Current-voltage Characteristics of Cd-doped *p*-Si Schottky-based diodes

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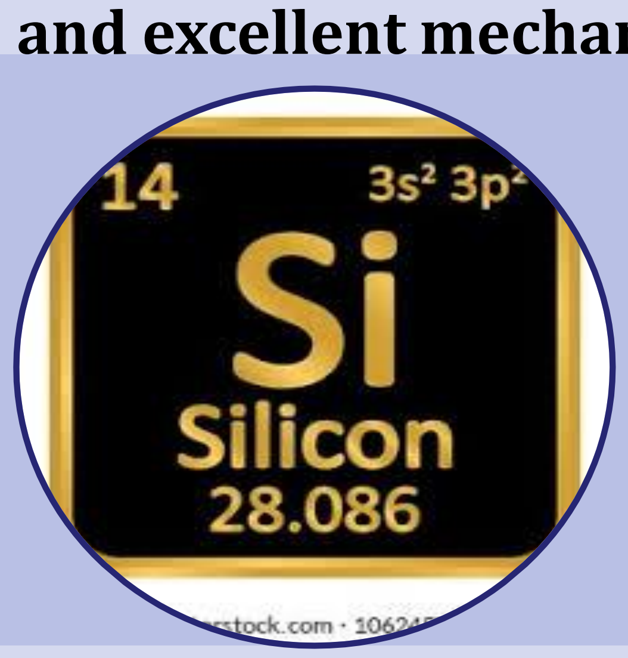
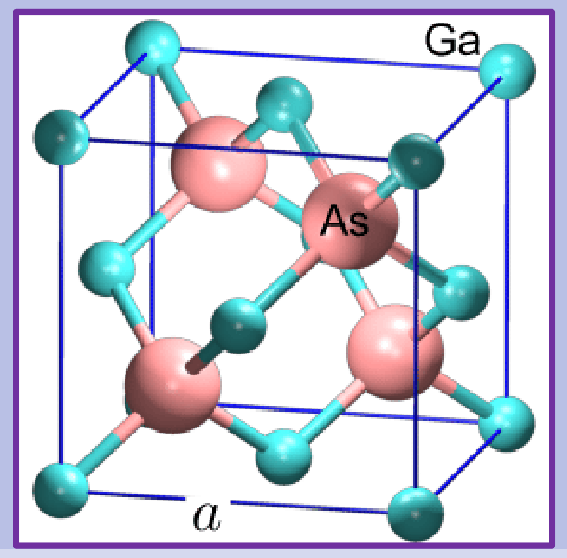
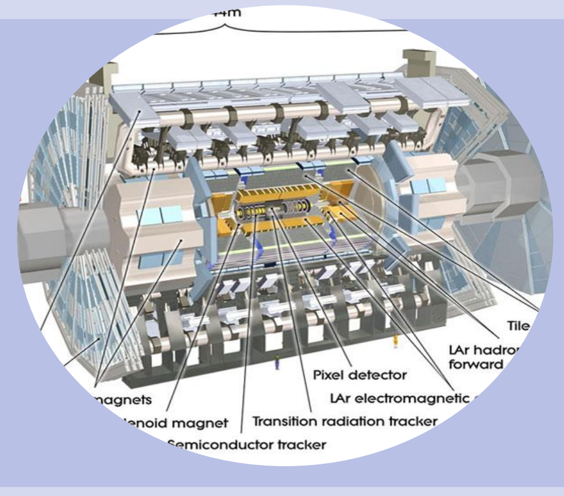
INTRODUCTION

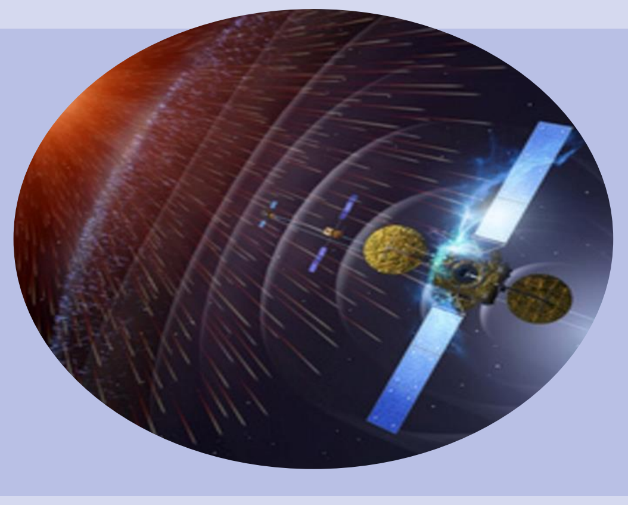
Si-based devices have gain more attention due to its reasonable band gap, low voltage operation, susceptibility to miniaturization, well-known technology, and excellent mechanical properties.

