GaN UV Detectors for Protein Studies

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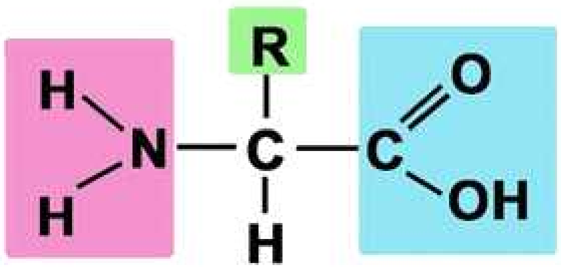
Outline

- Background + Motivation
  - Proteomics, Circular Dichroism
- GaN over Si as a UV detector
- July 2004 Status (A. Blue talk IWORID6)
- New material investigated + detector design
- Detector characterisation
- Results
  - I-V curves, Spectral Response Curves
- Fabrication of the 46 channel array detector + current status
- Conclusion

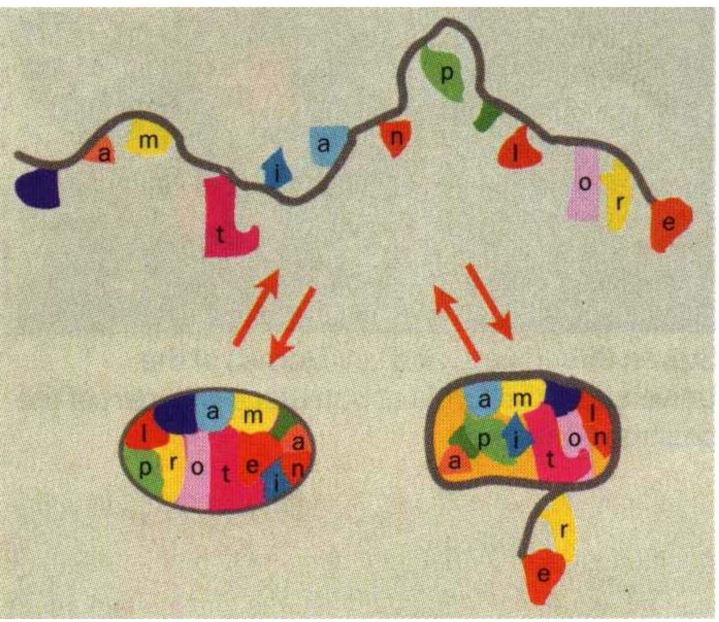
Background & Motivation

- Proteomics – the study of the full expression of proteins by cells in their lifetime



- Proteins are chains of amino acids

- For amino acids to form a protein the extended chain of amino acids must "fold" into a compact globular object with exactly the right shape

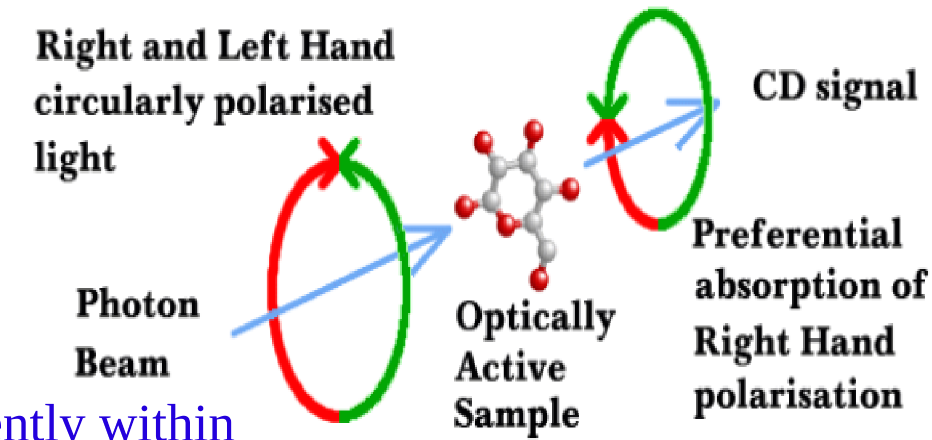


- We would like to know more about the "dynamic" and folded structures

- Offers insight to diseases such as Alzheimer's disease and Cystic fibrosis, caused by "mis-folding" of proteins

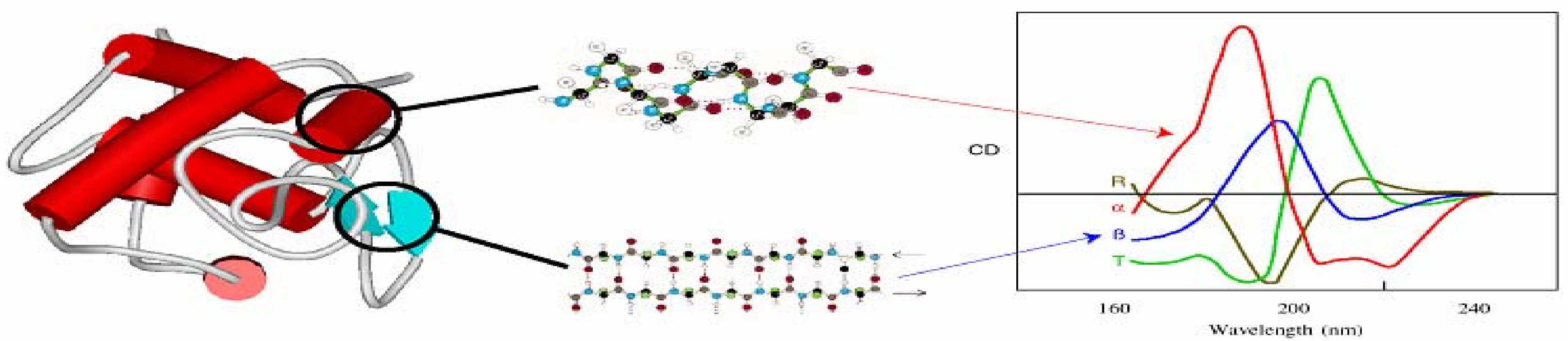
Circular Dichroism (CD)

