Use Of Displacement Damage Dose in an Engineering Model of GaAs Solar Cell Radiation Damage

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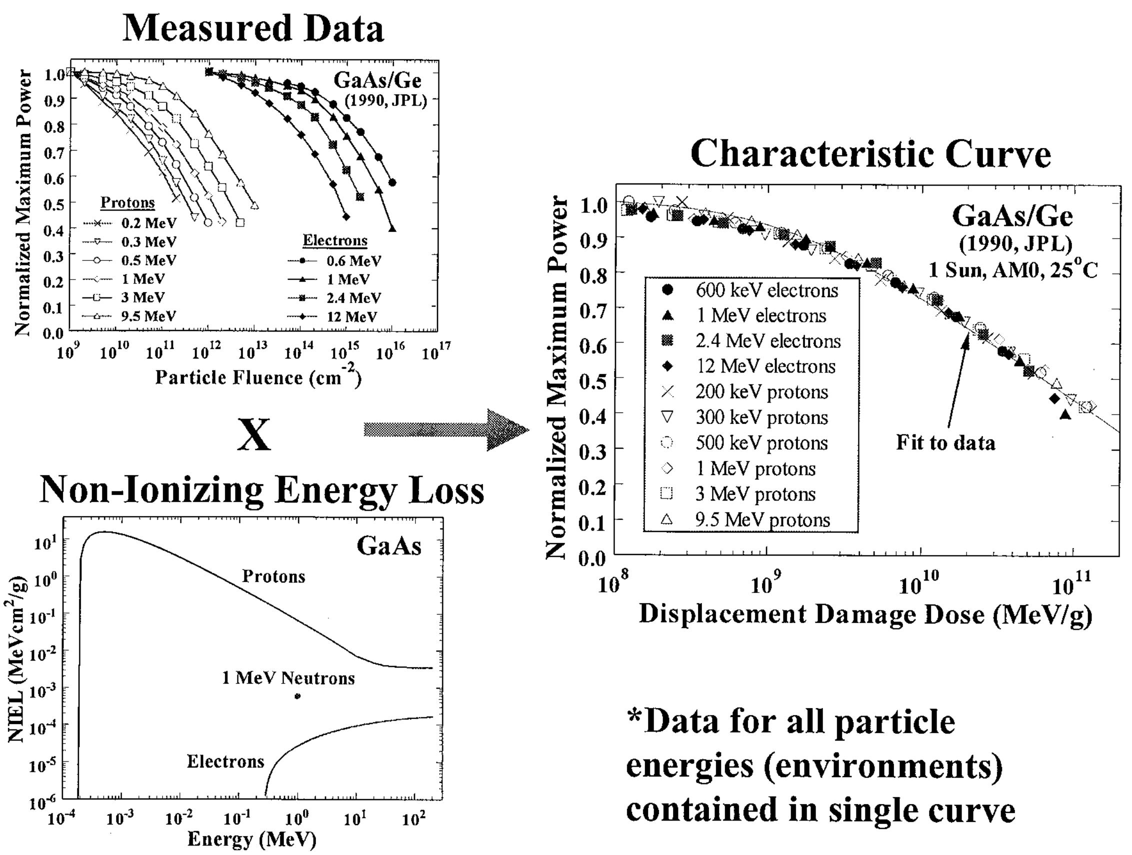
Introduction

Current methods for calculating damage to solar cells are well documented in the GaAs Solar Cell Radiation Handbook (JPL 96-9). An alternative, the displacement damage dose (D_d) method, has been developed by Summers, et al. This method is currently being implemented in the SAVANT computer program.

