**Charge Trapping and Impact Ionization in CDMS Detectors**

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**MOTIVATION**

- The Cryogenic Dark Matter Search (CDMS) and EDELWEISS experiments both use T~50mK high purity germanium bolometers in an effort to directly detect dark matter.
- Electron/nuclear recoil discrimination is performed by simultaneous measurement of ionization and phonons produced by incident particles.
- Charge trapping and impact ionization affects the nuclear recoil energy scale and compromises charge collection.
- Important to understand the fundamental charge transport/trapping/impact ionization physics over wide range of electric field.

**EXPERIMENTAL SETUP**

- CDMS high purity n-type Ge detector cooled to ~50 mK.
- Optical fiber is pulsed with a room temperature laser diode, creating electron-hole pairs at the surface of the crystal. (see Ref. [2])
- Electric field polarity determines whether electrons or holes drift to opposite face of crystal.
- Resulting drift current is measured by a high speed (~20MHz BW) charge amplifier.
- Fit each drift current pulse to obtain drift velocity and trapping length as a function of electric field.

**CARRIER DRIFT VELOCITIES**

- Charge carriers gain energy from the electric field and lose energy by emitting Luke phonons.
- Drift through the crystal with an average drift velocity (~1 µm/µs).
- Carriers are “hot” relative to crystal. (Tcarrier >> 50mK)
- Measured velocities in good agreement with the predictions of Sundqvist although we do not observe the onset of optical phonon emission. (See Ref. [1],[4])

**IMPACT IONIZATION**

- At higher fields, additional charge carriers are created by impact ionization. The slope of the drift current during the drift time is now positive.
- A secondary drift current is observed for both electron and holes. Drift time matches the opposite carrier.
- Rapid increase in trapping length/change in sign signifies impact ionization threshold.

**TEMPERATURE DEPENDENCE**

- **These initial studies were performed on a different (p-type) detector**
- **No changes observed until T~1.1K.**
- **Above 1.1K, evidence that A⁺ states become thermally unstable.**
- **Trapping improves for electrons due to decrease in A⁻ states.**
- **Trapping becomes worse for holes due to increase in A⁰ states.**

**CONCLUSIONS**

- A⁺ states have a smaller binding energy than D⁻ states. These overcharged states dictate ionization collection physics in CDMS detectors.

**REFERENCES**