

Temperature and Radiation-Related Power Diode

K Suresh Reddy

Department of Mechanical Engineering, MRCOE, Hyderabad

Corresponding Author: sureshceclaramsu@gmail.com

To Cite this Article

Suresh Reddy, "Temperature and Radiation-Related Power Diode", Journal of Civil and Mechanical Engineering, Vol. 01, Issue 01, July 2025, pp:14-17.

Abstract: Because power diodes are important in power electronics, this research explores how high temperatures and radiation impact their operation. A main aim of the analysis is to study forward voltage drop, reverse leakage current and switching characteristics from various radiation and temperature situations. Both simulation and experiments reveal that radiation can deteriorate how long diodes function and how effective they are, while rising temperatures raise leakage and drop breakdown voltage, understanding these effects is necessary to improve the reliability and working life of power diodes in space, nuclear and aerospace environments.

Keywords: Electrical properties, Diffusion length, Silicon diodes, Physical radiation effects, Radiation effects, P-N junctions, Semiconductor diodes

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I. Introduction

Power diodes are key elements found in many rectifiers, inverters and voltage regulators, as well as in other systems for control and conversion of power. Without reliable and dependable performance, electronic systems in difficult situations would not be effective or secure. Power diode operation is greatly influenced by temperature and radiation. Dramatic changes in a diode's properties happen as temperatures rise, for example, less breakdown voltage, more reverse leakage current and slower switching speed. Modifying the device may shorten its life and negatively affect its performance in applications that are hot or have high power requirements.

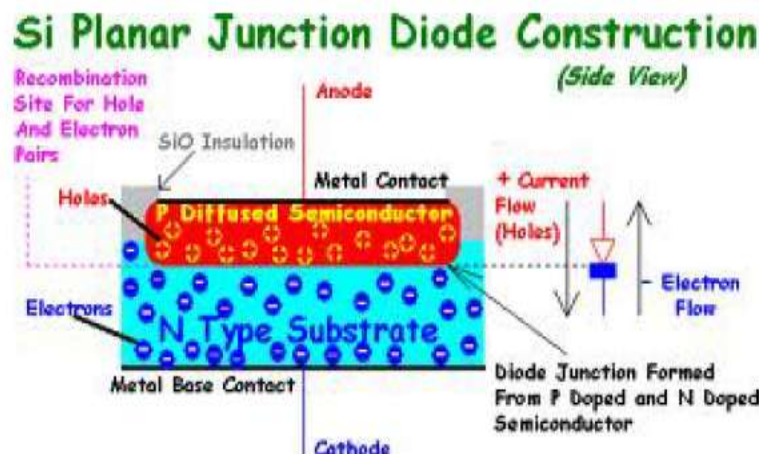


Fig 1: Power diode physical characteristics

Just as other types of radiation, exposure to ionizing radiation can often occur in nuclear, space and aerospace contexts and can do permanent harm to the diode's semiconductor structure. Damage to the crystal lattice and reduction in the minority carrier lifetime are caused by radiation and affect both the recovery time and forward voltage. The importance of Power diodes depends on the stress of different scenarios.

