National Institute of Information and Communications Technology

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THz range quantum well detector

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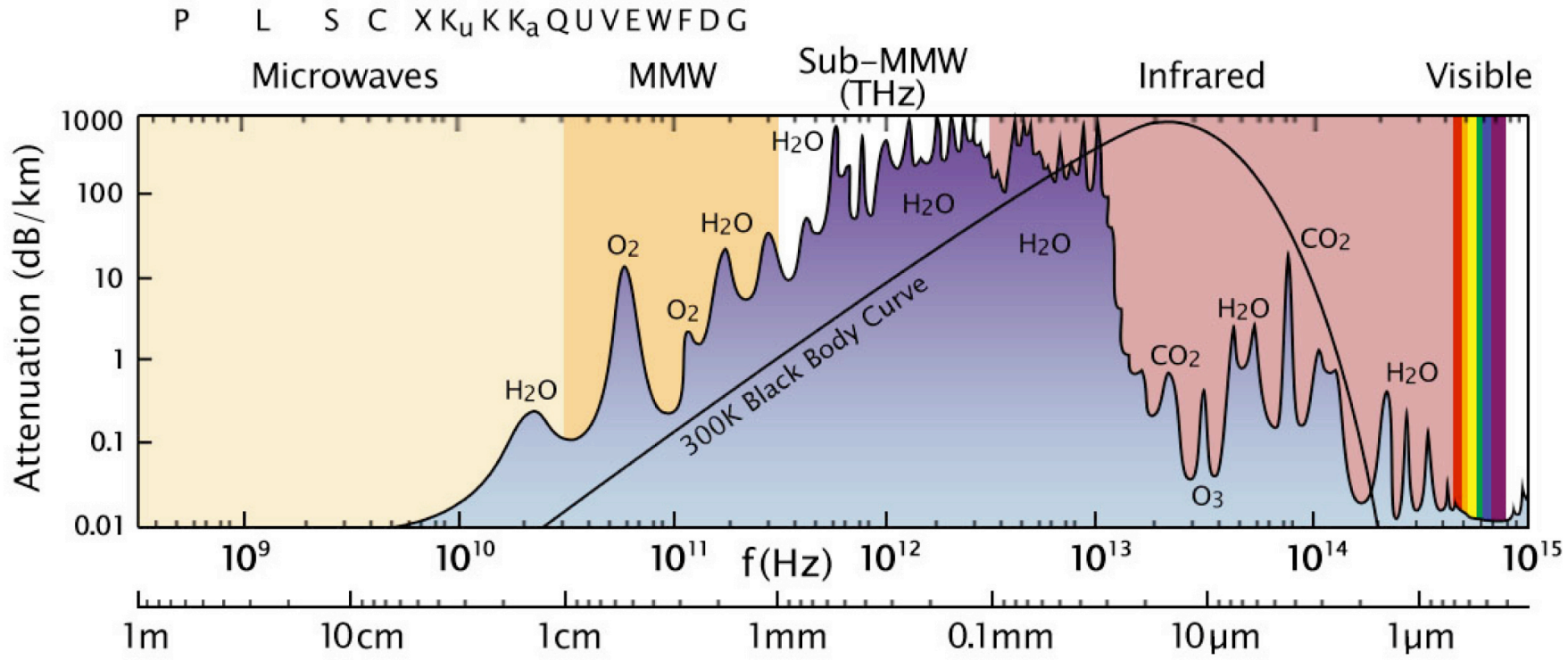
Outline

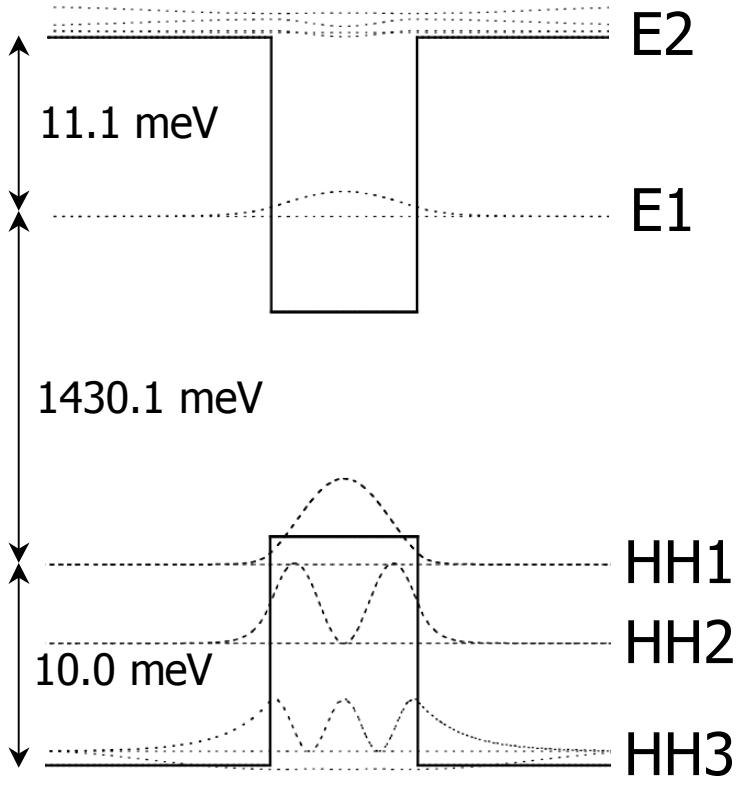
- THz spectral range and related applications
- Design of the THz QW detector
- Characterization (XRD, SEM/EDS, PL) of the structures
- Fabrication process and basic device characteristics
- Development of THz quantum well array detector

