Spectrometry of heavy ions below 1 MeV/amu with ND and CVDD detectors

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Vienna Environmental Research Accelerator (VERA) is a dedicated AMS facility.
Performance of other common detector types for heavy ions below 1 MeV/u

Silicon surface barrier (Si-SB) detectors
• quick radiation damage
• better resolution than DDs
• slower than DDs

Ionization chambers
• resolution better for heavy ions
• no radiation damage
• very slow
• very thin entrance windows needed => small
Specimens investigated

3× Natural Diamond Detectors (NDD)
Provided by V. Liechtenstein from the Kurchatov Institute, Moscow
  • Thickness 200 µm
  • 1× Aluminum contact (2 µm)
  • 1× Carbon contact (10 µg/cm²)
  • 1× Gold contact (20 µg/cm²)

1× Chemical Vapor Deposition Single Crystal Diamond Detector (SC-CVDDDD), thickness 320 µm
Provided by E. Berdermann, GSI, Darmstadt
  • Thickness 320 µm
  • Aluminum contact (100 nm)
Natural diamond is inhomogenous

Advantage of ND
- Large single crystals, readily available

Disadvantage of ND
- Inhomogeneities lead to "strange" spectra even if specimens are hand selected for purity.

Pulse height (channels)

counts

$^{197}$Au, 11.35 MeV
Setup for detector mapping
Microscope image of NDD

2 mm diameter
"Bad" regions

![Graph showing pulse height (channels) vs. counts](image)

- Total surface

![Venn diagram showing intersections of different regions](image)
Bad regions at higher spatial resolution
Shift of peak maximum

Graph showing channel counts against channel number.
Low energy tails
$^{63}$Cu, 11.25 MeV
Polarization of CVDSCD

$^{63}\text{Cu}, 11.25\ \text{MeV}$

$10^3\ \text{cps}$
Preparation of NDDs

- Octahedra crystals cut with laser cutting technique along the easiest slicing plates \textless 100\textgreater  or \textless 110\textgreater.
- Polished with synthetic diamond polishing powder (4 microns).
- Cleaning
  - washing with standard potassium dichromate (K$_2$Cr$_2$O$_7$)-H$_2$SO$_4$ solution
  - washing in ammonia solution
  - washing in (high purity) distilled water.
- Selection:
  - measuring the photoconductivity and absorption coefficient for UV to ensure nitrogen concentration below $10^{16}$ cm$^{-3}$.
  - overall purity deduced from the carrier lifetimes estimated from photocurrent.
  - measure I-VS curves
  - $\alpha$-particles
- Formation of contacts: thinnest possible front windows with no care on adhesion and Ohmic properties of the contact films.
  - Au contact (20µg/cm$^2$): thermally evaporated onto the front surface
  - Carbon contact (10 µg/cm$^2$): thermal cracking of methyl iodide (~ 1 mbar) at the surface of the hot sample.
- Ag paste/compound used as backing contacts.
Measurements with Si-SB detector

- Si-SB, C-12, 11.271 MeV
- Si-SB, Au-197, 11.35 MeV
- Si-SB, Cu-63, 11.35 MeV
- Si-SB, Al-27, 11.35 MeV
- Au-SRIM
- Cu-SRIM
- C-SRIM
SRIM: ionization by recoils
Modelling with SRIM
Influence of light

$^{12}\text{C}, 11.27 \text{ MeV}$
Influence of light

Field (V/mm)

Pulse height (channels)

NDD C, C-12, 11.271 MeV, pos.bias
NDD C, C-12, 11.271 MeV, pos bias, with light
End of presentation
NDD1 assembly as used at VERA-Lab
Spectra "corrected" for inhomogeneity

- Shift maxima to same position
- Use only "good" regions
Microscope image of NDD
Influence of bias polarity

- CVDDD, C-12, 11.271 MeV, neg. bias
- CVDDD, C-12, 11.271 MeV, pos. bias
- CVDDD, C-12, 11.271 MeV, neg. bias, 2nd meas.
Size of bad spots