CD is the measurement of the difference in absorption between left and right circularly polarised light as it passes through a medium



- A few characteristic patterns occur frequently within folded proteins
- These recurring shapes are called secondary structure

Different secondary structure types have characteristic CD spectra



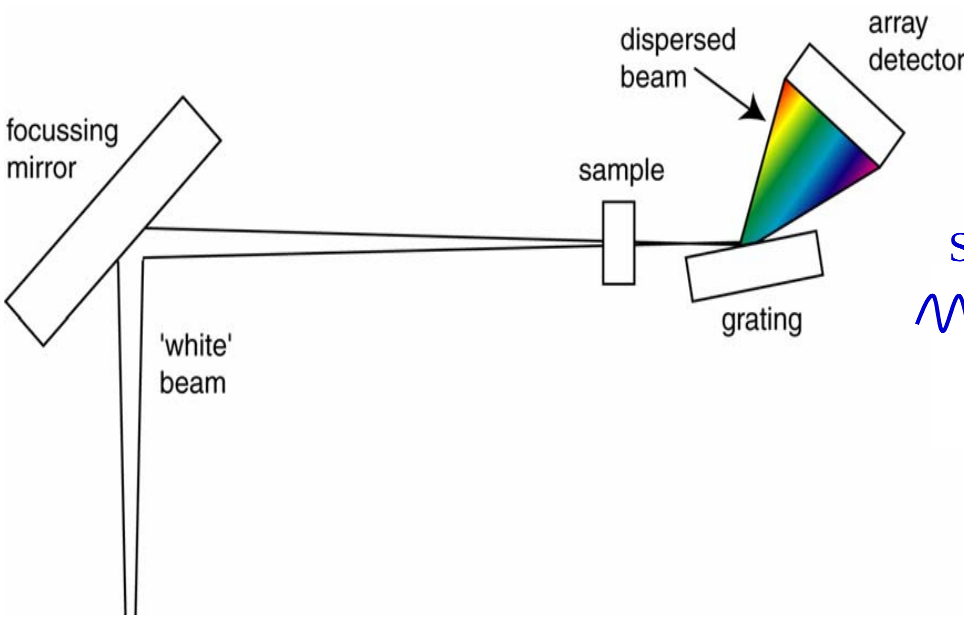
CD Experimental Set-up

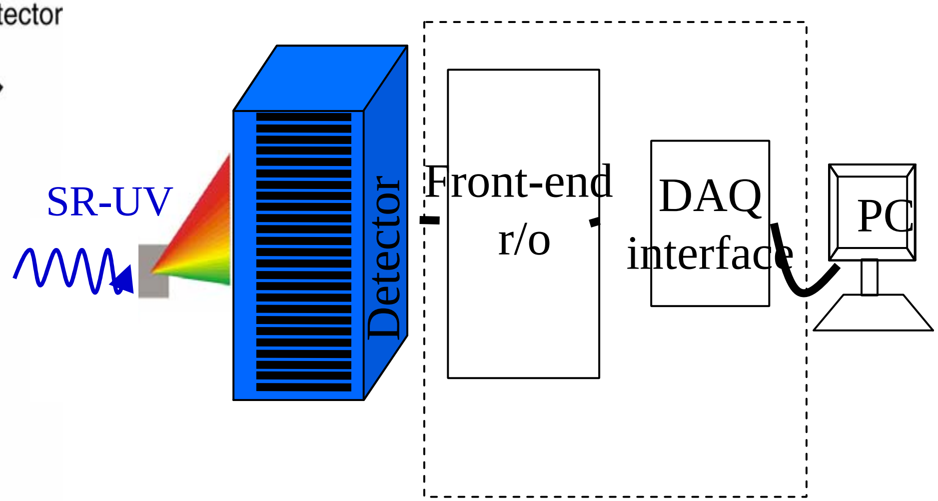
Old Method

- Measure CD at a λ
- Time consuming + Use high amounts of protein

New Method

- Use Array to measure all λ simultaneously
- Require design for diode with 46 channels





