Electrical Characterization of niobium-doped n-Silicon diodes

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1. Objective

- To Investigate the effects of niobium impurities on the electrical properties of n-type silicon diodes with a possibility of improving radiation tolerance of silicon.

2. Introduction

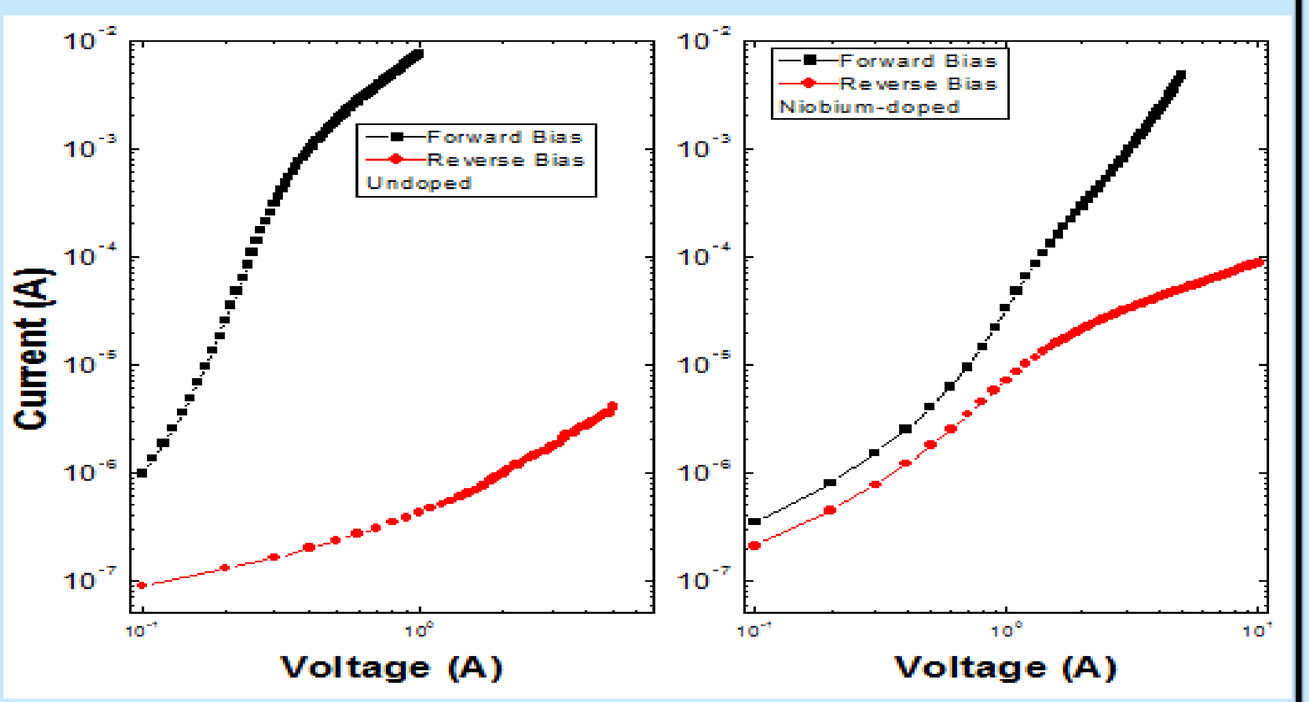
- Silicon detectors fail to operate efficiently under high radiation environments [1].
- The detectors suffer extensive radiation damage[2].
- Defects levels that are created by radiation change the electrical properties of a detector [3]
- Silicon needs to be made radiation-hard.

3. Experimental details

- Silicon diodes were fabricated on undoped and niobium-doped *n*- silicon.
- The diodes were characterised by current-voltage (I-V) and capacitance-voltage (C-V) techniques at room temperature.