Description of Model

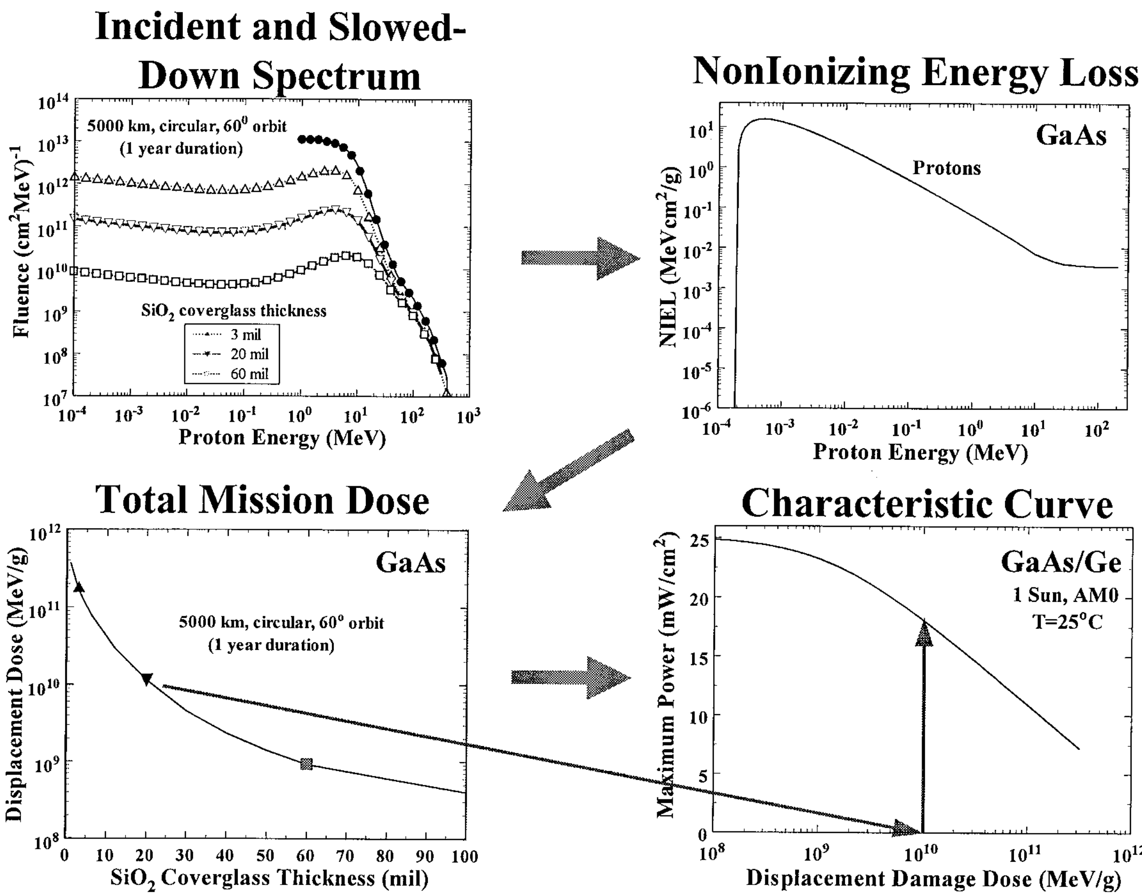
As illustrated in Figure 1, measured radiation damage when multiplied by non-ionizing energy loss (NIEL) leads to a single characteristic curve for all electron and proton energies.

Figure 1



The SAVANT program calculates differential fluence, transforms it to the slowed-down spectrum, and multiplies it by the appropriate NIEL factor to yield the displacement damage dose, D_d. The power loss is obtained from the characteristic curve, as shown in Figure 2.