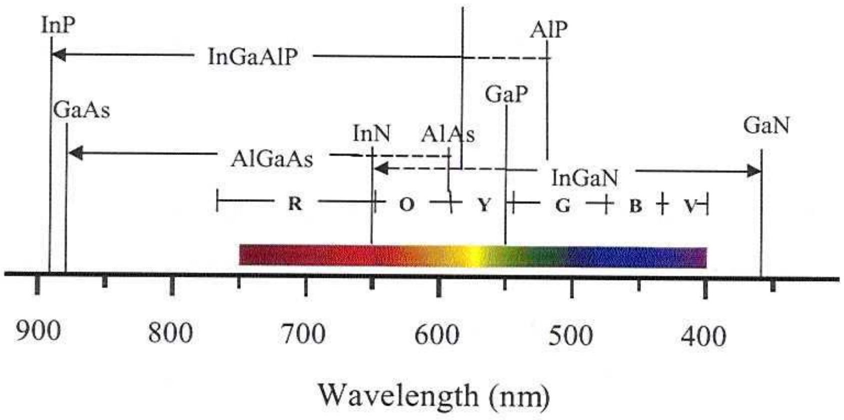
Properties of GaN

- Compound Semiconductor
- Direct Wide Bandgap (~3.4eV)
- Solar Blind Material (λ_{cut} ~ 360nm)

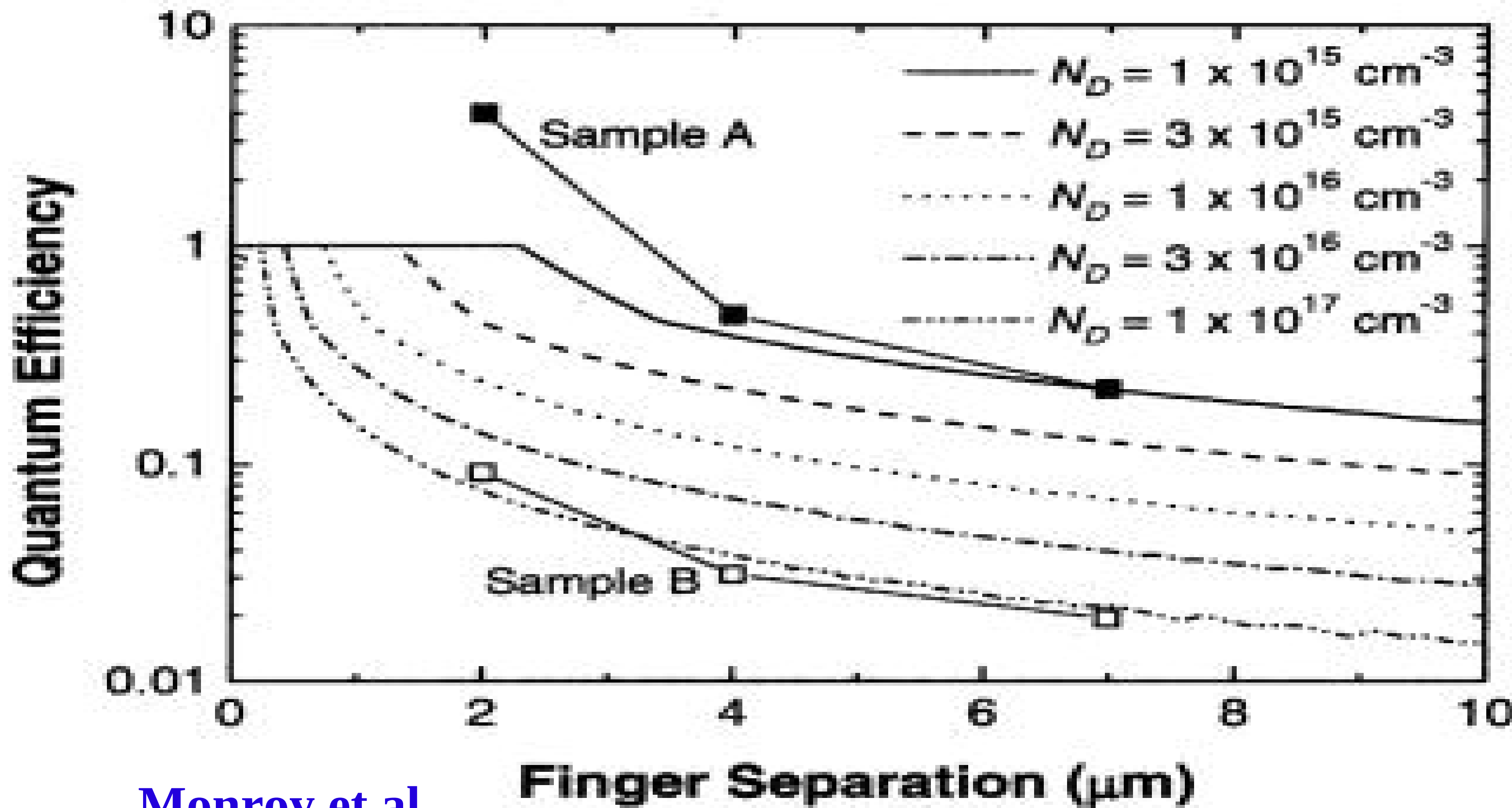
=> Higher SNR for UV than for Si.

=> Ideal Material for UV detectors

Also applications in blue and UV wavelengths such as lasers and high-brightness LEDs.



July 2004 Status



Monroy et al.

