Solar Energy

The Solar Energy Group (GES) performs research and development activities related with photovoltaic solar energy conversion. Main tasks are design, simulation, fabrication and characterization of crystalline silicon devices (solar cells and modules) for space and terrestrial applications. During 1997, solar cells based on monocrystalline Czochralski silicon with 17% conversion efficiency were obtained.

The development of solar devices for space applications begun by the end of 1995, within the frame of a cooperation agreement between this National Atomic Energy Commission (CNEA) and the National Commission of Space Activities (CONAE). On December 14th 1998, the Endeavour space shuttle launched the argentine satellite SAC-A at 410 km height. This satellite included the first experiment of Argentine silicon solar cells in space.

As continuity of the mentioned cooperation agreement with CONAE, CNEA and CONAE subscribed a specific agreement to fabricate, characterize and test solar panels for space applications. This agreement allowed the beginning of the Sub-project Solar Panels in April 2001 as part of CONAE's Project SAOCOM. For its execution, a special inter-departmental group from the Constituyentes Atomic Center (CAC) was appointed. Main goals of this Sub-project are: (i) installation of the solar panels integration facility, (ii) design and development of crystalline silicon solar cells, (iii) development of characterization techniques and lab test procedures (iv) development of interconnection and integration processes of solar cells to the module, and (v) fabrication and testing of the solar panels for the SAOCOM mission. During 2001 all these activities begun. Some of these activities included: theoretical and experimental studies of radiation damage by 10 MeV protons, development of characterization set-ups for solar cells, development of prototypes for cover glasses and solar cells bonding, and design and building of integration facility.

Other activities of the GES in 2001 were, in collaboration with the LAMEL (Istituto di Chimica e Tecnologia dei Materiali e dei Componenti per l'Elettronica), Institute of the CNR (Consiglio Nazionale delle Ricerche, Italy), research activities on simulation, elaboration and characterization of heterojunctions (HJ) on c-Si solar devices, participation in the establishment of national standards for solar energy systems in the frame of the Argentine Institute for Standards (IRAM), and the development of low cost solar radiation sensors based on photovoltaic cells.

Research activities related with the deposition and characterization of thin films (InP, CdTe, YBaCuO) for solar cells, gas sensors and superconductors, are also performed in collaboration with LAMEL Institute. In particular, the GES has participated in the installation in Argentina of a Laser Ablation Deposition (PLD) system for thin film growing in collaboration with the Physics Department-Facultad de Ingeniería, Universidad de Buenos Aires.

Since 1998, the GES participates in the development of SnO_2 thin film micromachinated solid state gas sensors in collaboration with LAMEL Institute of the CNR (Italy) and with CITEFA (Argentina). A NO_2 selective gas sensor in the ppm range has been developed and is being tested in an electronic nose developed by the group in collaboration with INQUIMAE (Facultad de Ciencias Exactas y Naturales-Universidad de Buenos Aires) and with the School of Science and Technology (Universidad Nacional de General San Martin). Since 2000, a strategic agreement was signed with an Italian e-nose producer, Technobiochip S.R.L., for developing specific algorithms using its commercial apparatus (LibraNose) for local industry applications.

"Ultrathin µc-Si Films Deposited by PECVD"

R. Rizzoli, C. Summonte, J. Plá, E. Centurioni, G. Ruani, A. Desalvo, F. Zignani

Thin Solid Films 383 (2001) 7

The crystalline fraction of microcrystalline silicon films 18-200 nm thick, deposited by VHF plasma and by chemical transport deposition (CTD) was characterised by Raman and optical measurements. On a p-type

CTD sample, thinner than 20 nm, a crystalline fraction as large as 78%, to our knowledge the largest obtained by VHF plasma on p-type films in this thickness range, was measured. Transmission electron microscopy shows crystallites extending to the interface with the substrate. Electrical conductivity in the range 10-2-100 S/cm, and 10-1-101 S/cm after annealing at 250ºC, was measured. Weak dependence of crystalline fraction and electrical properties on thickness was observed.

