THIN-FILM RELIABILITY AND ENGINEERING OVERVIEW

JET PROPULSION LABORATORY

R.G. Ross, Jr.

Scope

- Development of the reliability and engineering technology base required for thin-film modules
  - Emphasis on amorphous-silicon
  - Emphasis on module and array-level issues
  - De-emphasis of cell-intrinsic reliability issues such as light-induced effects
- Closely coordinated with SERI's thin-film cell research activities as a part of DOE's Amorphous Silicon Program, managed by Ed Sabisky

Thin-Film Differences Requiring New or Expanded Research

- New cell environmental durability (temperature/humidity/UV) failure modes
- Altered hot-spot heating failure mechanisms
- Short-circuit cell failure modes and effect on cell size and series/parallel redundancy
- New cell electrical interconnect failure modes
- Altered glass breaking strength
- Flexible substrate technology demands
- High cell stresses due to glass bending
- Non-linear electrical response and effect on module measurement
- Cell-to-cell electrical variability and effect on electrical mismatch and circuit design
R&ES Crystalline-Si Research Applicability to Thin-Film Modules

- Circuit reliability model development
- Interconnect mechanical fatigue
- Electrical insulation breakdown research
- Glass-fracture mechanics
- Cell-fracture mechanics
- Cell temperature/humidity endurance (Clemson)
- Module temperature/humidity endurance (Wyle)
- Module hail-impact resistance
- Optical-surface soiling
- Electrochemical corrosion
- Encapsulant photo-thermal degradation
- Encapsulant debonding
- Hot-spot heating
- Bypass diode integration studies (GE)
- Module flammability ar.d arcing research (UL)

● = generally applicable, ○ = significant changes

FY85 R&ES Thin-Film Research Thrusts

- Temperature-humidity reliability research
- Glass breaking strength research
- Point defect system analysis
- Hot-spot heating assessment
- Electrical measurements technology development
Temperature-Humidity Reliability Research

- **Objective**
  - Assess stability of $a$-Si cells in T/H environments
  - Assess requirements for encapsulation

- **Status**
  - Initial $a$-Si cell samples acquired (ARCO, Sanyo, Chronar)
  - Additional samples procurements underway (Hughes and Chronar)
  - Exploratory tests initiated at Clemson

Glass Breaking-Strength Research

- **Objective**
  - Determine breaking strength versus $a$-Si processing
  - Assess need for glass strength enhancement
  - Develop glass strength enhancement techniques
  - Develop glass support techniques

- **Status**
  - FY 1985 start, building on extensive experience with glass on crystalline-Si modules
  - Tin-oxide-coated glass samples acquired from Chronar for test

Point-Defect System Analysis

- **Objective**
  - Assess present areal density levels of defects
  - Assess economic penalty/allowable levels for defects
  - Determine optimum cell interconnection/geometry to minimize impact

- **Status**
  - Computer program operational for computing system power loss due to scotched cells
  - Laser scanner being modified to allow defect mapping
MODULE DEVELOPMENT AND ENGINEERING SCIENCES

Hot-Spot Heating Assessment

- Objective
  - Establish susceptibility of α-Si cells to hot-spot phenomena
  - Establish bypass diode recommendations for modules

- Status
  - Just initiated

Electrical Measurements Technology Development

- Objective
  - Establish means for accurate repeatable measurement of electrical I-V performance of α-Si cells and modules

- Status
  - LAPSS verified as appropriate light source
  - Filters identified to convert LAPSS to AM 1.5 global spectrum
  - Filters identified to alter crystalline-Si spectral response to provide reference cells for α-Si

Research Forum on Reliability and Engineering of Thin-Film Modules (San Diego, Feb. 18-20, 1985)

Focus: Reliability and performance issues relating to integrating α-Si cells into power modules, including:
- Review of current status,
- Identification of problems,
- Definition of needed research.

Tentative Agenda

- Cell performance overview
- Module reliability considerations
- Module performance considerations
- Electrical performance measurement