

Characterization of germanium photodiodes and trap detector

Antti Lamminpää¹, Mart Noorma¹, Tuomas Hyypää¹,
Farshid Manoocheri¹, Petri Kärhä¹, and Erkki Ikonen^{1,2}

¹ *Metrology Research Institute, Helsinki University of Technology (TKK)*

² *Centre for Metrology and Accreditation (MIKES)*

NEWRAD 2005



Outline

- Introduction
- Studied quantities
 - Spectral responsivity
 - Spatial uniformity
 - Temperature dependence
 - Effects of low shunt resistance
 - Spectral reflectance
 - Anti-reflection coating analysis
- Uncertainty analysis
- Conclusions

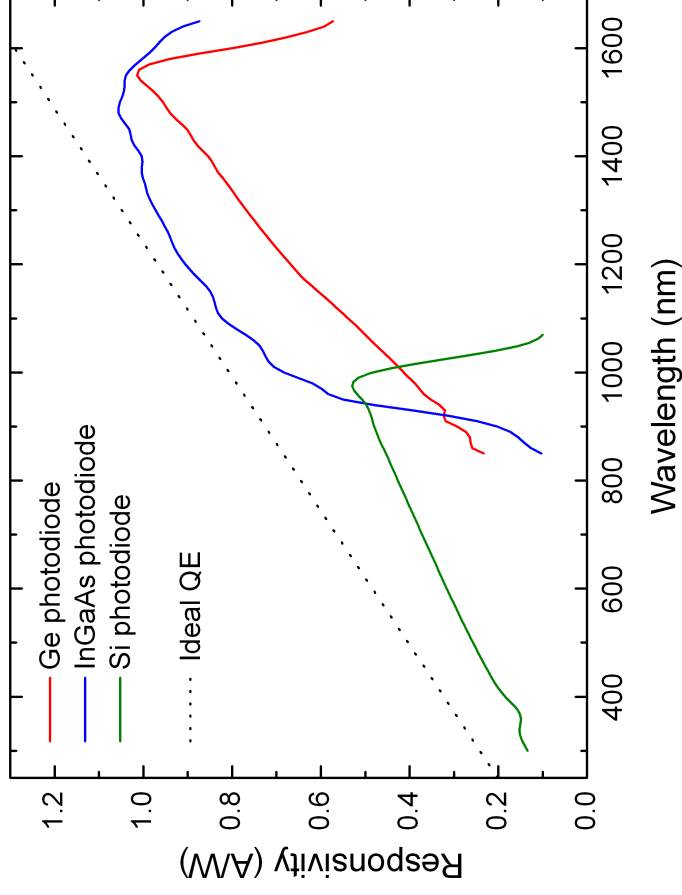
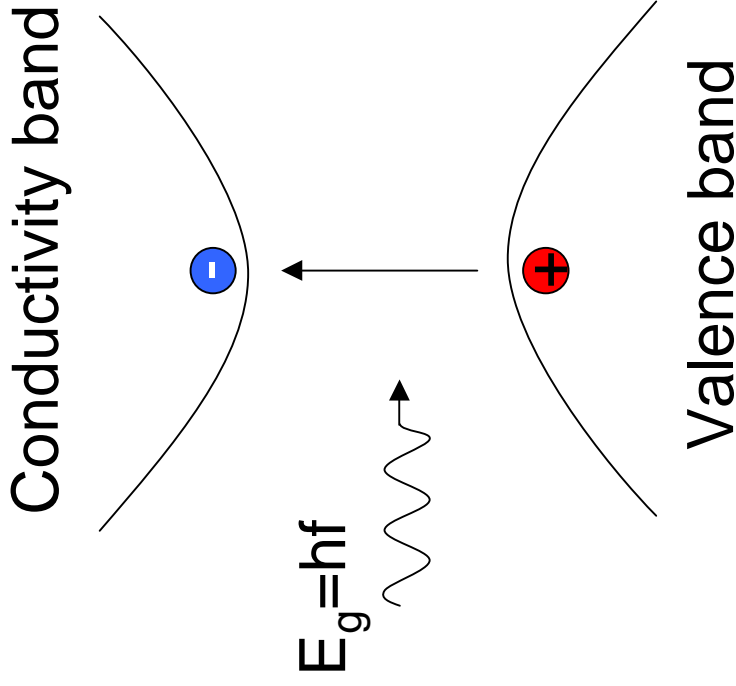


Motivation

- Existing scale realization for the spectral irradiance covers the wavelength range from 290 nm to 900 nm.
- Germanium photodetectors are used for the extension of the current spectral irradiance scale to near infrared wavelengths from 900 nm to 1650 nm.
- The combined standard uncertainty of the spectral irradiance scale is aimed not to exceed the level of 2%.