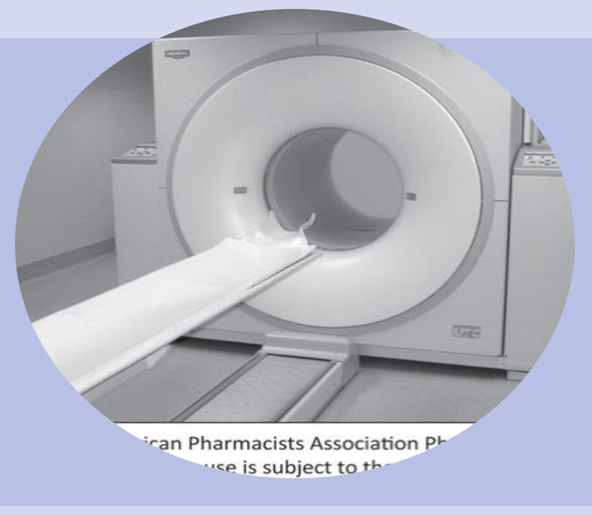




Si-based devices are used as detectors in scientific research such as high energy physics experiments astrophysics, and nuclear medicine.

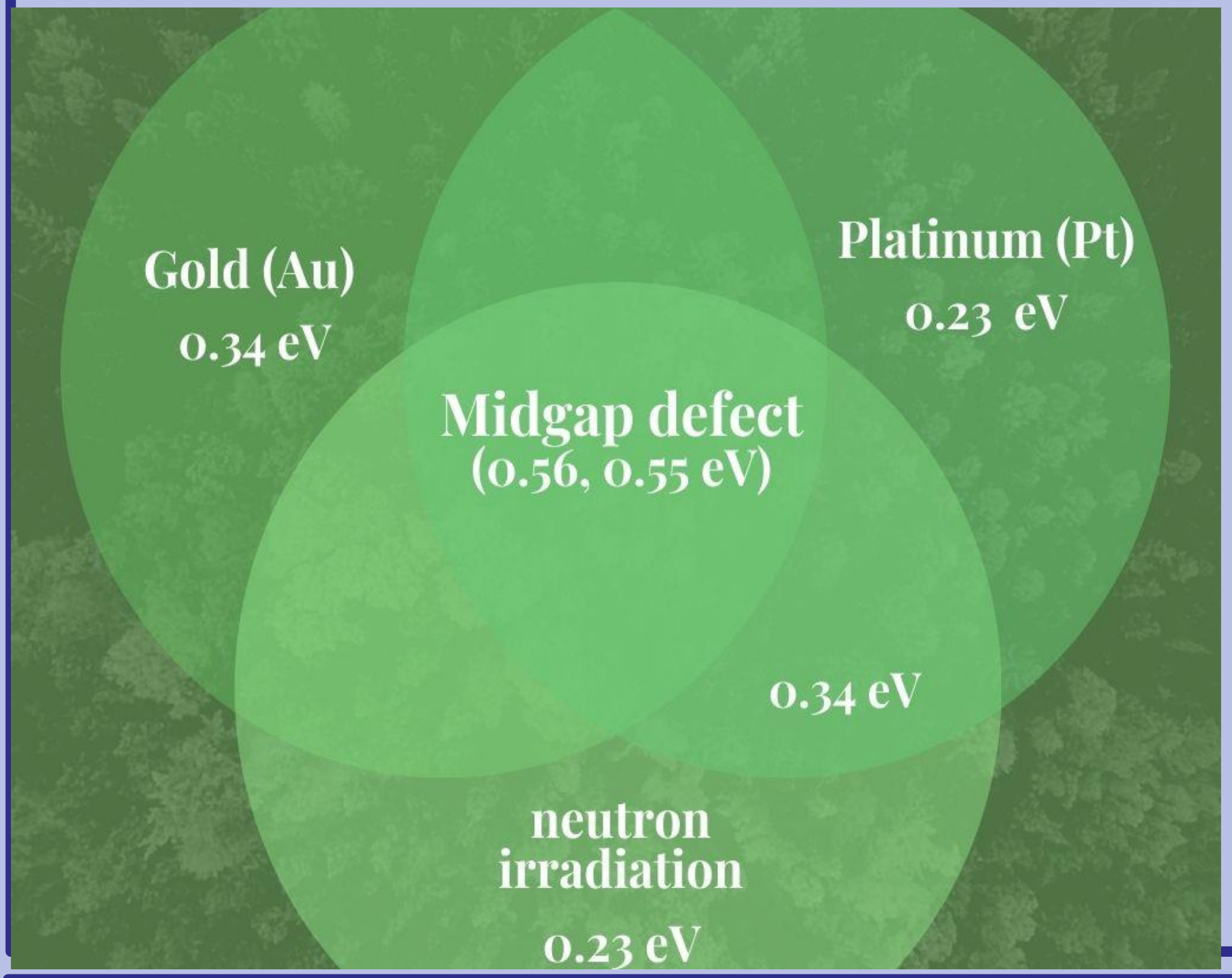






Major challenge: Radiation detectors get damaged when exposed to extreme radiations leading to instability during operation due to the defect levels created within the band gap of Si by incident radiation.

Defect engineering can be achieved by either pre-irradiation or metal-doping.



Challenges

- ➢Au and Pt are very expensive for research
- ➢High leakage current
- ➢High full depletion voltage (FDV)

AIM OF THE RESEARCH

The aim of this research is to determine the effects of Cd-doping on the electrical properties of Si-based devices in order to improve the radiation hardness of Si.