"Estudios de daño por radiación con protones de 10 MeV en celdas solares de silicio cristalino utilizando el acelerador TANDAR"

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Avances en Energías Renovables y Medio Ambiente 5 (2001) 08.43

Se desarrolló un montaje experimental que permitió medir in situ la degradación de celdas solares de silicio monocristalino elaboradas en el Grupo Energía Solar, irradiadas con protones de 10 MeV y fluencias entre 108 y 1013 p/cm^2, utilizando un haz externo del acelerador TANDAR de la CNEA. Dicho montaje permitió observar la degradación de las características eléctricas de las celdas, determinándose la corriente de cortocircuito, la tensión a circuito abierto y el factor de forma entre irradiaciones mediante la medición de la curva característica corriente-tensión. Asimismo, se realizaron simulaciones teóricas con el fin de verificar la relación entre la variación de los parámetros eléctricos y el deterioro de la vida media de los portadores minoritarios en la base, la cual se ve afectada directamente en este tipo de ensayo.

"Convenio de cooperación CONAE-CNEA: desarrollo, fabricación y ensayo de paneles solares para misiones satelitales argentinas"

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Con el fin de proveer total o parcialmente los módulos fotovoltaicos para las futuras misiones satelitales previstas en el Plan Espacial Nacional, la Comisión Nacional de Actividades Espaciales (CONAE) y la Comisión Nacional de Energía Atómica (CNEA) suscribieron, en marzo de 2001, un Convenio Específico de colaboración cuyos objetivos son: (i) montaje de un laboratorio para la integración de paneles solares, (ii) diseño y elaboración de celdas solares de silicio cristalino, (iii) desarrollo de los procesos de interconexión de las celdas y su integración al panel solar, y (iv) identificación y/o montaje de laboratorios para ensayos. En este trabajo se describen las principales características del proyecto, el cual tendrá una duración de 36 meses, analizándose el estado actual de desarrollo de los diferentes temas. Asimismo, se presentan las características del área limpia diseñada para el laboratorio de integración.

ITO Films for Heterojunction a-Si/c-Si Solar Cells"

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An Indium Tin Oxide (ITO) layer is frequently used as front contact for a-Si/c-Si heterojunction (HJ) solar cells. It must have appropriate characteristics from the electrical point of view (i.e., a good conductivity) as well as from the optical point of view (low absorption coefficient and good antireflection properties). However, higher conductivities imply more absorbent materials and then less transparency, thus a compromise between these effects should define the optimised device. In this paper, the optimisation of the ITO layer thickness was performed taking into account the influence of the a-Si layer thickness, the optical refraction indexes of both materials and the spectral response of the device. The code D-AMPS-1D was used for device simulation. Calculated spectral response and I-V curve are presented and compared with

experimental results. The optimisation of the front contact grid is also carried out taking into account the ITO sheet resistance. Optimal ITO thickness between 80 and 90 nm were obtained depending on the particular spectral response. A tolerance of ± 10nm was found acceptable with a minimal degradation on the device performance. Finally, the experimental conditions for the deposition of suitable ITO layers by means of a radiofrequency (RF) magnetron sputtering system were determined.

Junction formation and interface passivation in homojunction and heterojunction silicon solar cells deposited by VHF-PECVD"

E. Centurioni, C. Summonte, R. Rizzoli, D. Iencinella, J. Plá, K. Mellassi, M. Martínez Bogado, M. Tamasi, A. Desalvo, F. Zignani

Proceedings of the 17th European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany, (2001) 3001

Homo- and heterojunction silicon solar cells were grown by VHF-PECVD at low temperature. The deposition conditions of the intrinsic layers at the junction interface were varied to obtain epitaxial and amorphous Si buffer layers. The passivating properties of the epitaxial silicon, associated to lower absorption losses compared to amorphous silicon, are investigated. A comparison between amorphous / crystalline heterojunction solar cells and epitaxial c-Si devices shows that in the latter case the larger Jsc partially compensates the inferior passivating properties of the intrinsic epitaxial buffer layer. The Voc of the epitaxial devices is strongly affected by the hydrogen dilution of the gas mixture in the intrinsic buffer layer deposition, and increases up to 613 mV for the higher dilution used. The result is attributed to an improvement of the interface quality for growth conditions as close as possible to equilibrium. The recombination losses in the junction region are also investigated by the saturation current density measurements as a function of temperature. The best cell performance, Voc = 637 mV and 13.7% extrinsic efficiency on planar devices, is obtained in the case of an amorphous i-layer with a p-microcrystalline emitter.