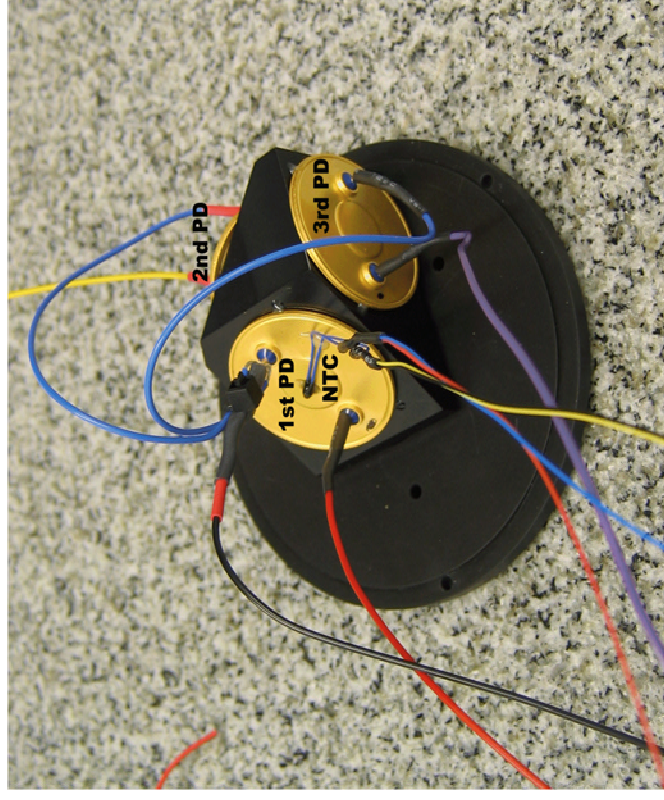
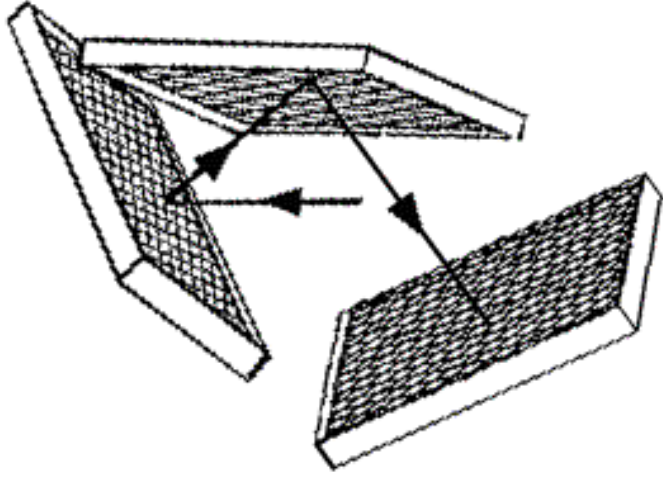
Introduction - photodiodes



