Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Solar Energy Materials & Solar Cells 87 (2005) 629–636
Solar Energy Materials & Solar Cells
www.elsevier.com/locate/solmat

Electron irradiation facility for the study of radiation damage in large solar cell arrays in the energy range $0.5 < E \leqslant 5$ MeV

C. Vargas-Aburto[a], R.M. Uribe[b,*]

[a]*Academic Affairs, Central State University, P.O. Box 1004, Wilberforce, OH 45384, USA*
[b]*Program on Electron Beam Technology, Kent State University, P.O. Box 1028, Middlefield, OH, 44062, USA*

Received 15 May 2004; received in revised form 16 July 2004; accepted 20 July 2004
Available online 28 November 2004

Abstract

In this work, a description is presented of the use of an accelerator facility to uniformly irradiate with electrons large samples (of the order of m^2) in the energy range from 0.7 to 5 MeV, and currents ranging from hundreds of micro amps to tens of milliamps. The accelerator has a scanning system that allows for large area irradiations. Reference is made to a sample handling system used for solar cell irradiations and a Faraday Cup designed to measure the electron fluence in this facility. Measurements performed with these systems show a typical irradiation area of 6200 cm^2 and fluence values of 10^{13} e/cm^2 achieved in about 60 s of irradiation time.

Keywords: Electron beam; Solar cells; Radiation damage

1. Introduction

Electron beams with energies in the MeV range are used in research and industry to develop new materials and to change the physical and chemical properties of

*Corresponding author. Fax: +1 440 632 1622.
E-mail address: ruribe@kent.edu (R.M. Uribe).

0927-0248/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.solmat.2004.07.042

materials of technological interest (e.g. polymeric materials or semiconductors). These beams are also used to study the effects of space-ionizing radiation in solar cell power modules [1] found in spacecrafts and satellites. However, most of the facilities that are traditionally used to study radiation damage in solar cells have been retrofitted from accelerators that were used in Nuclear Physics studies and can only produce beams with a spatial homogeneity of a few cm^2, thereby limiting the size of the samples to be irradiated in a uniform radiation field. This type of irradiation facilities are useful to study the effects of radiation on small area solar cells, however, they cannot be used to study the effects of radiation in solar cells with areas of the order of $10\,cm^2$ or larger, or in complete power module assemblies, which may have an area larger than $1\,m^2$.

In this paper, a description is presented of the use of a radiation processing facility for the irradiation of large area solar cells and satellite power modules. The facility is the result of a partnership between a private plastics company and Kent State University (KSU) with the main purpose to do production work and to provide beam time for research and teaching activities in support of the mission of the university. To carry out production work, the facility includes a large warehouse area of $300\,m^2$, and two types of product conveyor systems, a cart conveyor system consisting of 27 carts, each cart with a surface area of $2.16\,m^2$ and a maximum product load of 340 kg driven by an underground chain, and a reel-to-reel system that allows irradiation of bulk tubing with outer diameters between 0.48 and 3.17 cm and maximum reel weight of 5400 kg. The control console computer of the accelerator is interfaced to both product handling systems and changes the speed of the product under the electron beam with any change in the electron-beam current, guaranteeing in this way that the energy from the electron beam deposited in the product is the same regardless of any change in that current.

To conduct research activities in the facility, the experimental samples can be irradiated on the cart conveyor system or in a linear motion system (LMS) specifically developed in our facility. The facility also includes a dosimetry laboratory to determine the dose in irradiated experimental samples treated with electrons, using different physical techniques (e.g. optical absorption, electron spin resonance, and calorimetry). The main purpose of this paper is two fold: first, to describe how this facility is being used for the study of radiation effects in extended area solar cells, and refer to the instrumentation available to conduct these types of studies; and secondly, to provide some experimental results that show the capabilities of the facility to carry out radiation damage studies in solar cells.

2. Experimental

2.1. Description of the accelerator

The electron source is an electrostatic type Dynamitron accelerator, manufactured by Radiation Dynamics Inc., capable of providing electron energies in the range from 0.7 to 5.0 MeV and a maximum beam current for each energy range given as