THz range and potential applications



- Short range high-speed (>1Gbps) wireless communication
- Secure intersatellite communication links
- T-rays for medical diagnostics
- T-rays for security systems

THz GaAs/AlGaAs QW structure



Bound to quasi-bound configuration

QW: 18 nm

[Al] = 2%

$Si_w = 1x10^{11}\ cm^{-2}$

E1 - E2 = 11.1 meV (~3THz, 100μm)

THz GaAs/AlGaAs detector design

n^+-GaAs (Si doped, $2x10^{18}$ cm^{-3})	300 nm
$Al_{0.02}Ga_{0.98}As$	80 nm
GaAs (4-14 nm, Si doped, $1x10^{17}$ cm^{-3})	18 nm
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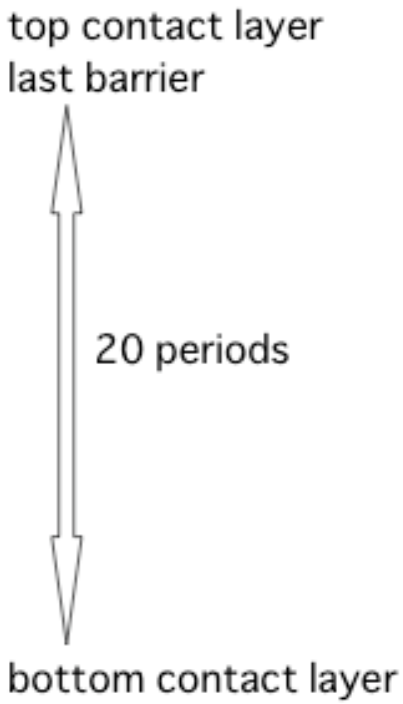
n^+-GaAs (Si doped, $2x10^{18}$ cm^{-3})	800 nm
Semi-insulating GaAs substrate	