Absorbed photons create electron-hole pairs → photocurrent



Trap detector configuration

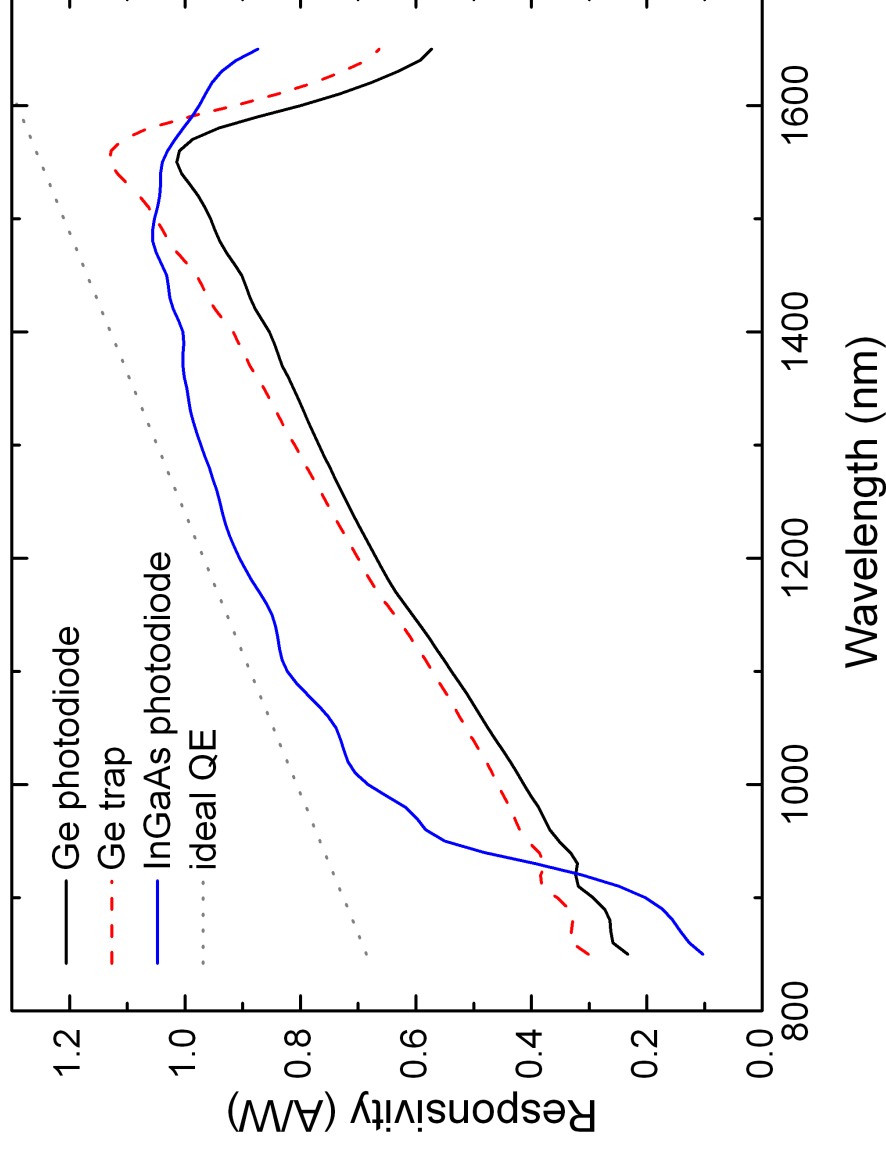


Ge photodiodes: Judson Technologies LLC, J16-P1-R10M-SC

Five interreflections → captures light effectively → low reflectance.