- **Conclusion: Need smaller finger widths/spacings.**

Materials + Detector Design

- 6 different materials investigated

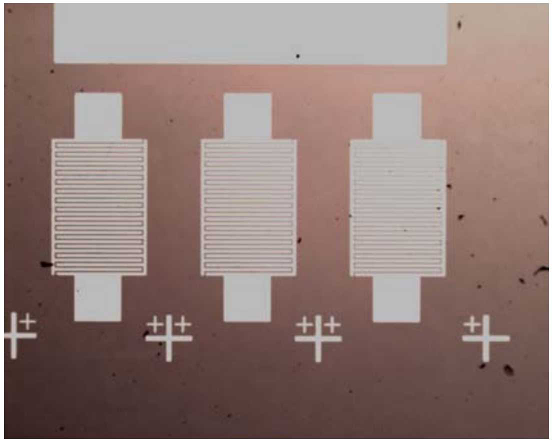
  -4 epitaxial GaN wafers grown on a sapphire substrate. Epitaxial region 2.5µm thick

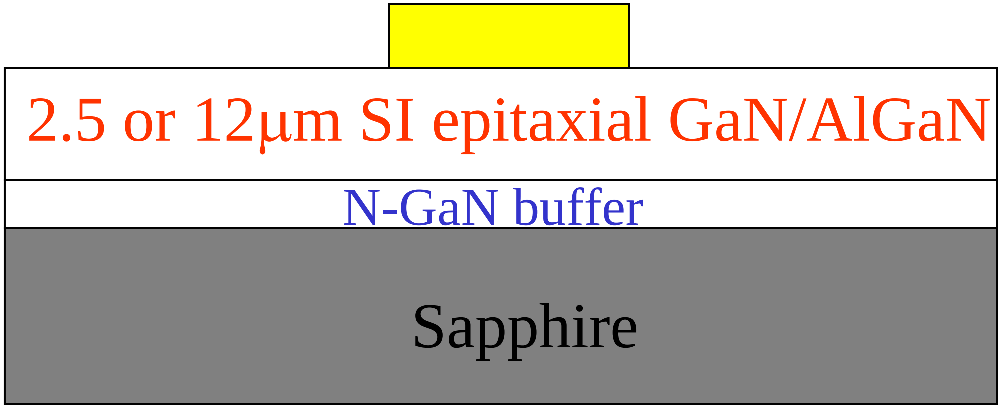
  - 1 epitaxial GaN wafer grown on a sapphire substrate. Epitaxial region 12µm thick

  - 1 epitaxial AlGaN wafer grown on a sapphire substrate. Epitaxial region 2.5µm thick

- MSM interleaving finger design. Pd/Au metal deposited.
- Two different detector designs fabricated and characterised on each material.

  - 5µm and 10µm finger width/spacing

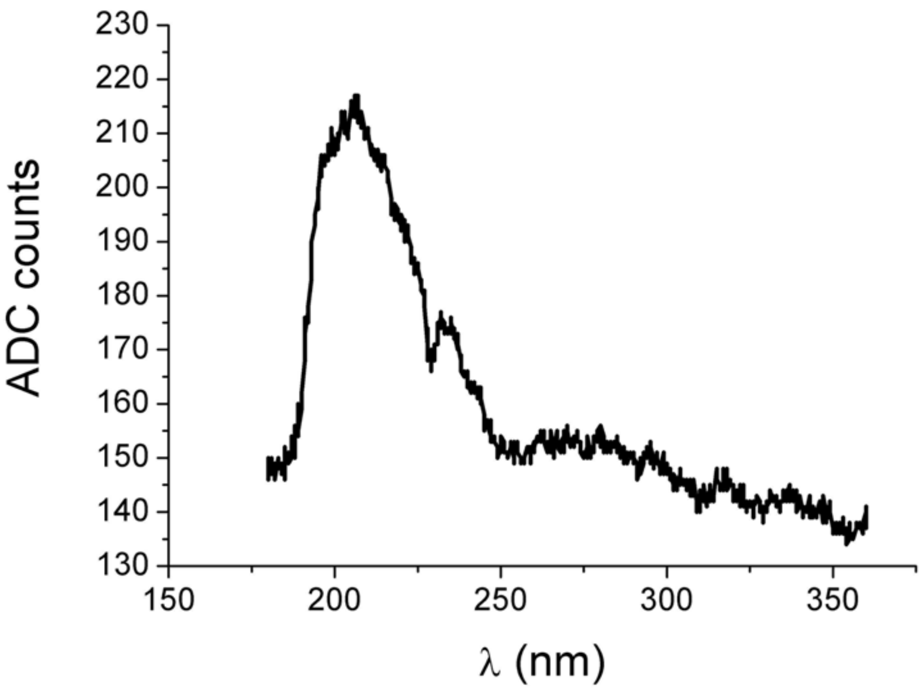


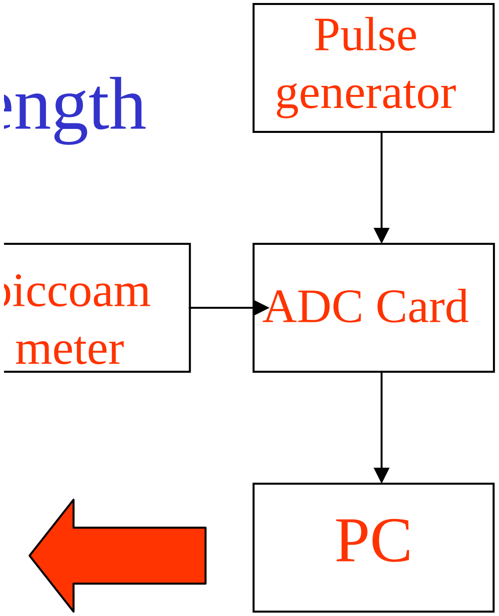


Detector Characterisation

- I-V measurements performed using a Keithley 237 measurement unit
- Spectral response measurements using

