

RECENT ACHIEVEMENTS IN DETECTORS FOR EYE SAFE LASER RANGING

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Abstract

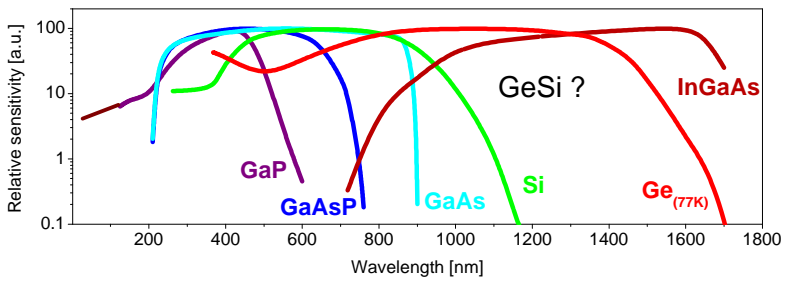
We are reporting on the latest results in the research and development of the solid state proton counters suitable for detecting individual photons in the near infrared wavelength region. The separate absorption and multiplication layer avalanche photodiode based on an InGaAs are one of the most promising candidates for the solid state photon counter for the eye safe laser ranging. Using the laboratory sample of InGaAs structure we have achieved the dark count rate as low as 30 kHz at modest temperature -60 C. The detector active area is 80 microns in diameter, its timing resolution of the detector is 1.8 nsec.

Recent Achievements in Detector for Eye Safe Laser Ranging

Goal

- Laser ranging at 1500 nm wavelength range
- Photon counting detector
- high quantum efficiency (QE > 10 %)
- low dark count rate (<< 1 MHz)
- high timing resolution (FWHM < 200 ps)
- fieldable

Single Photon Avalanche Diodes Semiconductor materials



Laser wavelengths used for SLR / SPADs

Eye safe

Germanium SPAD Detector Package

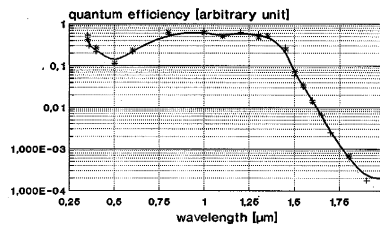
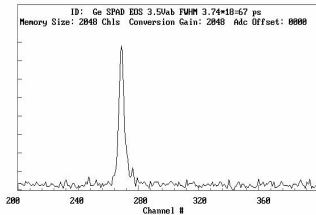
The first eye safe SLR in Tokyo, CRL & PESO & EOS, 1996



Ge SPAD, 100 μm
compact liquid N_2 cryostat, 77 K
the electronics built in
timing resolution 25 ps rms
QE 2-5% @ 1540 nm
dark count ≥ 1 MHz



May 19 2003 00:57:07 am E14: 000000 Seconds. Real Time: 000011



InGaAs Detectors for Photon Counting



- quantum efficiency $> 10\%$
- operating temperatures 150-300 K
- high after pulsing effects
- high serial resistance \Rightarrow low avalanche currents ($\ll 1$ mA)
- structure is difficult to manufacture, limited chips availability



InGaAs SPAD Detector Package New active quenching and gating circuit

- GOALS**
- to minimize the charge flowing through the APD
 - to reduce after-pulsing and hence the dark counts
 - to respond to APD small pulses

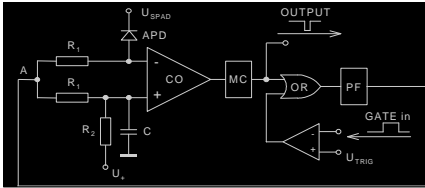
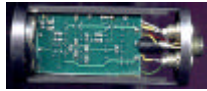


Figure 1: Active quenching circuit for the laser transponder

CO comparator
PF pulse forming
MC monostable
OR gate

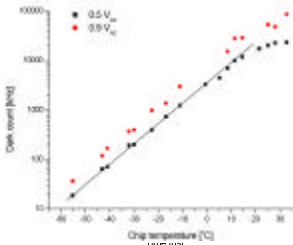


responds to 10 mV / 1 ns pulses
loop delay 2.6 ns
ECL logic, SMD
=> 1 V above break max.



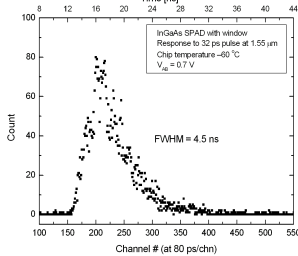
Low dark count rate InGaAs SPAD

Chip 80um in diameter, ECL active quenching, 1 kHz gate



Dark count rate

25 kHz @ -60°C

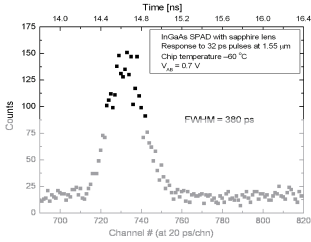


Timing resolution

FWHM 4.5 ns
rms 1.8 ns

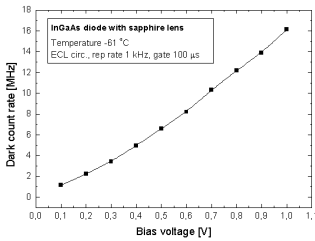


Fast response InGaAs SPAD



Timing resolution

FWHM 380 psec
rms 160 psec



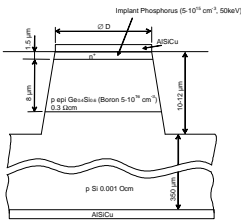
Dark count rate
small drop with temperature

12 MHz @ -60°C



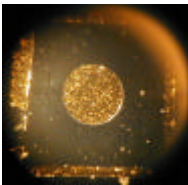
SPAD on Ge_{0.4}Si_{0.6}

Development status quo

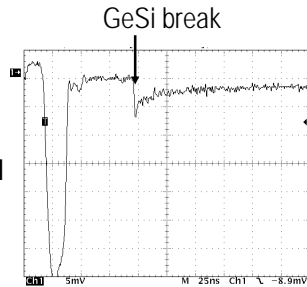


technology tests:

- GeSi layer 5 μm on top of the Si
- diffusion, implantation, masking,...
- test purpose MESSA structure,



The first Geiger operation reported



Conclusion

- PROGRESS
in solid state photon counters for eye safe laser ranging
- new APD structures on InGaAs (30-80 um)
- new control circuits
- new cooling setups for 150 - 210 K
- ACHIEVED PARAMETERS (InGaAs @ 1550nm)
 - quantum efficiency 13 %
 - dark count 25 kHz @ -60 C
 - timing resolution 160 psec
 - however, the last two not at the same time
- „long way “ to operational GeSi detectors

Available Detectors Summary

Status Quo 2004

- Si
 - compact package, 0.25 - 1.1 um, ps timing,
 - gated, not-gated operation
 - 20 .. 200 um, TE cooling, low noise,
 - photon number estimate
 - space qualified
- GaP
 - room temperature, X .. 0.8 um
 - 300 um, ps timing
- Ge
 - 77 K , 0.25..1.6 um
 - 100 um, 1 MHz dark, gated, ps timing,
- InGaAs
 - 150..210 K, wavelength 1...1.8 um
 - 30 - 80 um diameter
 - ns timing, dark < 30 kHz
 - ps timing, dark ~ 10 MHz