INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
34100 TRIESTE (ITALY) - P.O.B. 586 - MIRAMARE - STRADA COSTIERA 11 - TELEPHONE: 2240-1
CABLE: CENTRATOM - TELEX 460392 - I

SMR/382- 11

WORKSHOP ON SPACE PHYSICS:
"Materials in Micorgravity"
27 February - 17 March 1989

"Introduction to Materials: Gordon Conference Microgravity 1987"

E. KALDIS
ETH
Zurich, Switzerland

Please note: These are preliminary notes intended for internal distribution only.

α-HgI_2, THE MATERIAL

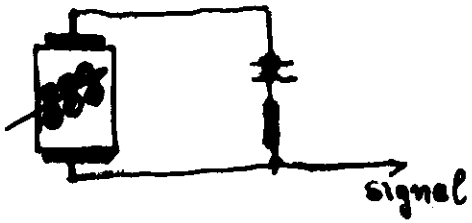
Importance for applications

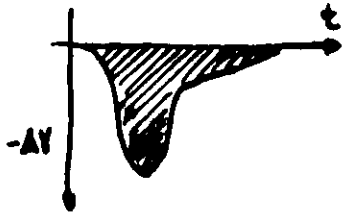
x- and γ-ray ROOM TEMPERATURE semiconductor detector

due to band gap 2 eV
no thermal noise
at room temperature

On the contrary, presently used detectors
<u>need refrigeration due to small bandgap</u>

Silicon ΔE = 1.08 eV
Germanium = 0.67 eV





Possibility to work without refrigeration brings enormous advantages for technological applications

Additional advantage of α-HgI_2
much stronger absorption

also need for very large crystals (thick)
for quantitative γ-ray absorption

γ- Ray detectors

State of the art:

- Miniature Geiger - counters and γ- spectrometers
- Portable devices for nuclear plant safety
- Miniaturized EDAX- system for interplanetary vehicles
- Portable EDAX - system for mineral prospecting (for Z > Al x-ray penetrates the atmosphere)

Expected breakthrough
if better crystals

ARRAYS OF DETECTORS

- Tomography
- γ- cameras

α-HgI_2, presently best RT nuclear detector

Theoretically calculated resolution 0,8%

For 60 keV radiation (Am^{241}) → 0.5 keV

best Detector 1.15 keV

presently, good detectors 2-3 keV (3-4%)

Applications (counters and γ-spectrometers):

- Nuclear medicin
- Tomography
- Environmental Protection
- EDAX-systems
- nuclear sciences
- space sciences
- nuclear plants
- defence

Advantages of room temperature detectors:

- Miniaturization (in contrast to scintillators or Si, Ge - detectors) } arrays < tomography, γ- cameras
  ↳ easy measurements: human + environm. protection
- Remote sensing → spacecrafts

Drawbacks of α-HgI_2 detectors:

- LOW MOBILITY OF HOLES

μ (cm²/V.s)

electrons $\mu_e \approx 100.0$ — holes $\mu_h = 4.0$

This is due to the existance of TRAPS in the crystal lattice

- VERY EASY PLASTIC DEFORMATION

creating many traps: large crystals deformate under theirown weight, particularly at the growth temperature.

X-RAY DETECTORS

→ Ionization efficiency

HgI_2) $\dfrac{\text{Band gap}}{\text{energy to produce el-hole pair}} = \dfrac{2.2\,eV}{4.2\,eV} = 52$%

Si) = 30%

Detector Fabrication

→ Electrodes

Pd-Electrodes 100-200 Å

→ BeO Ceramic Substrate

low dielectric const.
excell. thermal cond

→ Encapsulent

Poly-methylmethacrylate (PM
not reprod. thickness; cracks

Poly-dichloro-di-para-xylylene
Un. Carbide Parylene - C. Vaku

Amplification Electronics

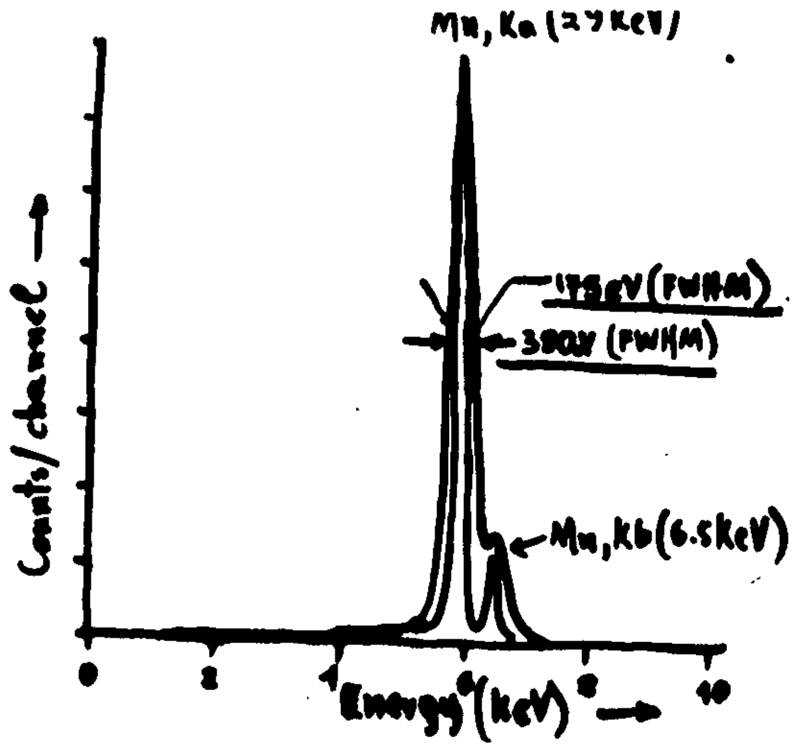
Ultra-low noise preamplifiers
without cryogenically cooled FET's
necessary

- lowest commercially available
  500 eV (FWHM) for HgI_2.

Cryogenic cooling · Deencapsulation
· Remounting low-noise Substrates

Pulsed-light feedback
Cooling input FET's with mini-thermo-electric coolers: (0.5 m^3 <), 250 mV, $T \approx -10°C$
180 eV (FWHM)

DETECTION OF O k-line
(523 eV)



Source Fe-55
Detector HgI_2 ($1\,mm^2 \times 400\,\mu m$)
at Room TEMPERATURE
Preamplifier: Pulsed light feedback
Input FET
1. ROOM TEMPERATURE
2. CRYOGENICALLY COOLED

Al, k (1.5 eV)
FWHM 145 eV

Entrance Elektrode negative. X-ray small Penetr.
Holes travel very small distances