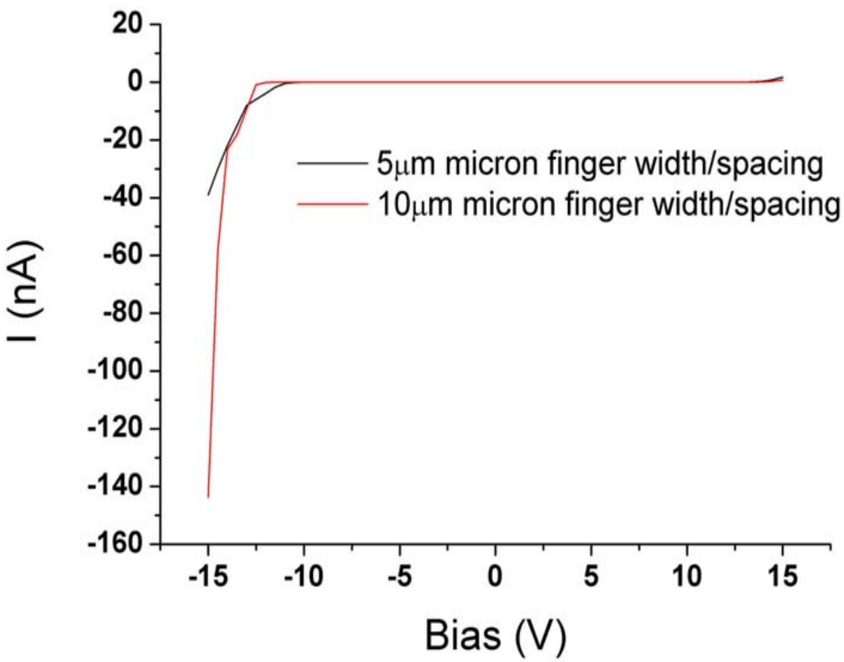
ngth

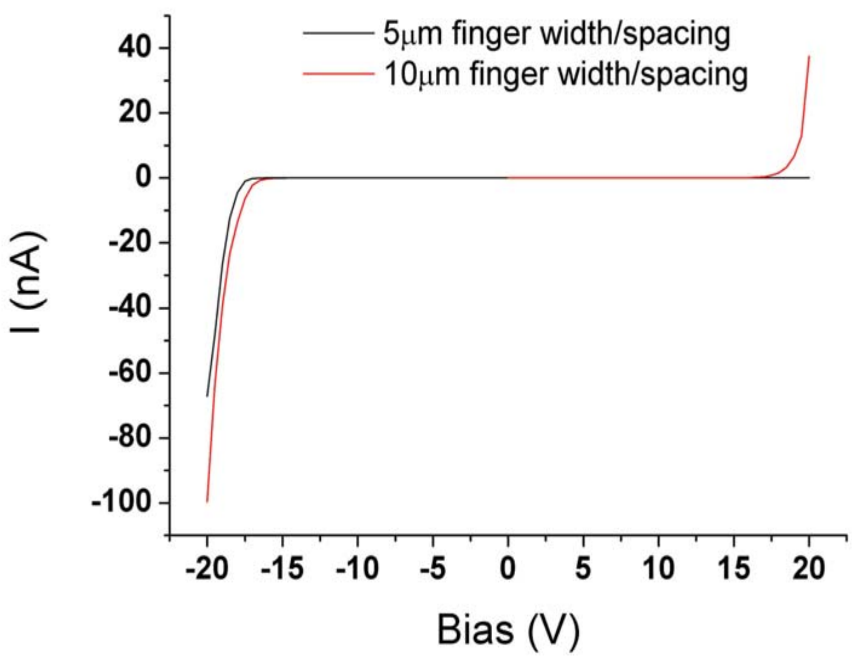




I-V Curves

- Show results from 2 wafers. Both are 2.5µm thick epitaxial GaN known as “36GaN”, “45GaN”