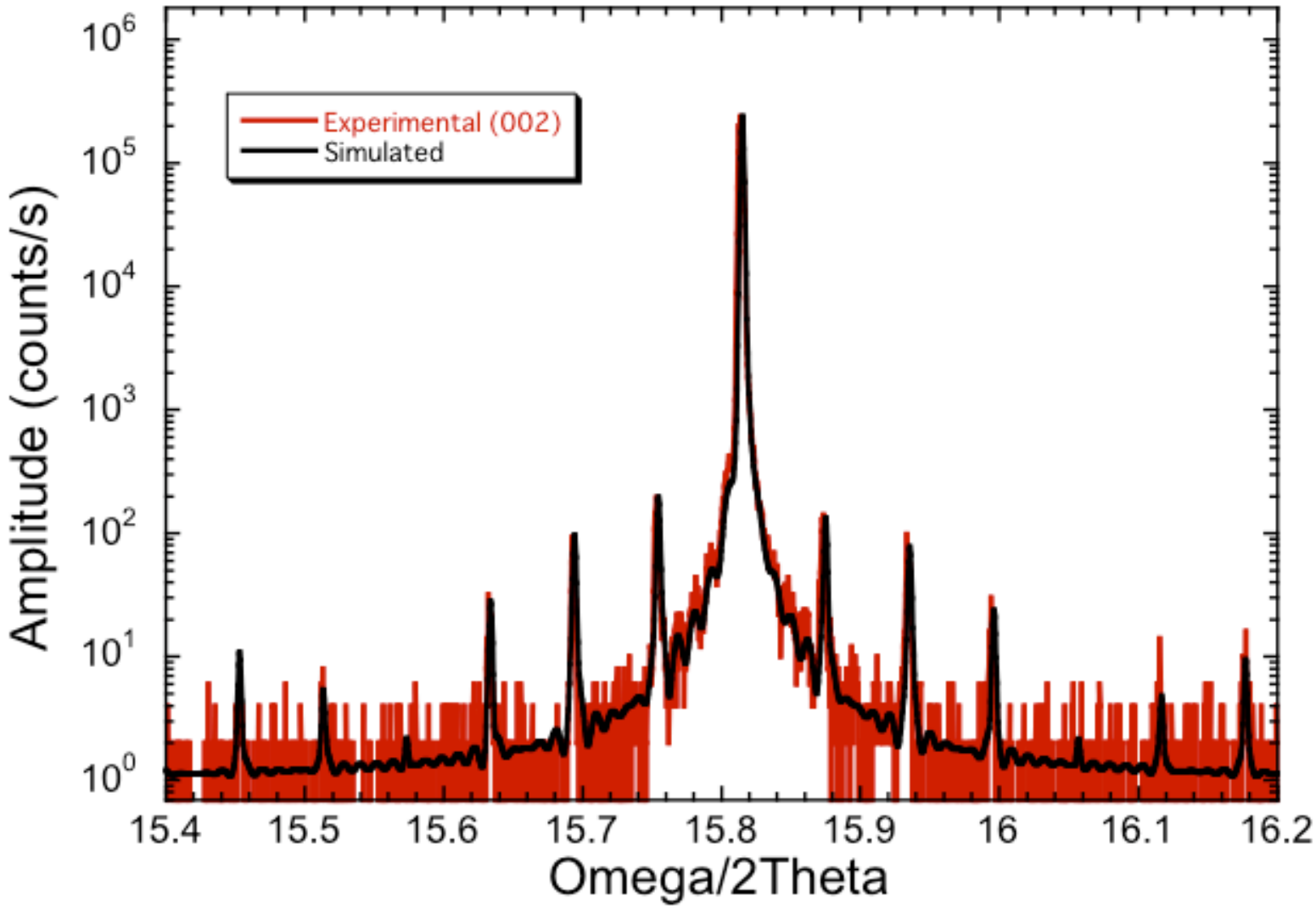


- 20-60 periods of 18/80 nm GaAs/AlGaAs wells/barriers with Al fraction 2%
- In-well doping $1x10^{11}$ cm^{-2}, contacts $2x10^{18}$ cm^{-3}
- diffractive grating coupler is deposited on the top contact layer