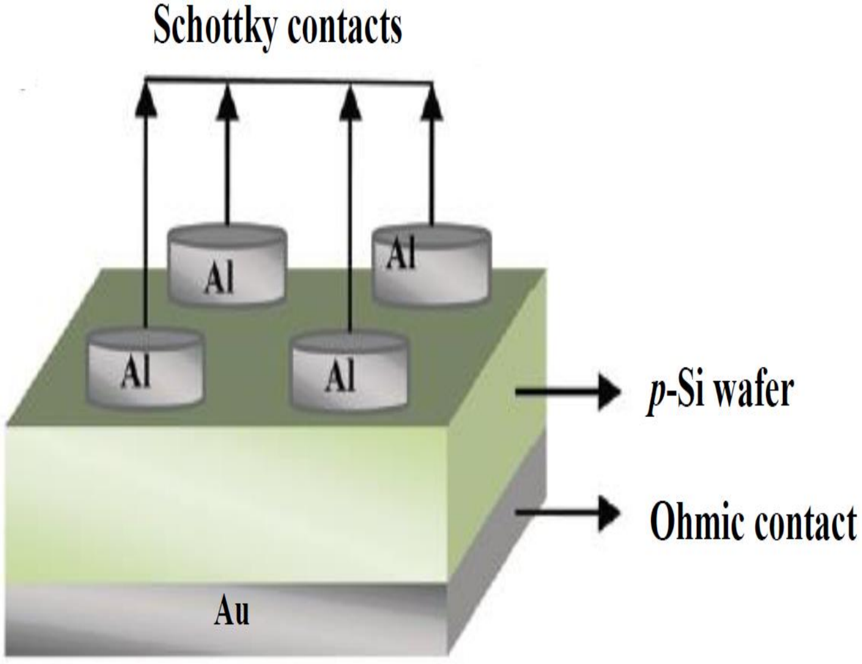
EXPERIMENTAL PROCEDURE

Cd-implantation

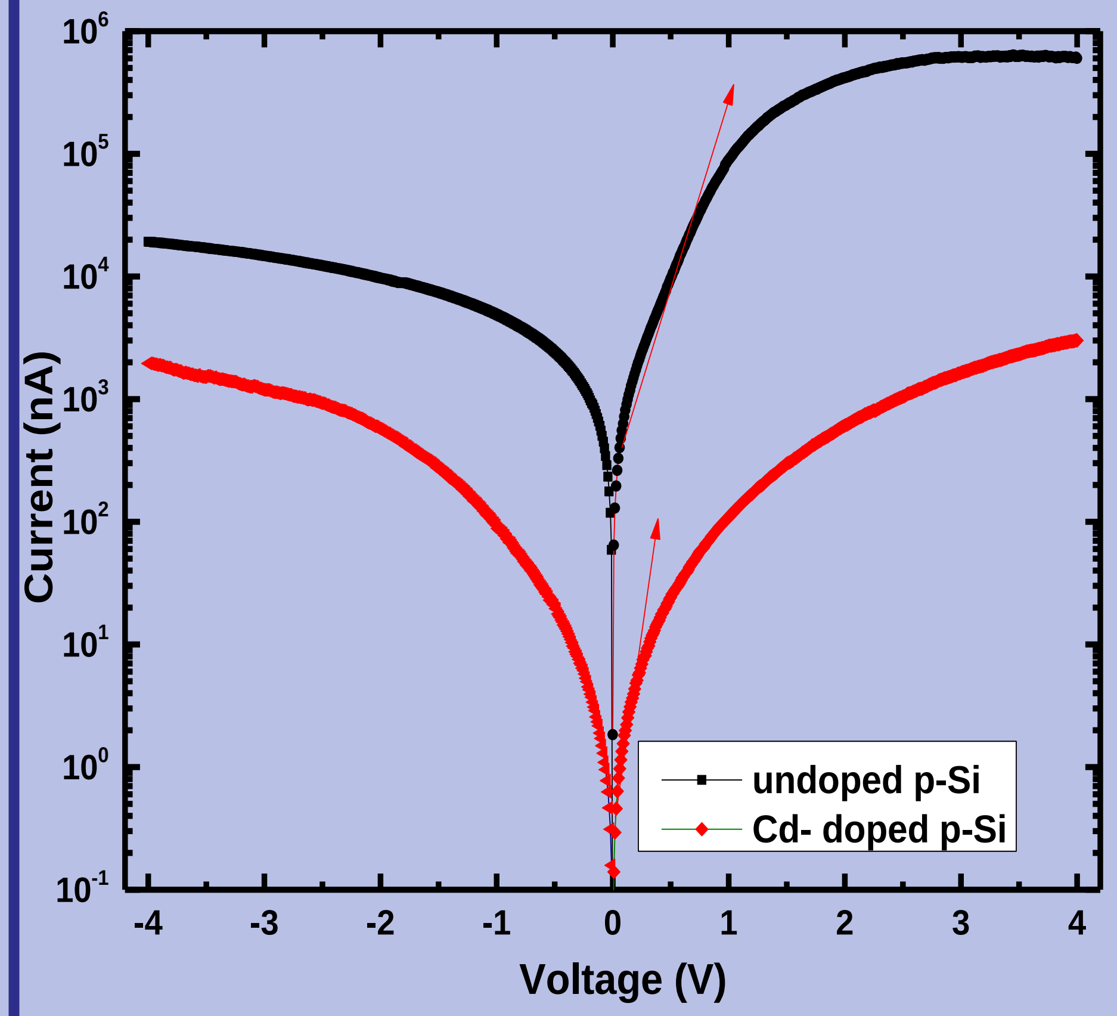
Material Characterization

Device Fabrication

Device Characterization



RESULTS AND DISCUSSION



Considering a thermionic emission theory, *I-V* characteristics of a diode with series resistance, R_s is given as