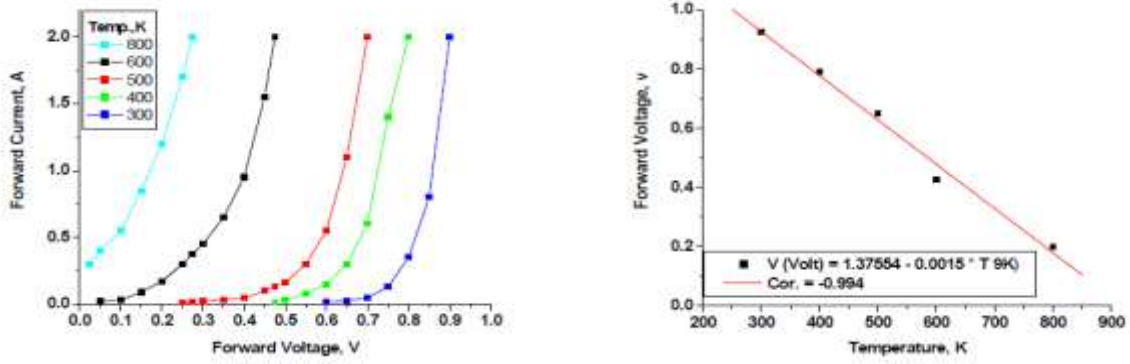


Fig 2: Power diode V-I characteristics

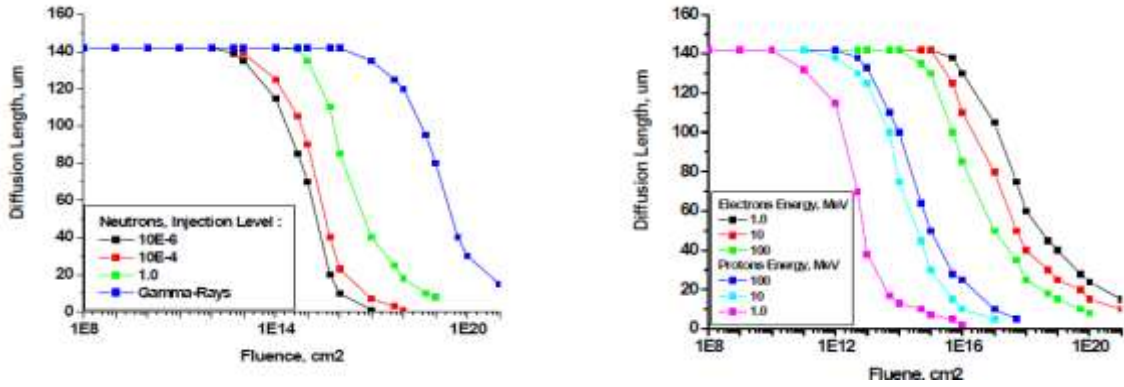


Fig 3: Neutrons and Protons of Power diode

II. Theory of Operations

The effect of temperature and radiation of the power diodes has been investigated by using the MATLAB simulation. The effects of radiation and temperature in different scenarios have been investigated thoroughly using experimental data. The goals of the power diodes in different conditions have been tested in simple and harsh environmental conditions.