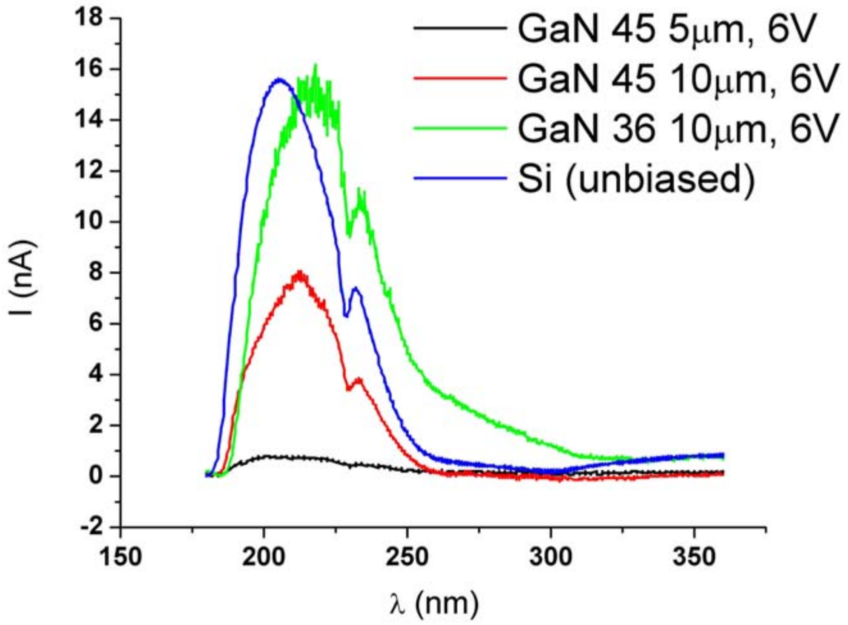


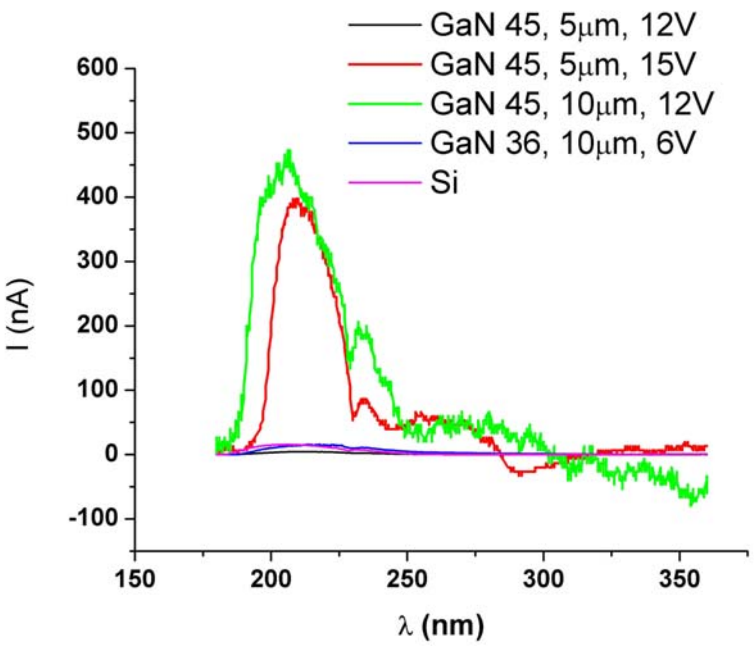


- 36GaN material on left, 45 GaN material on right.
- Almost identical I-V characteristics!
- This is expected since both designs have ~ the same metal contact area

Spectral Response Results

- Compared GaN detectors to a Hamamatsu Si photodiode
- GaN detectors have an active area 1/9 that of the Si photodiode.