➢ $$I = I_S\left[exp\left(\frac{eV-IR_s}{\eta kT}\right)\right] \quad (1)$$

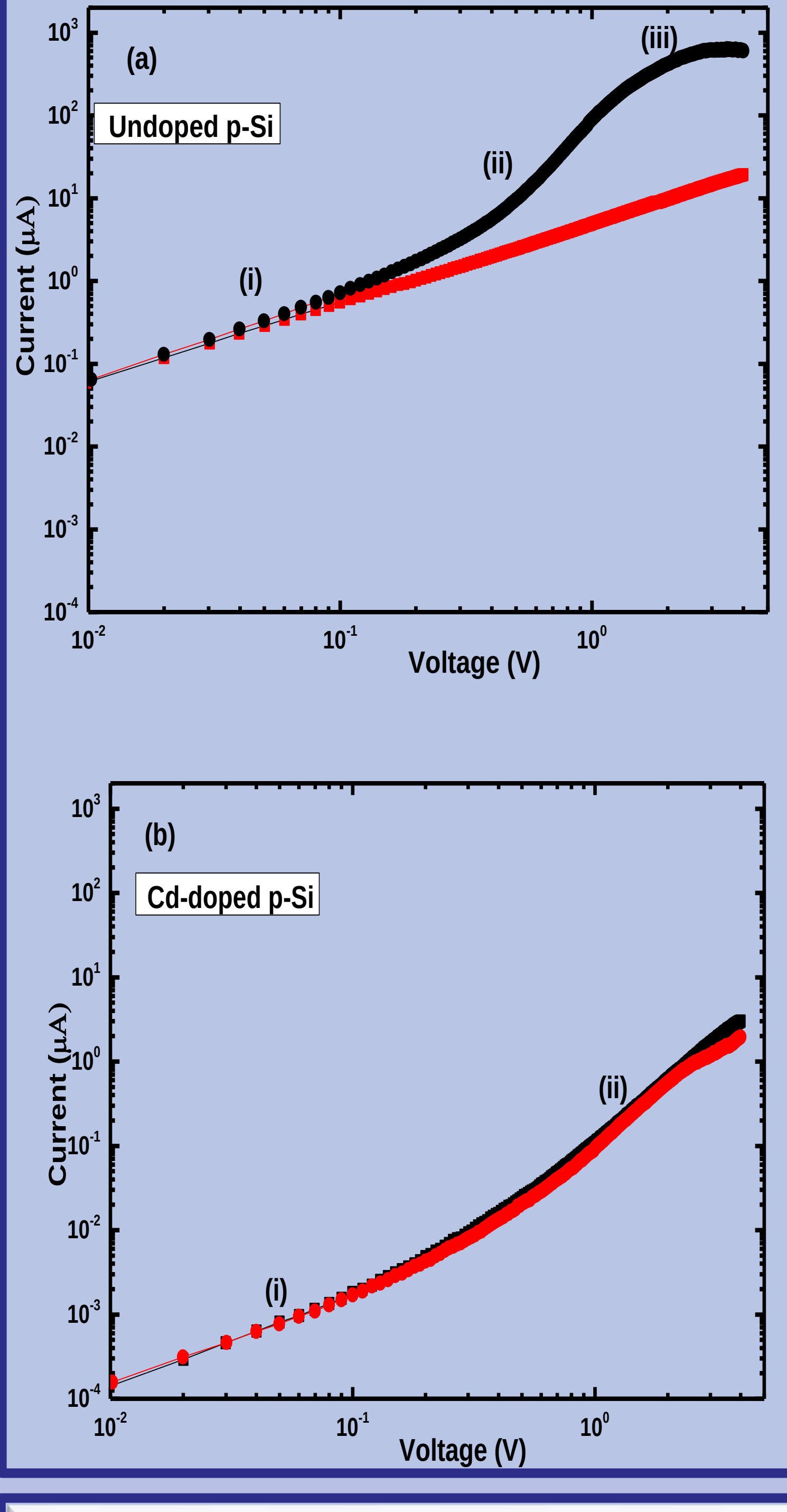
➢ $$I_S = AA^*T^2\left(\frac{-e\Phi_B}{kT}\right) \quad (2)$$

➢ $$\eta = \frac{e}{kT}\frac{dV}{d(\ln I)} \quad (3)$$

➢ $$\Phi_B = \frac{kT}{e}\ln\left(\frac{AA^*T^2}{I_S}\right) \quad (4)$$

- ➢A linear increase of forward current is observed at low voltage regions.
- ➢The linear region is used to extract the diode parameters.
- ➢The linear region disappeared at high voltages possibly due to the effect of R_s, interface states, and interfacial oxide layer.
- ➢At 4 V, the current trends decreased by a factor of ~ 10^1 and 10^3 for reverse and forward current trends, indicating an increase in resistivity of the material.

p-Si	I_s (nA)	$\emptyset_b$ (eV)	η
Undoped	2.23	0.66	2.23
Cd-doped	3.34	0.80	3.34



- ➢Three conduction mechanisms are involved in the undoped *p*-Si diode while only two are involved after Cd-doping.
- ➢An ohmic *I-V* behaviour is observed after Cd-doping, indicating that the charge carrier generation (g) and recombination (r) rates are equal. The rates are equal to show that generation-recombination (*g–r*) centres dominate the conduction mechanism.
- ➢The reverse and forward current becomes the same after Cd-doping, indicating the diode in general is ohmic.
- ➢The current trend decreased after Cd-doping indicating that the resistivity of the material has increased.

CONCLUSIONS

In general, the results indicated that the diode conduction mechanism was dominated by charge carriers generated in the centre of the Si energy gap as confirmed by diode ohmic *I–V* behaviour after doping. This ohmic behaviour have been reported on the diodes fabricated on Au- and Pt-doped Si diodes and those heavily irradiated by neutrons and have been found resistant to radiation damage. Thus, Cd is also a suitable dopant in defect-engineering studies to improve radiation-hardness of Si for fabrication of detectors to meet the current and future demands.

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