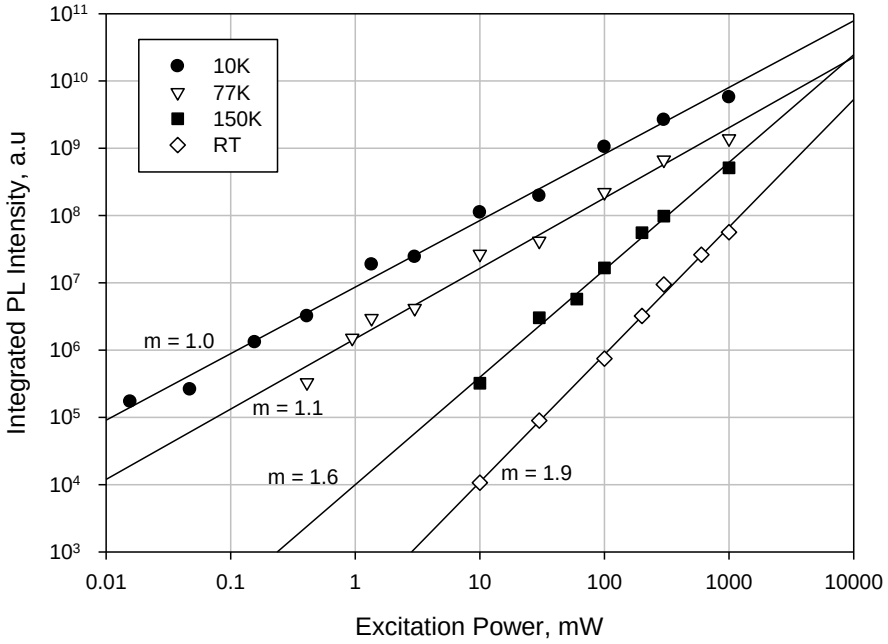
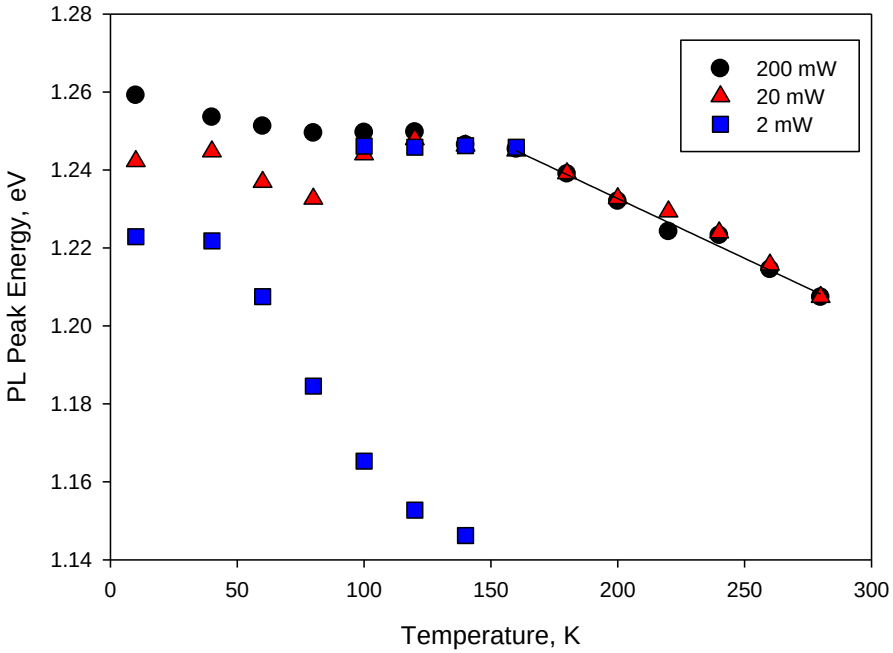
Power dependent PL



- At 10 K, radiative recombination is dominant (m=1).
- Non-radiative recombination dominated at RT (m~2).
- Mixture of both at intermediate temperatures (m=1-2).