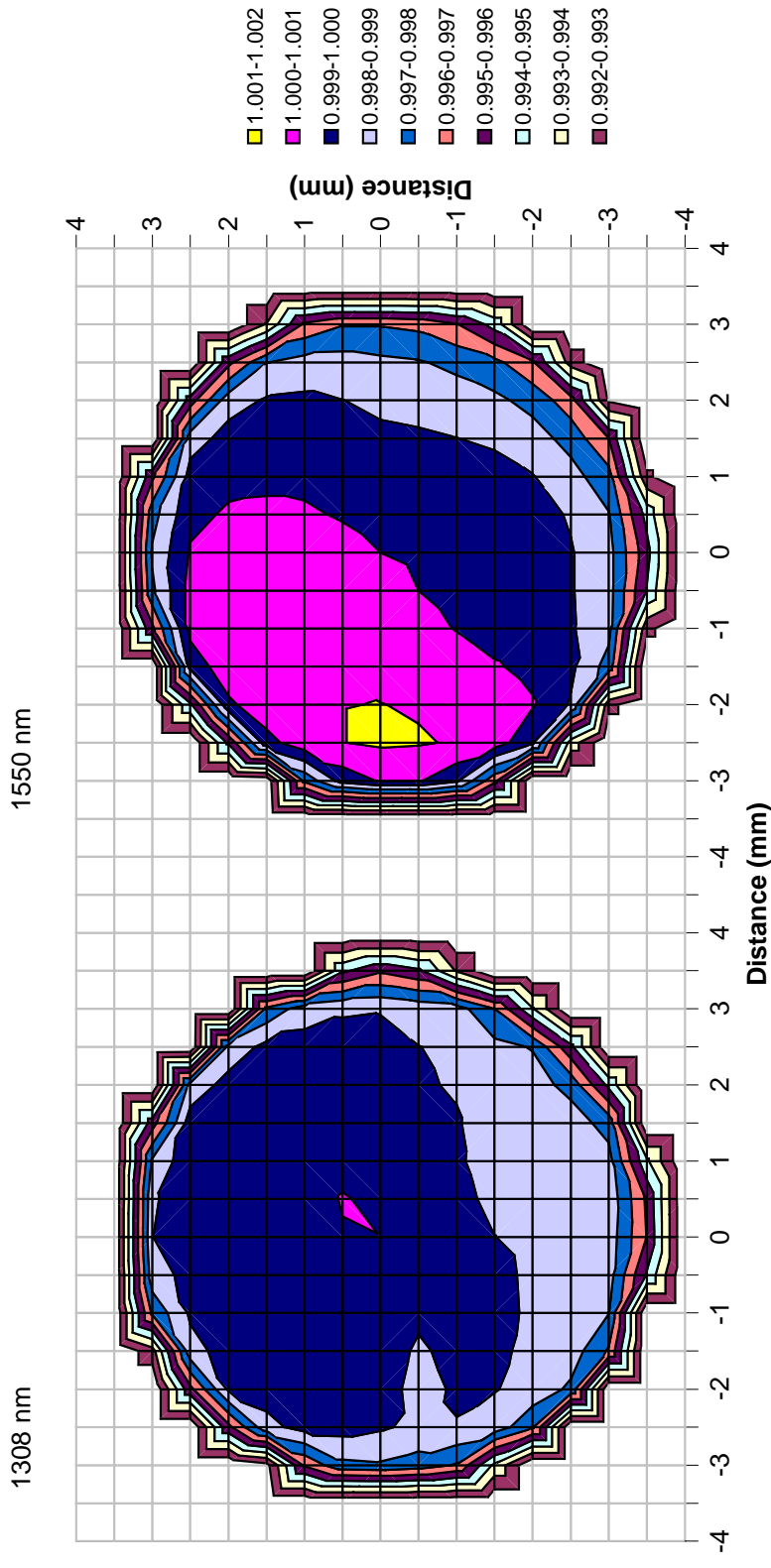
Spectral power responsivity



Trap detector configuration increases spectral responsivity.