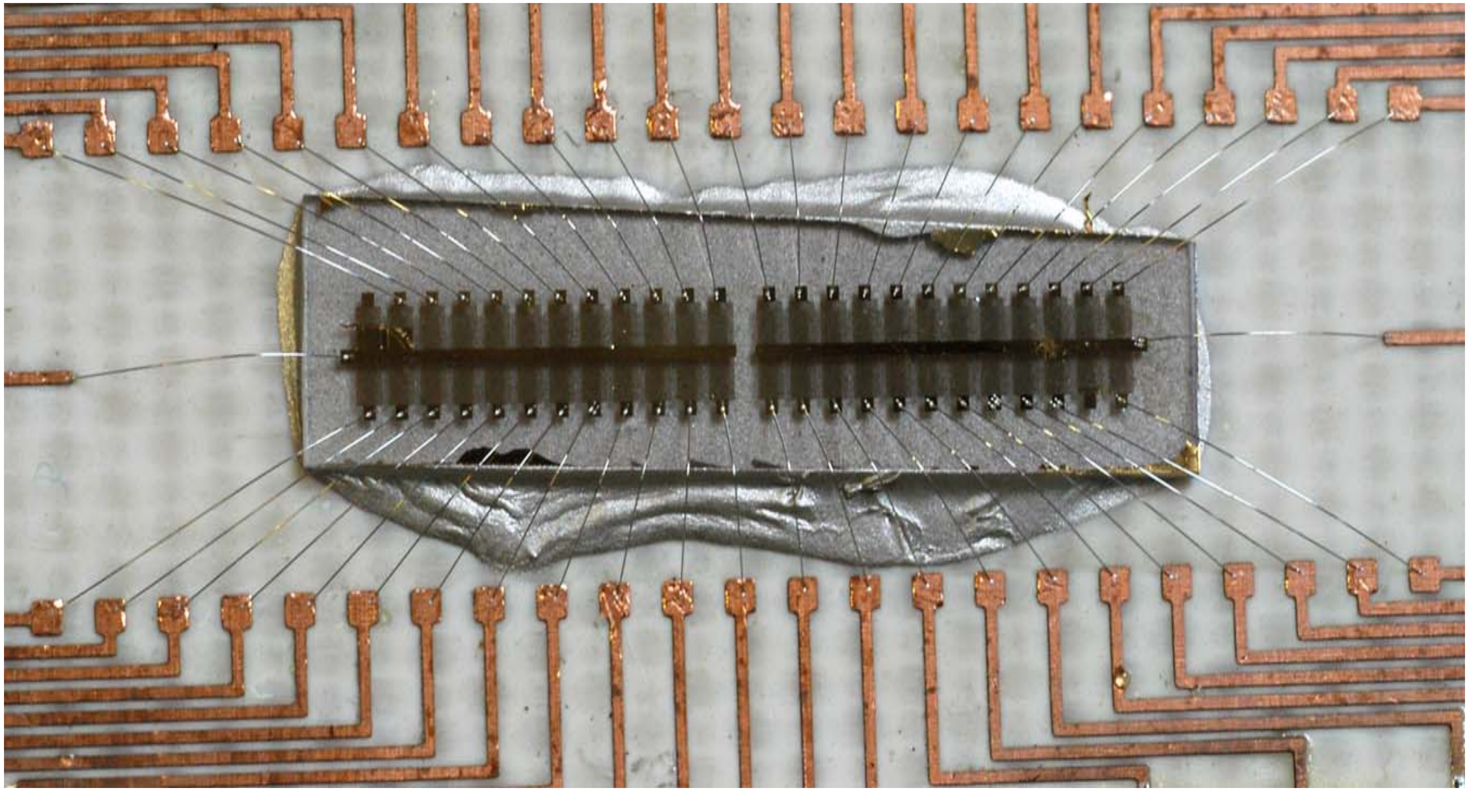




- Response from detectors at 6V applied bias
- Maximum response from detectors

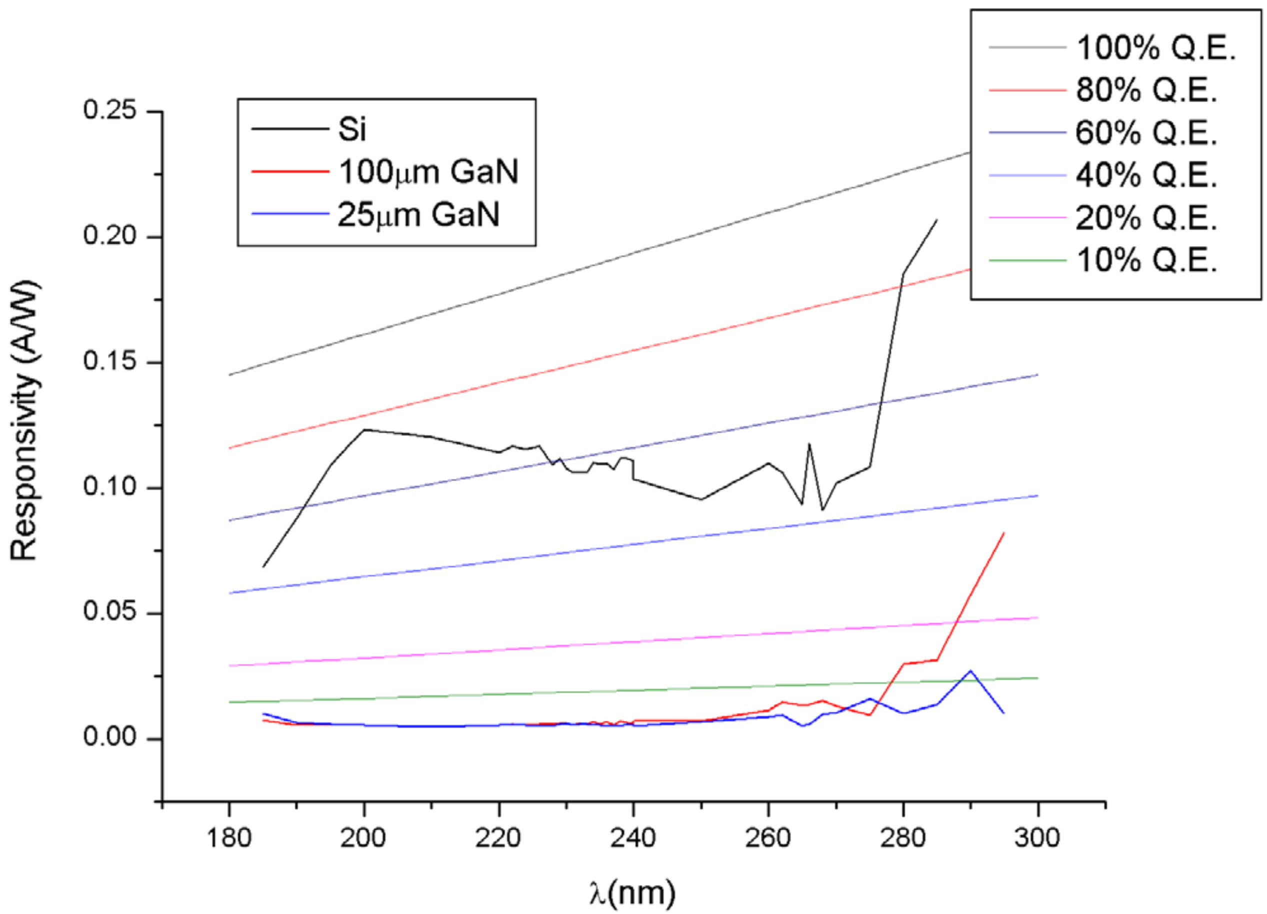
Discussion

- Best Detectors made on 45GaN material
- Not much difference in performance between the 5μm and 10μm finger width/spacing designs
- Decided to use the 10μm design for the 46 channel array detector. Easier to fabricate!