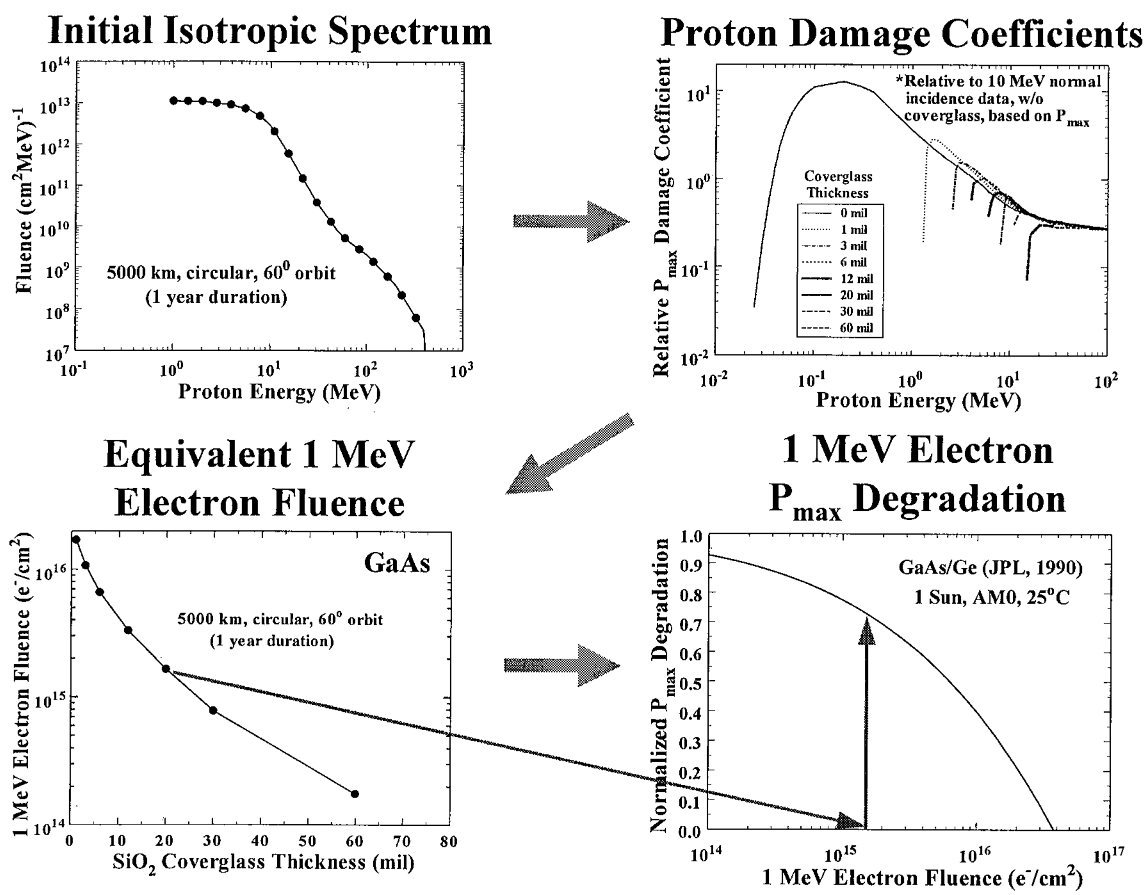
Figure 2



By comparison, the equivalent fluence method of the Radiation Handbook attempts to scale all the energies to 1 MeV electrons, in the form of damage coefficients. These are tabulated for specific thicknesses of coverglass. The algorithm is to multiply the incident differential fluence by the damage coefficient for the corresponding coverglass thickness to derive the equivalent 1 MeV electron fluence. The experimental curve tabulated for 1 MeV electrons is then used to determine the damage.

To date, damage coefficients have only been measured for Si and GaAs, limiting applicability of the equivalent fluence method to other cell materials. This equivalent fluence model requires measuring as many as thirteen discrete particle energies, whereas the displacement damage model requires only three, making it easier to extend to new materials.

Figure 3



The SAVANT computer program combines an orbit generator with AE-8/AP-8 and IGRF-95 to calculate radiation fluence for a desired orbit. SAVANT applies the continuous slowing down approximation to calculate a slowed-down fluence. The user can enter a desired orbit, solar condition (MAX/MIN), mission duration, and coverglass thickness. The program currently is able to calculate D_d and power loss for GaAs cells. To perform trade studies, the user may enter a range of values for one of the input parameters, such as altitude, inclination, or coverglass thickness.