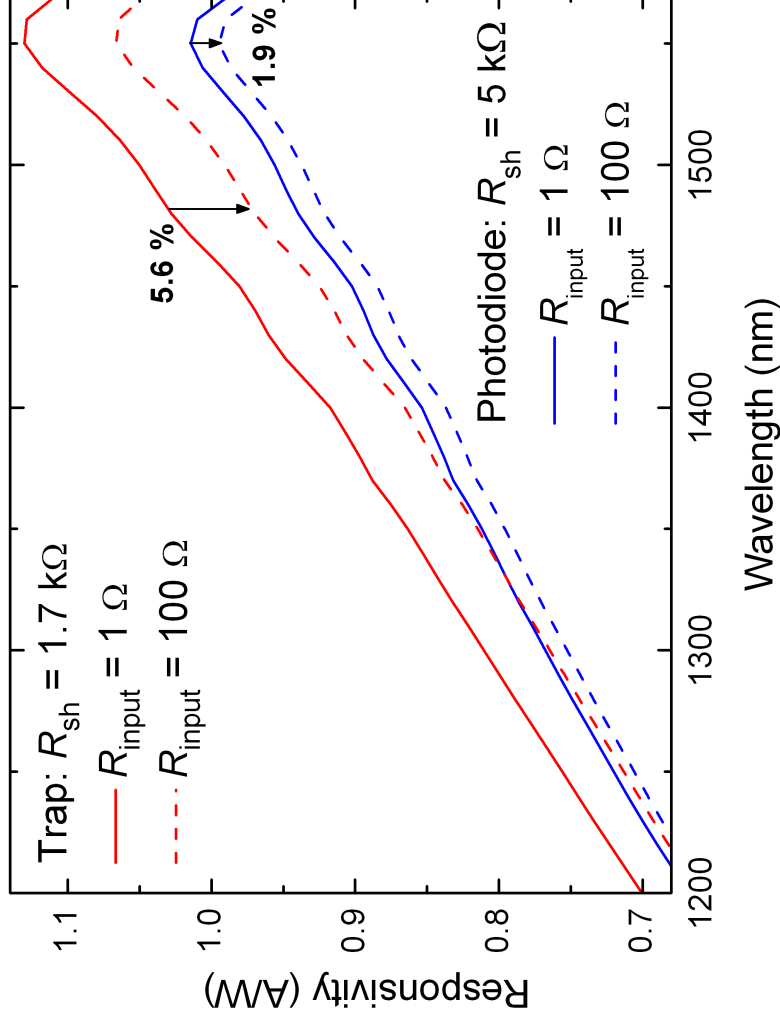
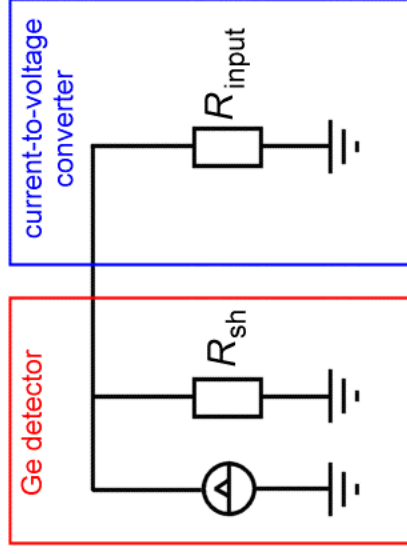
Spatial uniformity of spectral responsivity



Introduced uncertainty is below $\sim 0.1\%$ in central area of 5-mm diameter.



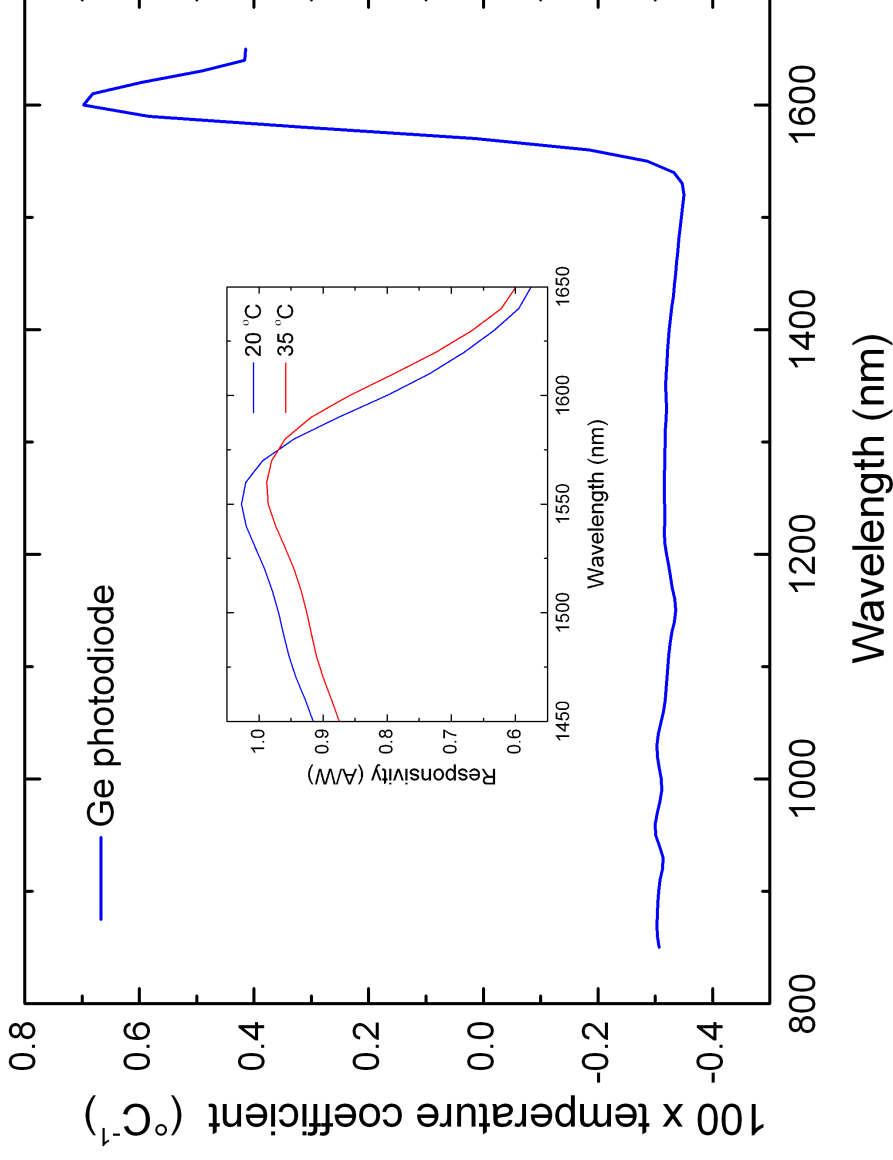
Effects of shunt resistance on responsivity