4. Results and discussion

I-V



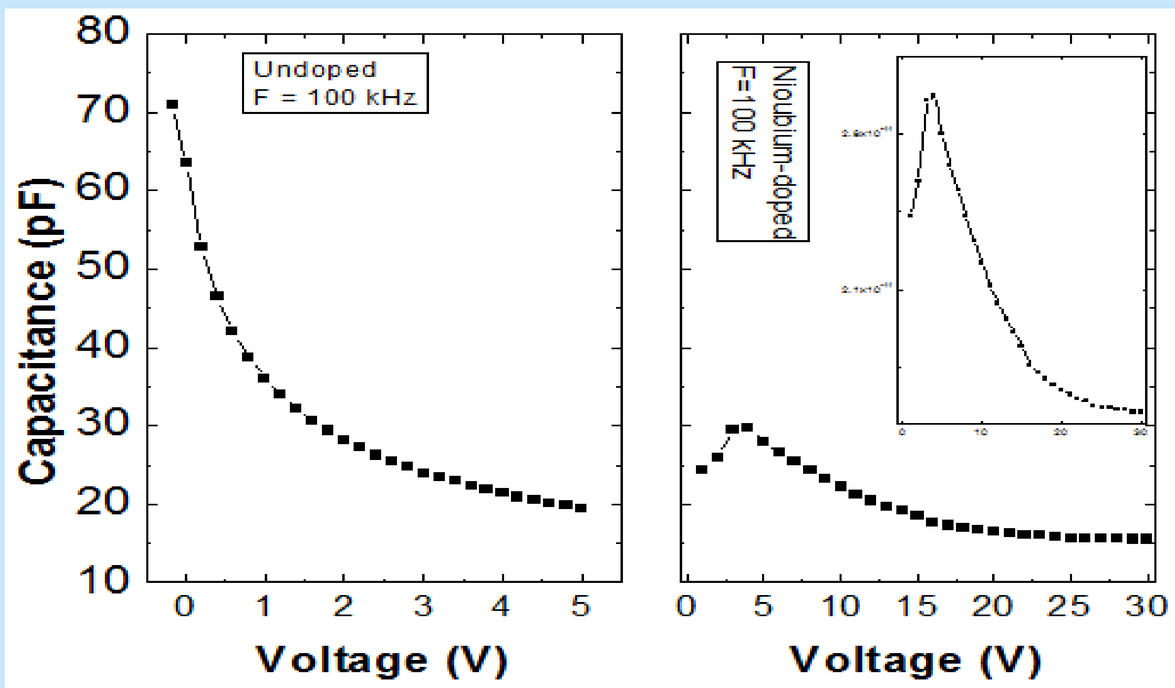
Undoped

- Typical diode characteristics - exponential behaviour in forward bias
  - independent of voltage (at low voltages) in reverse bias
  - onset of breakdown

Doped

- Ohmic behaviour
- No sign of breakdown within the range

C-V



Undoped

Typical diode characteristics - rapid decrease of capacitance at low voltages
- capacitance shows a tendency of saturation at 2 V.

Doped

- low –voltage peak
- Gentle decrease of capacitance at low voltage up to 15 V showing an increase in full depletion voltage

- Ohmic behaviour and low-voltage peak are features of relaxation devices [4]
- Relaxation devices are radiation-hard [4]

5. Conclusion

Niobium impurities change the electrical properties of silicon diodes and are responsible for relaxation behaviour of the devices. Relaxation devices are radiation-hard since the effects of radiation are supressed [5] and the Fermi level of relaxation material is not affected by incident radiation [6].

6. Future work

Irradiate diodes with neutrons or protons to ascertain this suppression of radiation effects on the properties of the devices.

7. References

[1] Van Lint V A J 1987 *Nucl. Instr. Meth. A* **253** 453.
[2] Li Z, Chen W and Kraner H W 1991 *Nucl. Instr. Meth. A* **308** 585.
[3] Moll M *et al*. 1997 *Nucl. Instr. Meth. A* **388** 335.
[4] Jones B K, Santana J and McPherson M 1998 *Solid State Commun.* **105** 547
[5] McPherson M, Sloan T and Jones B K 1997 *J. Phys. D: Appl. Phys*. **30** 3028.
[6] Brudnyi V N, Grinyaev S N and Stepanov V E 1995 *Physica B* **212** 429.

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