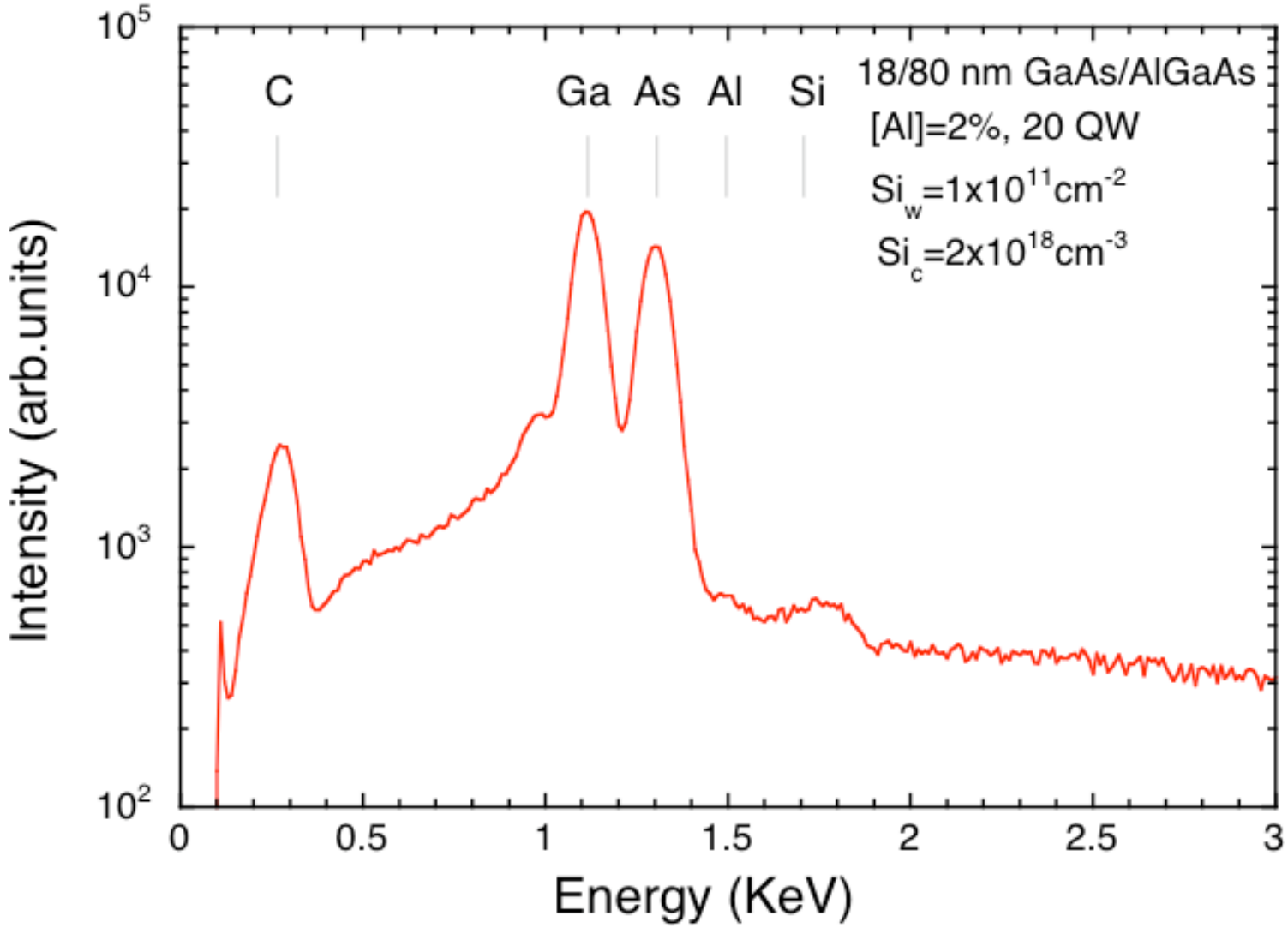
Samples

sample	well	barrier	well doping	contact doping	periods
V104	18	60	4e17	2e18	60
V205	18	80	2e17	2e18	40
V305	18	80	5e16	2e17	40
V506	18	80	1e17	2e18	20
V606	18	80	1e17	2e18	20