Must be calibrated with different gain settings or needs knowledge on impedances.



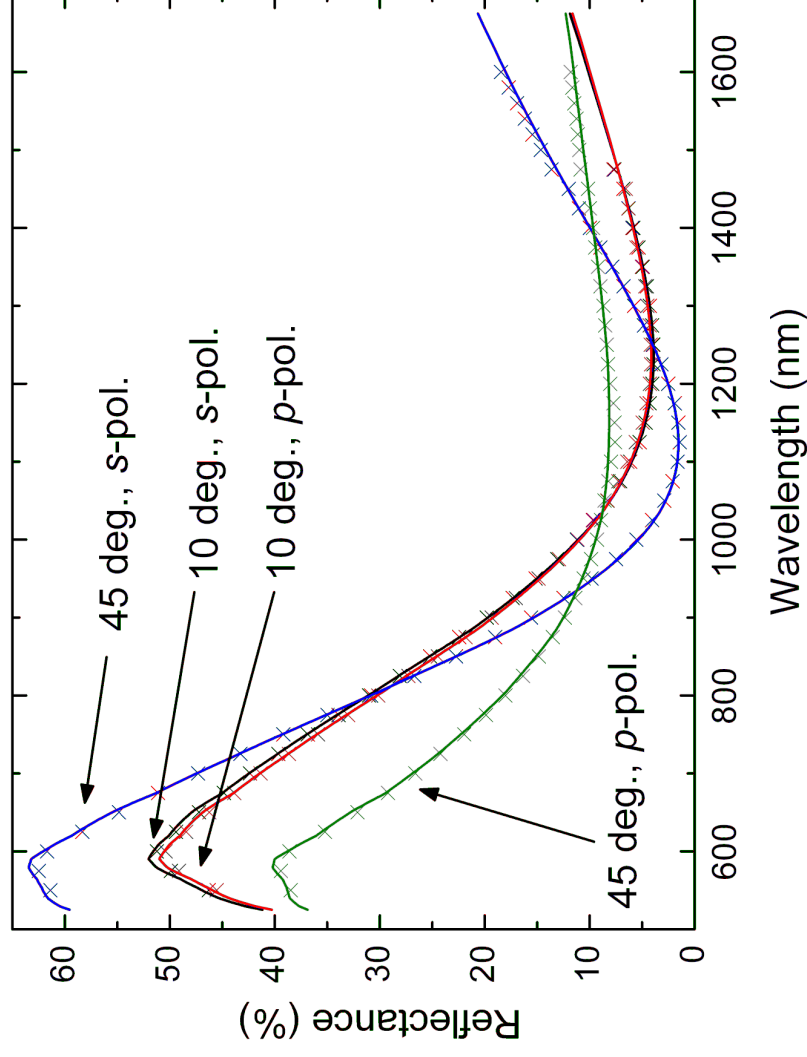
Temperature dependence of responsivity



Sign of the temperature coefficient changes after the responsivity maximum.