Figure 4 compares the two methods for a range of coverglass thickness from 6 to 60 mils. The equivalent fluence model shows only the results for five coverglass thicknesses, while the displacement damage dose modelling in SAVANT calculates damage for a range of thicknesses within the 6 to 60 mil interval.

Figure 4

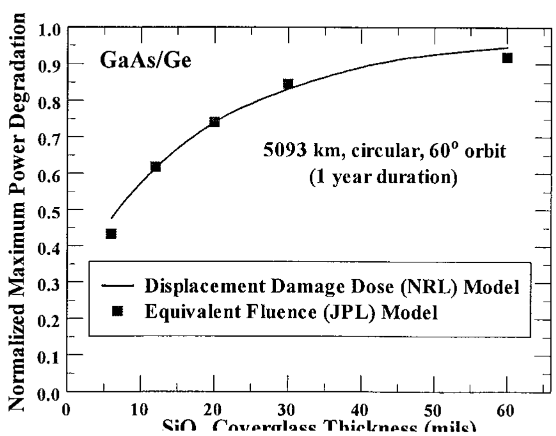
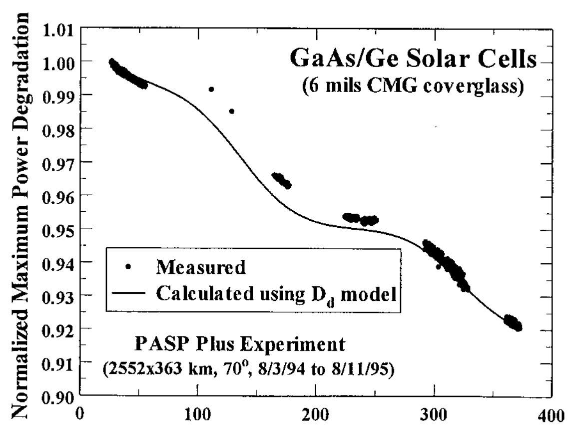


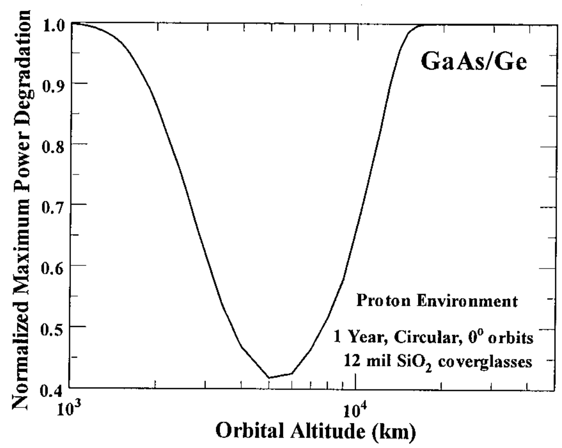
Figure 5



The SAVANT program is used to calculate damage to Module 11 (GaAs/Ge) of the PASP Plus experiment. Results, for albedo-free days only, are shown in Figure 5.

As a final example, Figure 6 illustrates a SAVANT calculation for a range of orbital altitudes. It can be readily observed that the proton radiation belt lies near 5000 km altitude.

Figure 6



Conclusions

The displacement damage dose model, as incorporated in the SAVANT program, is a tool for rapid calculation of radiation damage. It accurately reproduces GaAs Radiation Handbook results, and agrees well with PASP Plus data for the GaAs/Ge test module. This model should lend itself to analysis of newly developed photovoltaic materials.

Future development of the displacement damage dose model will improve electron damage calculation, analyze cell geometry effects and end-of-life specific powers, and extend these calculations to new materials. A user-friendly interface is currently under development.

References

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