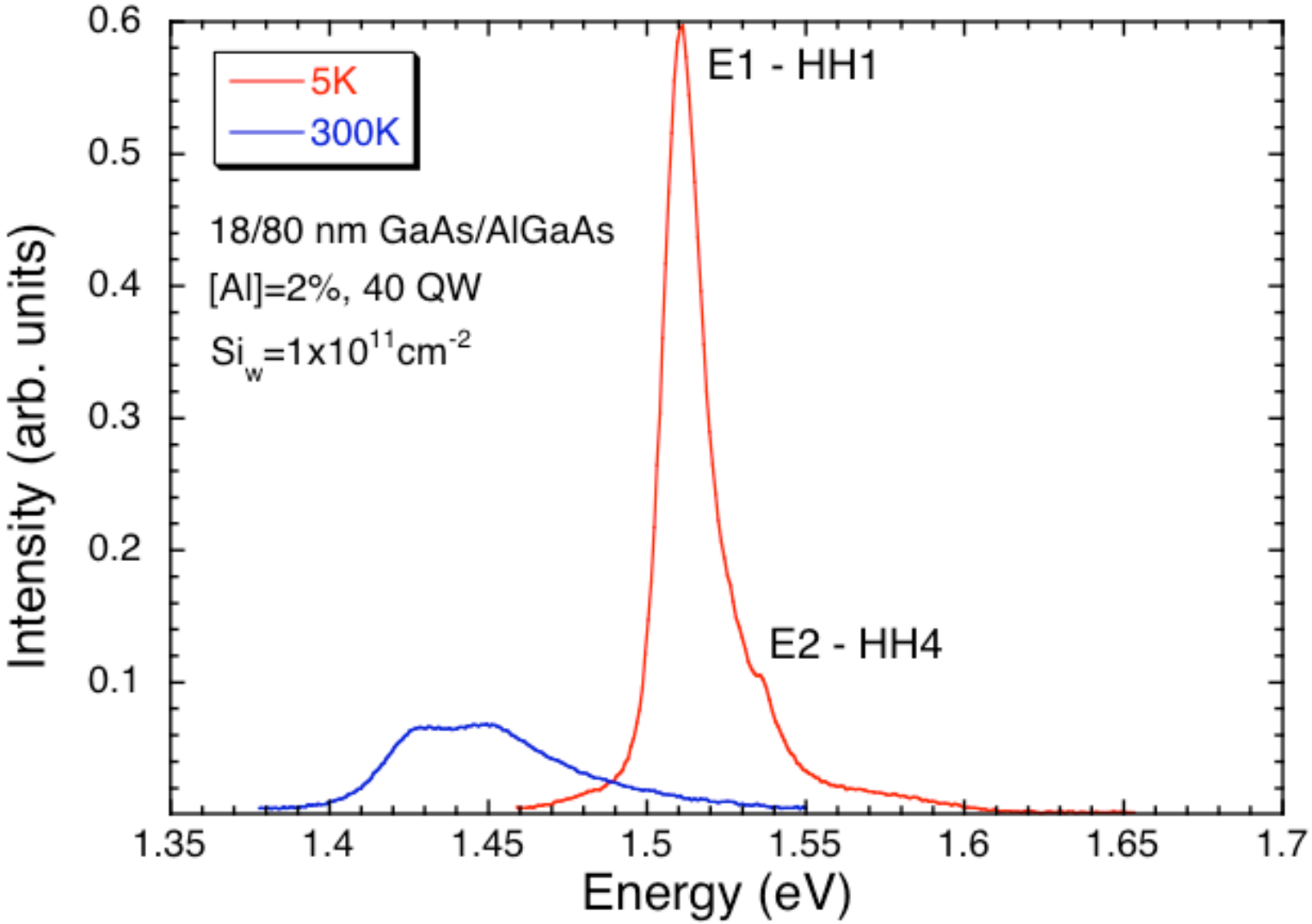
XRD measurements



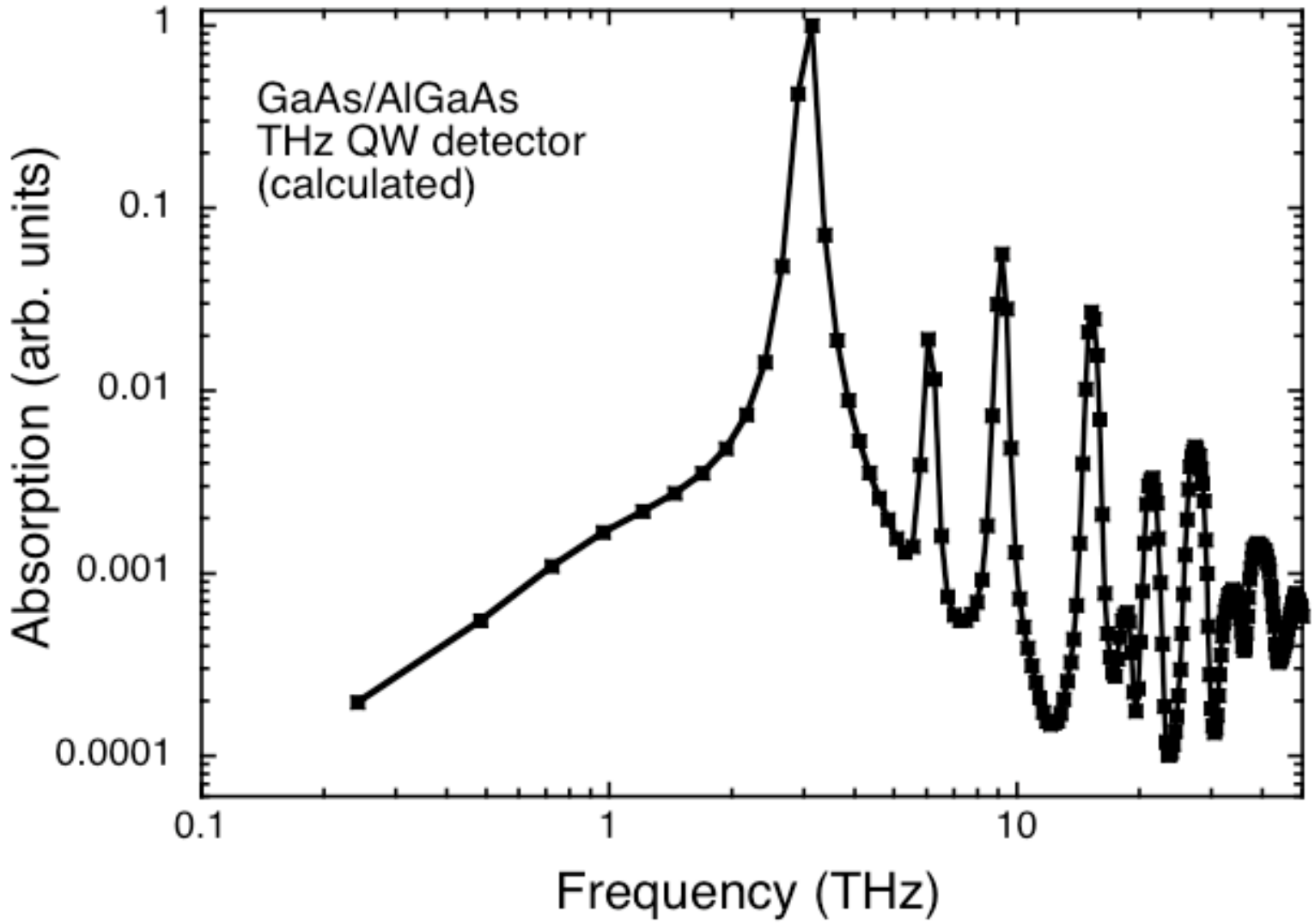
SEM/EDS spectrum



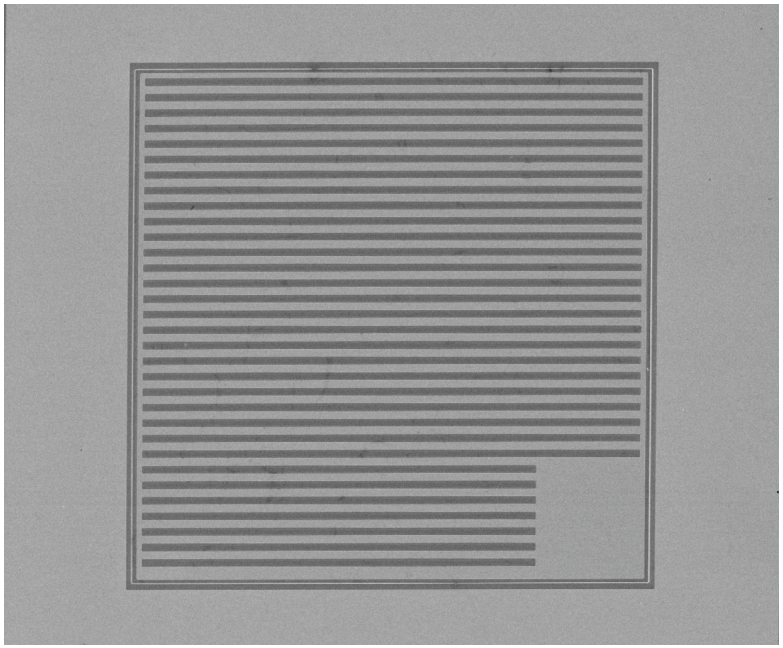
PL spectra

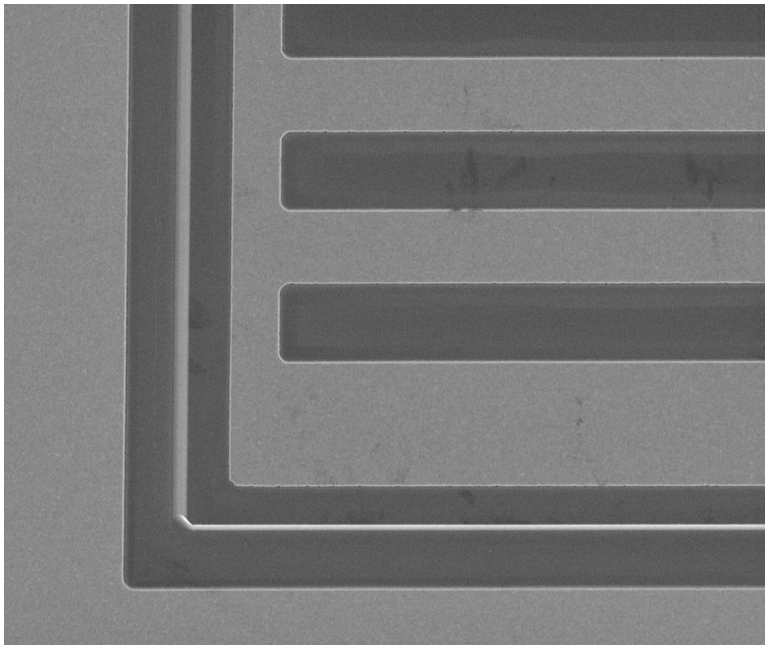

5K
300K
18/80 nm GaAs/AlGaAs
[Al]=2%, 40 QW
Si_w=1x10^11cm^-2
E1 - HH1
E2 - HH4
Intensity (arb. units)
Energy (eV)
0.6
0.5
0.4
0.3
0.2
0.1
1.35
1.4
1.45
1.5
1.55
1.6
1.65
1.7