Spectral reflectance of photodiode



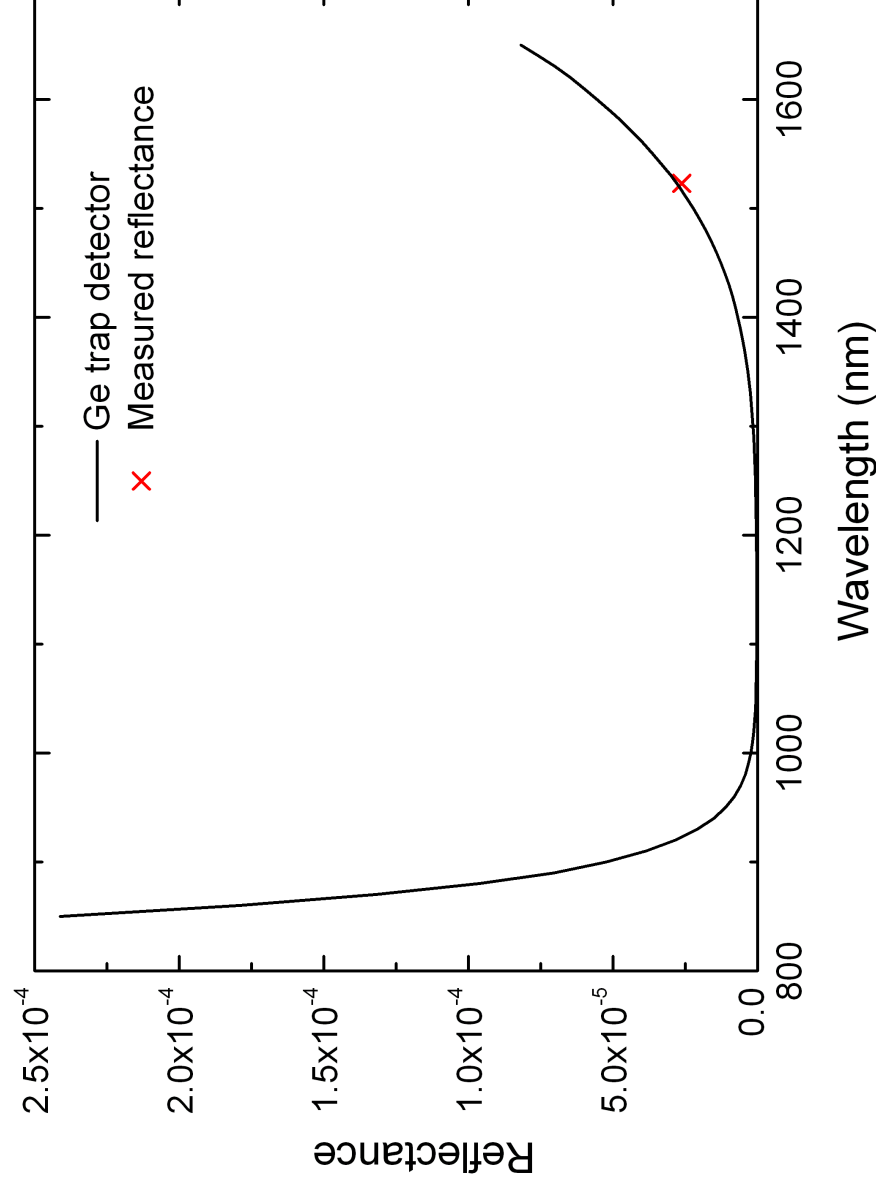
Analysis of AR coating

→ layer thickness ~ 180nm

→ refractive index ~ 1.7



Spectral reflectance of trap



Very low reflectance → suitable for e.g. filter radiometers.



Uncertainty budget - spectral responsivity

Uncertainty component	Photodiode (%)	Trap (%)
Reference detector	1.26	1.26
Test detector	0.48	0.49
Nonuniformity	0.04	0.08
Interreflections	0.10	0.01
Wavelength uncertainty	0.02	0.02
Uncertainty in temperature coefficient	0.20	0.20
Repeatability	0.15	0.20
CVC gain and nonlinearity	0.40	0.40
Combined standard uncertainty	1.35	1.36



Conclusions

- Germanium photodetectors
 - good spatial uniformity ~0.1 % at the best
- Ge trap
 - lower shunt resistance
 - more complex and expensive design
 - + improves spectral power responsivity
 - + very low reflectance
- The additional uncertainty in the measurements of spectral power responsivity is ~0.5 % ($k = 1$).