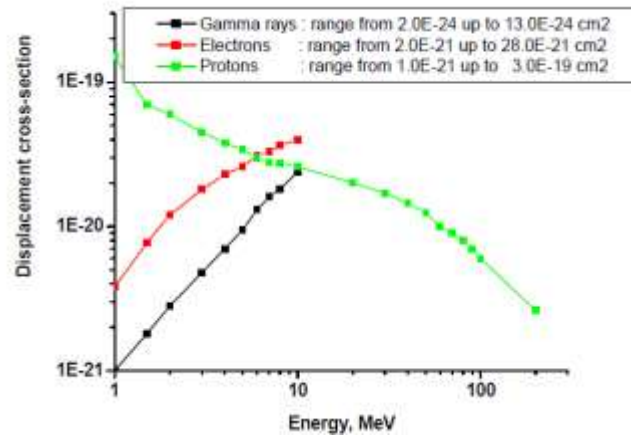


Fig 4: Displacement cross section of power diode

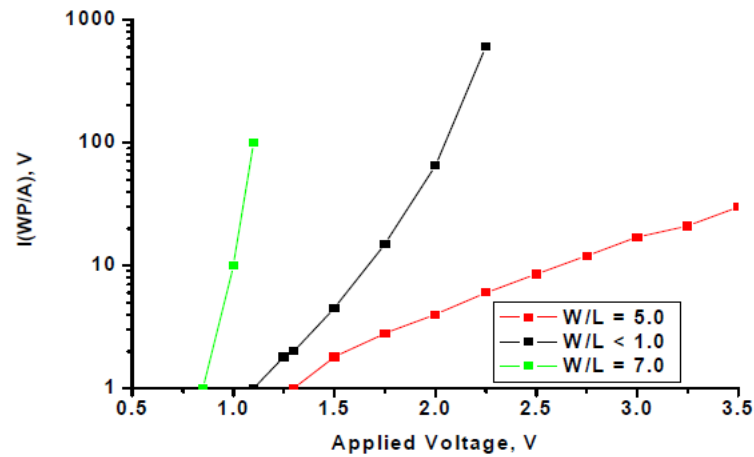


Fig 5: V-I relations of power diode

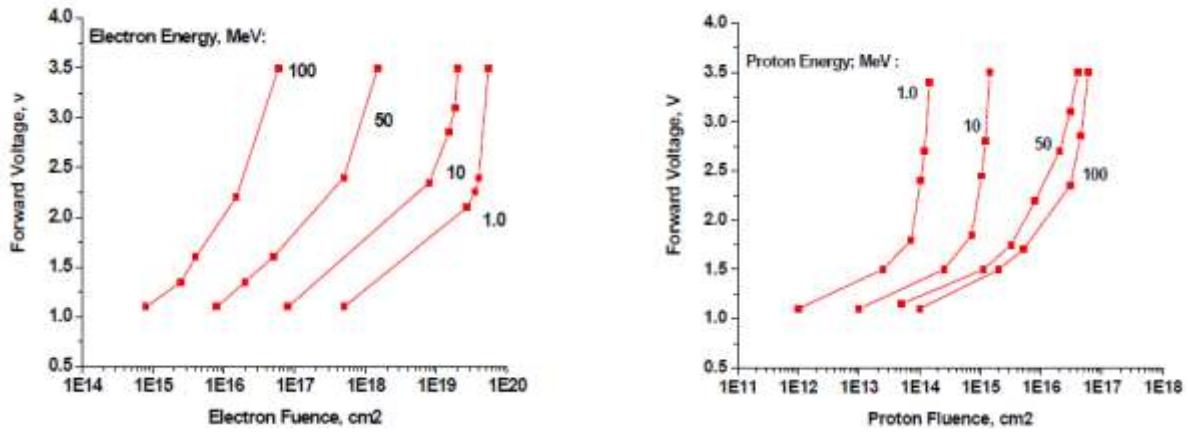


Fig 6: Effect of irradiance of power diode

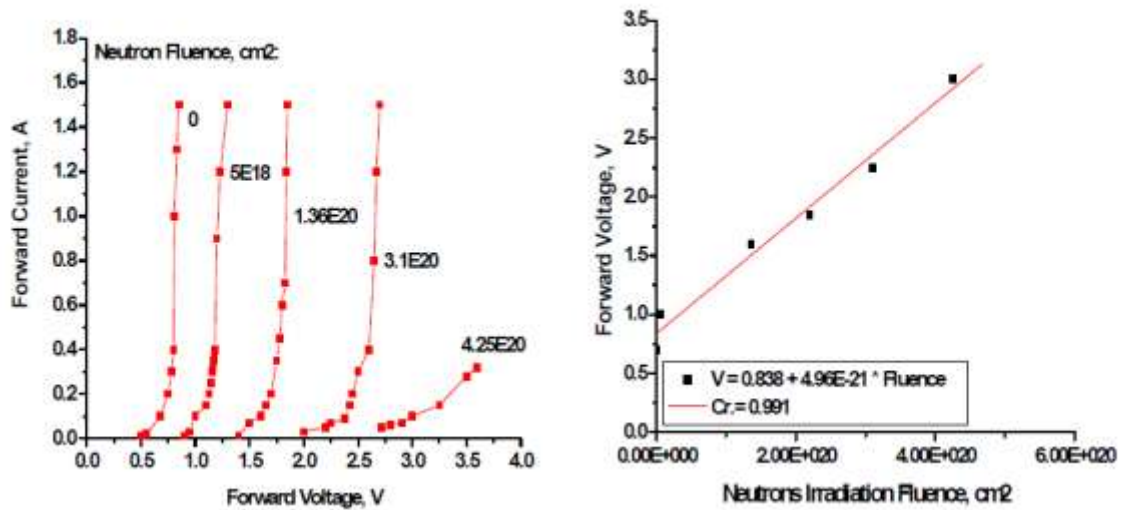


Fig 7: Power diode neutrons irradiance

III. Conclusion

Diode performance and reliability in nuclear space applications is directly affected by temperature and radiation. Reverse currents increase with temperature while the breakdown voltage decreases and the movement of carriers and hence device lifetime are limited by radiation exposure. These factors affect stability, switching behaviour and efficiency of the diode. So, in order to improve diode design and material selection we must understand these critically important stressors. Because diodes must perform in difficult conditions, future work should design them to handle intense radiation and high temperatures.

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