THz absorption in QW



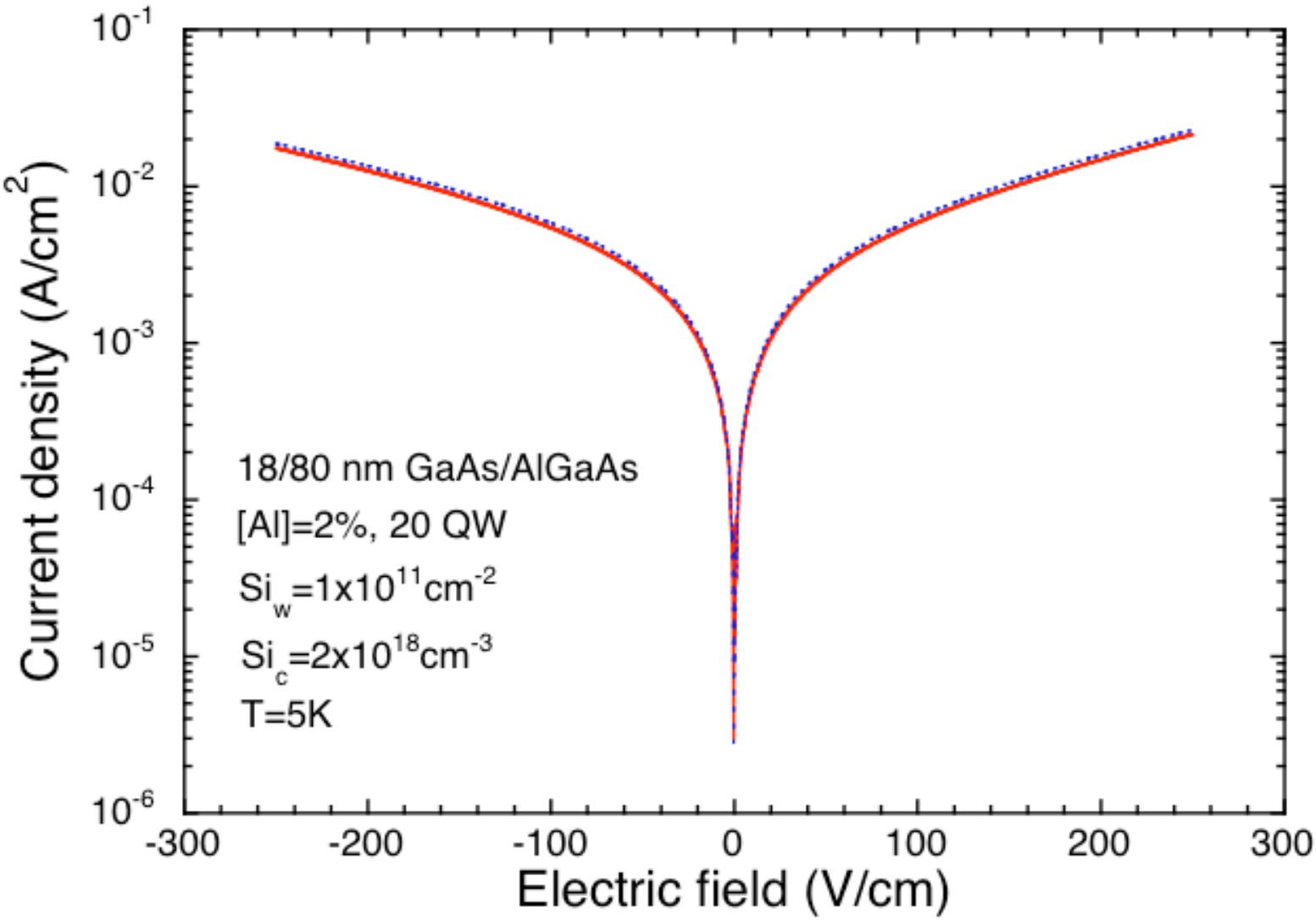
THz QWIP fabrication



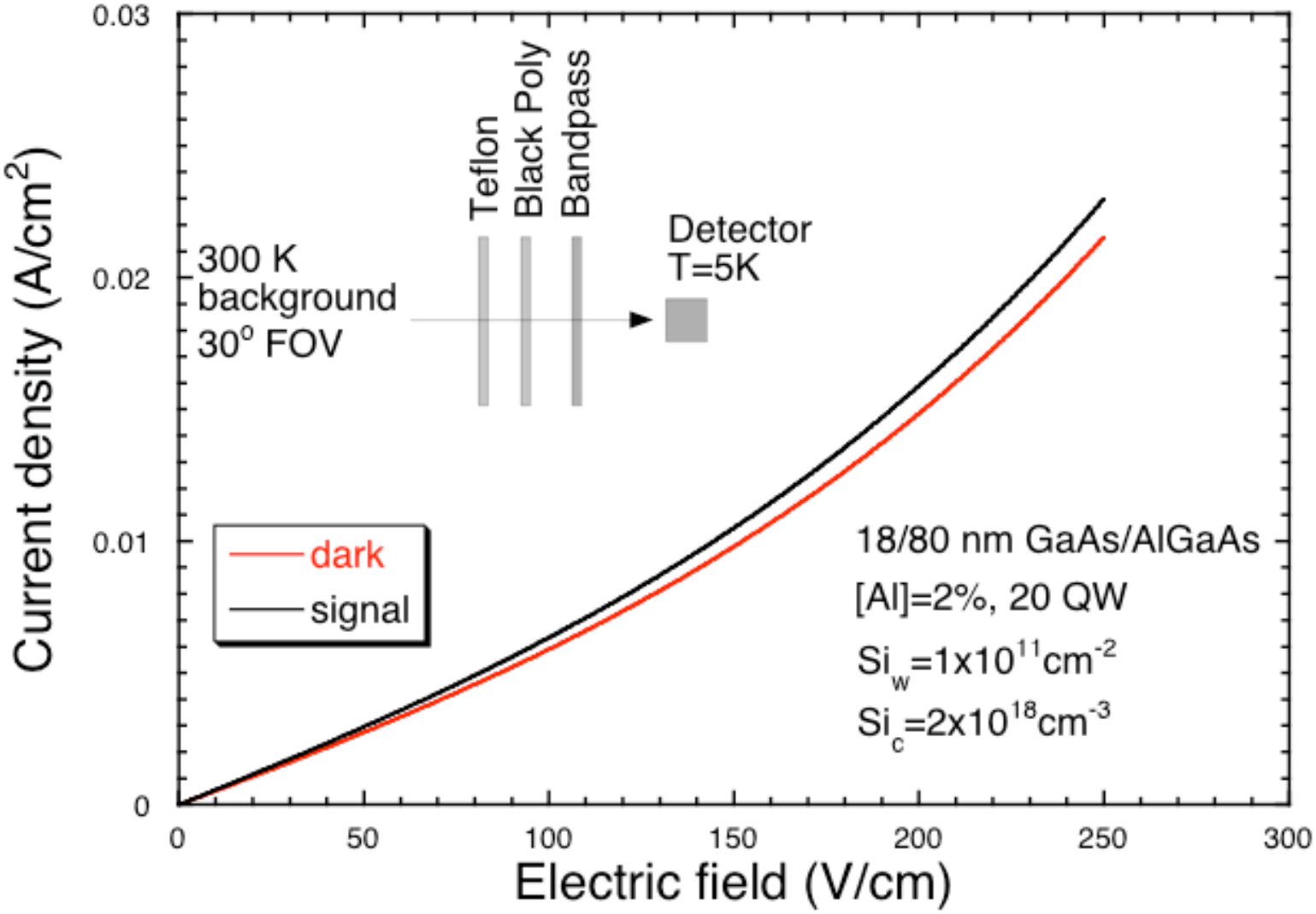


Samples were processed into square shaped mesas of different sizes (1000, 710, 500, 350, 250, 180, 130 μm) using standard photolithography, wet etching with H_2SO_4:H_2O_2:H_2O and lift-off procedure.