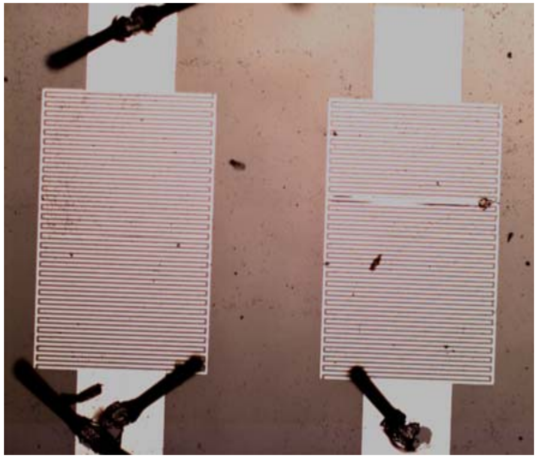


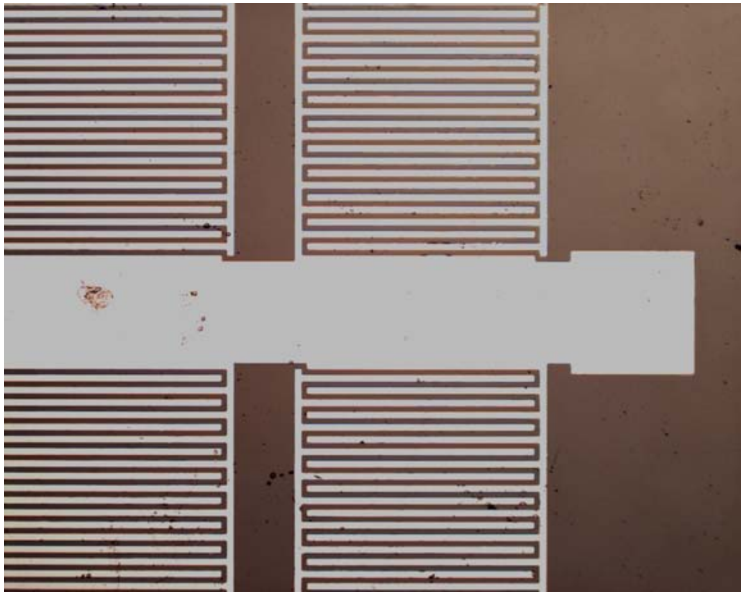
Conclusions

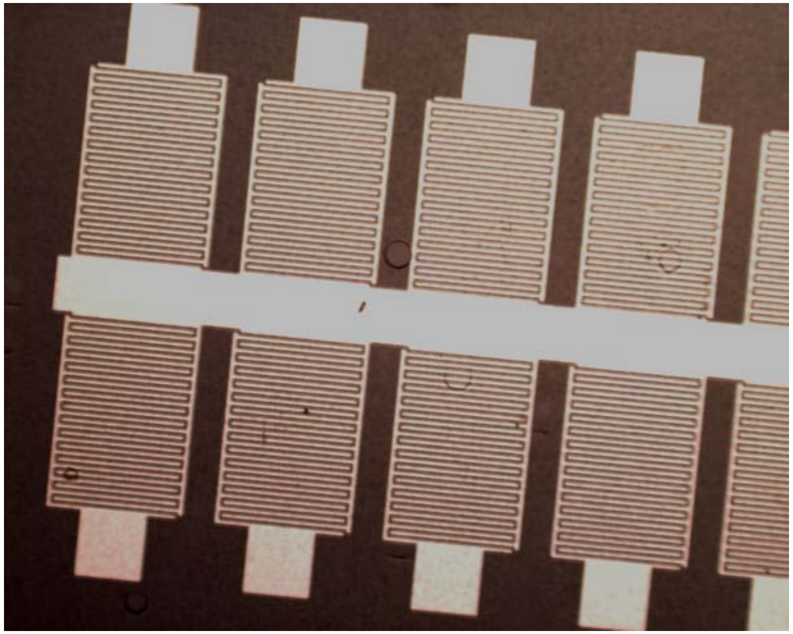
- Two main aims in this talk
  1. What material is best use?
  2. What detector design works best?
- Not much difference in performance between the 5μm and 10μm designs
- Fabricated 46 channel array on 45GaN material incorporating 10μm finger width/spacing design.
- I-V/Spectral Response measurements of 46 channel array this month
- Test 46 channel array at a CD experiment at Daresbury in September



Si
100μm GaN
25μm GaN
100% Q.E.
80% Q.E.
60% Q.E.
40% Q.E.
20% Q.E.
10% Q.E.
Responsivity (A/W)
0.25
0.20
0.15
0.10
0.05
0.00
180
200
220
240
260
280
300
λ(nm)







$$\tau_C = R_L C$$

$$C = \frac{A\varepsilon_0(\varepsilon_{GaN}+1)}{L+W}\frac{\pi}{4\ln(\frac{\pi}{8}+\frac{L}{W})}$$

- Larger finger separation (100μm) τ_c ~2s