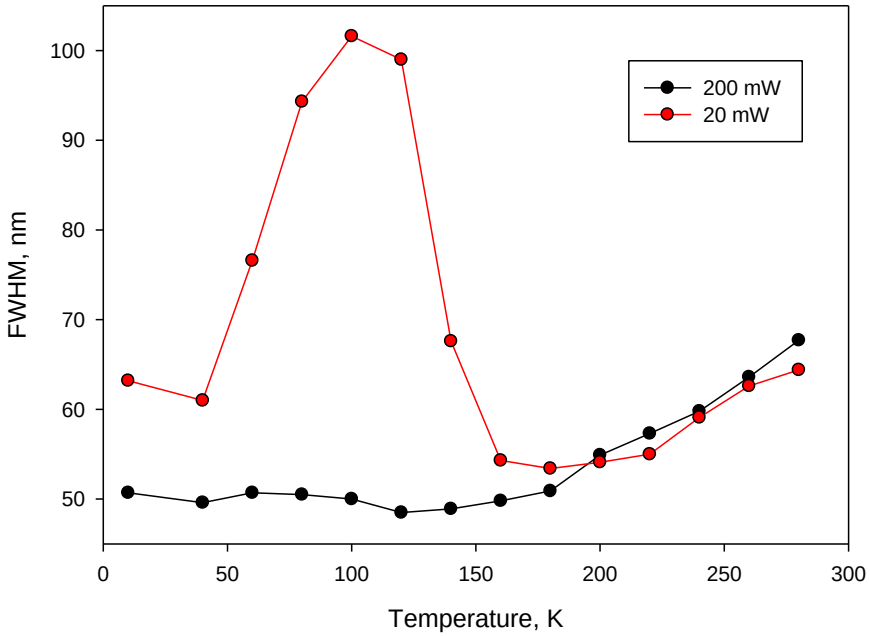
Temperature dependent PL



Source	Bi content	*a* (meV/K)
GaAs	0	0.46
Pettinari *et al*	0.019	0.36
Sheffield BA	0.032	0.31
Imhof *et al*	0.04-0.05	0.27

- S-shape behaviour observed – localisation.
- Localisation potential = 15 meV.
- Expect *a* to decrease with increasing [Bi]. (GaNAsBi; 0.15 meV/K, [Bi]=0.026).
- Origin of peak at 1.22 eV (10 K) is unknown.

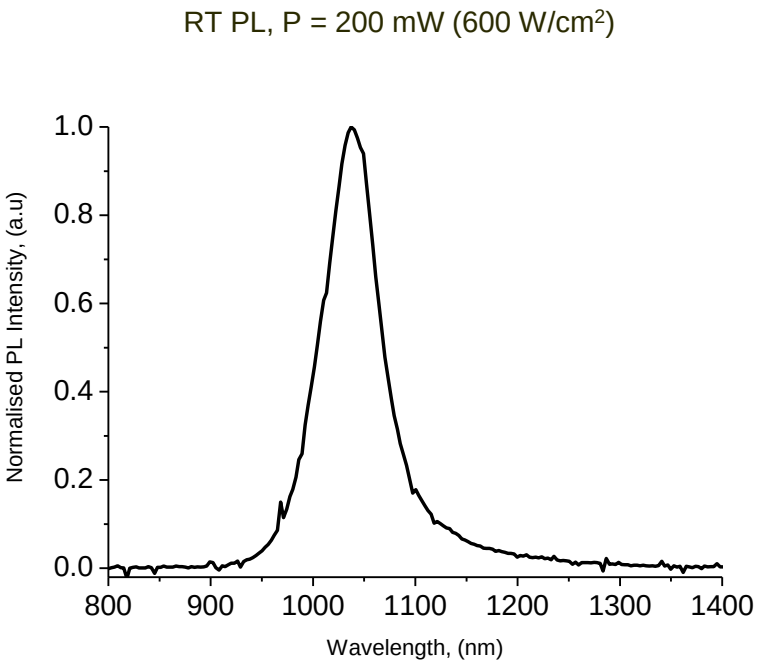
Temperature dependent FWHM



- FWHM maxima due to increase in exciton mobility.
- kT@160 K = 14 meV. Consistent with localisation energy (15 meV).
- FWHM increase at T>160 K due to thermal distributions and phonon scattering.

Room Temperature FWHM

Source	Bi content (%)	FWHM (nm)	λ_p (nm)
Tixier *et al* 2003	0.013	101	979
Lu *et al* 2009	0.014	85	-
Sheffield B2	0.022	69 (45@10K)	990
Lu *et al* 2009	0.023	107	1016
Bertulis *et al* 2006	0.029	195	1055
Tixier *et al* 2003	0.031	118.8	1078
Sheffield BA	0.032	65 (51@10K)	1038
Lu *et al* 2009	0.036	130	-



- FWHM of 65 nm (75 meV) > ~45 meV due to thermal distribution broadening. Wide FWHM is due to Bi fluctuations.
- Narrowest RT FWHM compared with reported values in literature.

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Conclusions

- HRXRD shows clear fringes for [Bi] up to 3.2%, indication of good interface.
- Radiative recombination is dominant at 10 K while non-radiative recombination dominated at RT. Mixture of both at intermediate temperatures.
- Evidence of localisation effects:

  - PL peak energy dependent on excitation power.

  - S-shape with localisation potential of 15 meV.

  - FWHM peaking at 100 K.
- a = 0.31 meV/K between 150 K <T< 280 K.
- Demonstrated $GaAs_{0.973}Bi_{0.032}$ with FWHM = 65 nm (75 meV) at RT. Possibility of growing high quality GaAsBi.


Questions