INDUSTRIAL HYGIENE WALK-THROUGH SURVEY REPORT OF ROCKWELL INTERNATIONAL THOUSAND OAKS, CALIFORNIA

Prepared by

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Prepared for

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INDUSTRIAL HYGIENE

WALK-THROUGH SURVEY REPORT

OF

ROCKWELL International
Thousand Oaks, Californai

PURPOSE:	The National Institute for Occupational Safety and Health (NIOSH) is conducting health research studies in various developing energy technologies. An area of rapid anticipated growth is that of photovoltaic solar energy conversion to direct electrical current. This survey is a part of our investigation of this technology. Based on walk-through survey findings, facilities will be chosen for indepth sampling surveys to characterize worker exposures to chemical and physical agents.
DATE OF SURVEY:	February 6, 1979
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PERSONS CONDUCTING SURVEY:	Terry Briggs Mark Boeniger
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SUMMARY OF SURVEY FINDINGS

The Rockwell International Thousand Oaks Research Center is conducting basic research and development work on single crystal gallium arsenide (GaAs) photovoltaic cells starting with GaAs wafer material. Work is conducted on a small laboratory scale under well controlled conditions. The use of well trained scientists and technicians reduces the industrial hygiene concern. All toxic materials appeared to be adequately contained.

PLANT DESCRIPTION

The photovoltaic research is conducted within the larger III-V materials group of this large multifacited research center. Most of the photovoltaic work is conducted in two laboratory rooms.

DESCRIPTION OF WORK FORCE

Well trained scientists and technicians conduct the research. Technicians are non-union.

MEDICAL, HEALTH AND SAFETY PROGRAM

The Research Center uses a medical clinic for emergency medical care and does have a full-time nurse on the staff.

New employees are given a medical examination and an annual or semi-annual examination thereafter, dependent upon the chemicals used in their work area.

Ms. Noreen Considine serves as the facility safety and industrial hygiene officer. No routine industrial hygiene measurements are taken; however one survey has been conducted for airborne arsenic.

DESCRIPTION OF PHOTOVOLTAIC PROCESSES

Although Rockwell is producing a demonstration GaAs concentrator GaAs array, the cell production processes are primarily focused on research. Currently the starting material is purchased GaAs wafers.

Wafer Preparation

Rockwell buys polished wafers which they first clean in solvents in the following sequence: trichloroethylene, acetone, methyl alcohol, and isopropyl alcohol to dry. Each solvent is used to remove different organic residues. These operations are performed by dipping a group of wafers in a holder in beakers of solvent under a laboratory hood.

Wafers are then individually etched in a beaker of sulfuric acid-hydrogen peroxide solution. Wafers are then rinsed with water and dried with isopropyl alcohol.

Liquid Epitaxial Growth

Layers of GaAs and GaAlAs are added to the GaAs starting substrate surface by liquid phase epitaxial growth (LPE). Preweighed source materials (Al, Ga, GaAs) are added to a multicompartment boats in a closed quartz tube, vented at one end. The quartz tube is initially pumped with a carbon vane pump and then a cryogenic sorption pump. The tube is then back filled with high purity H_2 gas and is subsequently maintained with a continuous H_2 flow of 250 cc/min. The quartz tube is guided part way into a cylindrical Marshall furnace, far enough to heat a multi-compartment boat. The metal melt is allowed to equilibrate and then the melt is positioned over the substrate and the furnace temperature is lowered to form the required GaAs and GaAlAs layers. After growth, the wafers are ready for cell processing. The LPE melts contain 99 percent Ga and are re-cycled by the Ga supplier to recovery the Ga.

Metallization and Anti-Reflective Coatings

The cell fabrication consists of defining the cell area on the wafer, applying an ohmic metallization and an anti-reflection coating. Wafers are first rinsed in a sequence of beakers containing trichloroethylene, isopropyl alcohol, and acetone. This is done manually under a laboratory nood. Next, wafers are etched with bromine solution, also under a laboratory hood. A photoresist pattern is formed on the wafer by spinning on a photoactive material with a photodeveloper. The mask is positioned on the wafer using a microscope aligner.

Metallization layers were formed in vacuum bell jars. The top side ohmic contacts contact metals include zinc, silver and manganese. Layers of silver and germanium are applied to the back surface to form ohmic contact.

Wafers are mounted on holding plates in the bell jars which contain 6 evaporation positions to evaporate metal in carbon crucibles using an electron beam. The vacuum pumps for the bell jars are located on the lower floor of the building.

The inner surfaces of the bell jar are cleaned periodically using a hand vacuum and blowing with nitrogen. This operation is performed to prevent flaking of the metal from the jar surface.

The photoresist mask is removed by dipping the wafers in acetone under a laboratory hood. The thickness of the top-side ohmic contact metallization is then built-up by electrochemical plating. The wafers are mounted on a metal substrate and dipped into a silver cyanide plating solution. The plating process is conducted under a laboratory hood.

Anti-reflective coatings of tantalum pentoxide and silicon dioxide are vacuum evaporated on the wafer to reduce the losses in the cell and provide an encapsulation.

Future Expansion

Rockwell will have the capability to grow their own gallium arsenide ingots and to slice wafers. An czochralski puller has been purchased which is capable of producing 7.5 cm (3-in.) diameter ingots weighing up to 5 kg (12 lb) each. Currently, 3.25 cm (1.25 in.) square is the largest ingot available on the market. The puller will operate at 200-500 psi and 1230°C (2245°F) with a boric oxide cover layer over the GaAs melt to prevent arsenic loss. An inert (Ar) blanketing gas will also be used in the chamber.

They will saw wafers with a gauge saw to be hooded to contain metal dust emissions.

Module Development

Rockwell has a demonstration project with Sandia Labs to design and build a 256 cell GaAs Dense Array. This is a dense array design with the modules tightly packed for large area highly concentrated sunlight. The Dense Array is designed for operation at concentrations up to 1500 SUNs and temperatures of 180°C. An overall efficiency of 16 percent is anticipated, with individual cells exceeding 20 percent efficiency. The cells are bonded to a BeO substrate which is subsequently bonded to the Cu heat sink which forms a module. Modules of 16 cells each are designed with central plumbing systems to handle the heat load. The array will be tested on the Solar Thermal Test Facility (STTF) at Sandia.

An alternate concentrator design using Fresnel lenses to focus sunlight onto individual cells is also being investigated.

SURVEY OBSERVATIONS

Processing steps appeared to be generally well controlled. The laboratory research operation scale limits the industrial hygiene process evaluation.

The liquid epitaxial growth process appeared well controlled. The purge hydrogen was well contained.and appeared to effectively limit potential arsenic release. Equipment maintenance and cleaning appear to present larger potential chemical exposures. Accidental breakage of the glass cylinders or hydrogen fires present potential problems.

The etching and plating operations were performed in beakers under laboratory hoods. These processing steps appeared well controlled.

The metallization and anti-reflective coating processes were done in vacuum bell jars. The vacuum pumps discharged away from the work area minimizing worker exposures. Bell jar cleaning appeared to be the main potential metal exposure.

The laboratory areas were quite crowded with equipment indicating that a fairly high general room ventilation rate is called for particularly in view of the toxic materials handled; especially arsenic.