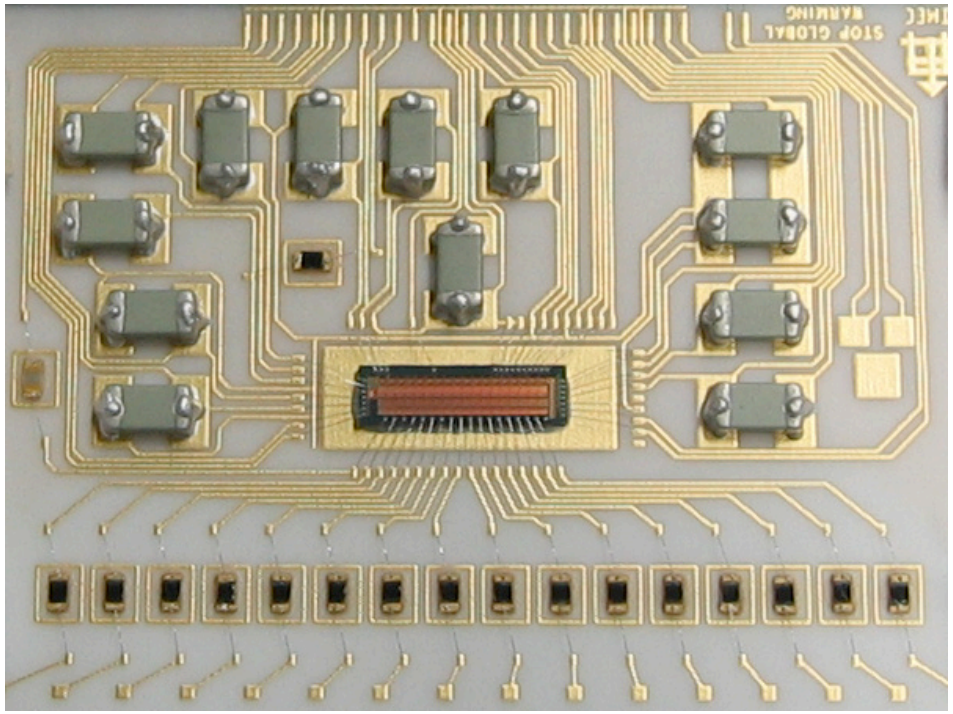
Dark current



THz photoresponse

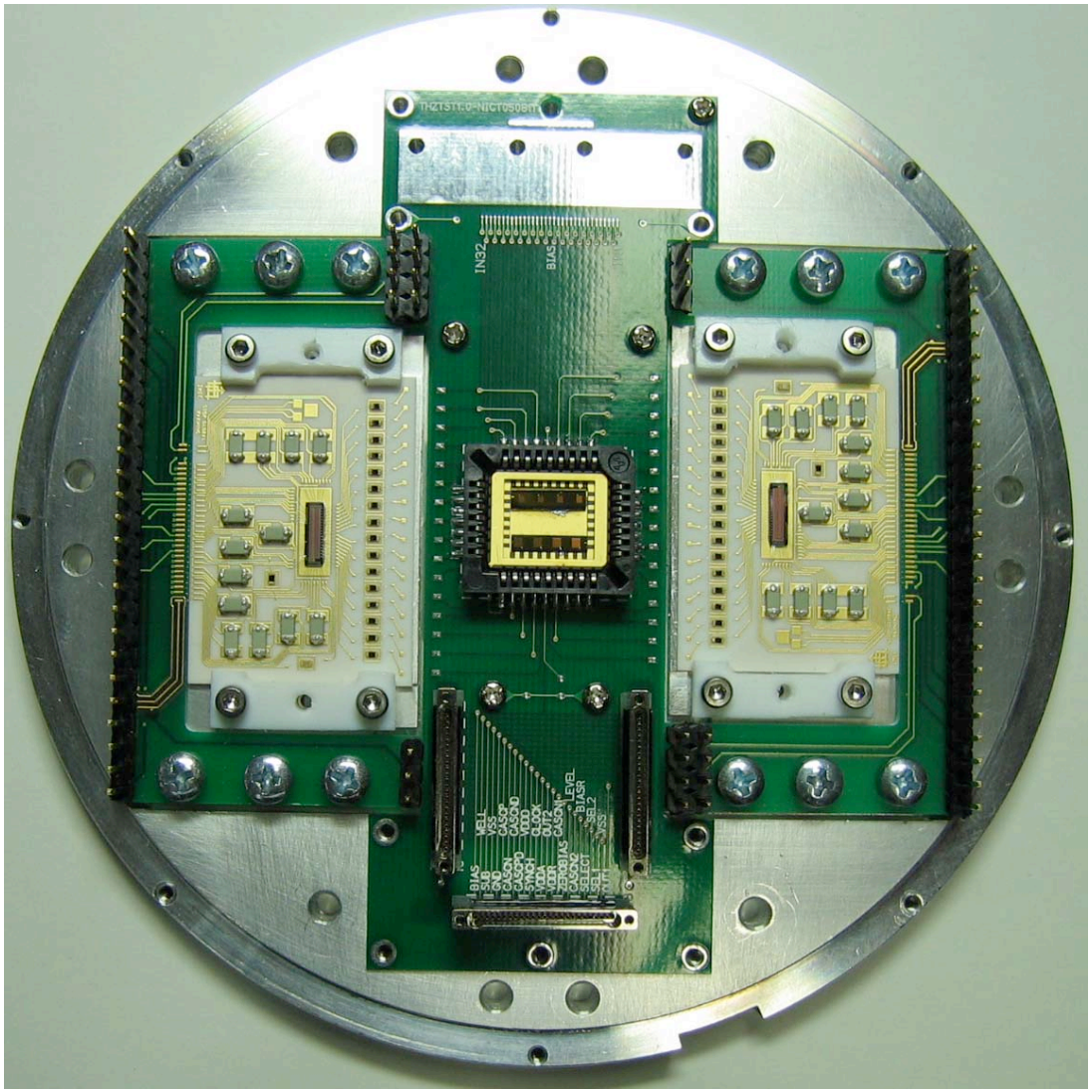


Readout Electronics/Multiplexer



- Cryogenic ROIC developed by IMEC (Leuvin, Belgium)
- 16 channel capacitive transimpedance amplifier (CTIA)
- 4 selectable integrating capacitors to accommodate various input signals
- Operates at room temperature and down to 4K

Prototype of focal plane unit



- 32 element array with charge integration
- Advanced CTIA circuit for low biased detectors
- Cryogenic operation down to 4K

Summary and further work

- We have demonstrated operation of THz GaAs/AlGaAs photodetector based on intersubband absorption in quantum well
- Device characteristics, such as dark current and responsivity, require futher improvements in order to be suitable for practical applications. We think that better performance can be attained by optimizing doping levels in the structure
- To evaluate suitability of quantum well detectors for THz imaging, a small (up to 32 elements) prototype array will be tested