Electric Drive Semiconductor Manufacturing (EDSM) Center

Don Morozowich

Powerex, Inc.

May 15, 2012

Project ARRAVT030

Project Overview

Timeline

- Project start date: 12 Mar 2010
- Project end date: 30 Sep 2012
- Percent complete: 90+%

Barriers

- Equipment integration
- Material handling
- Agility to meet variety of products and industry standards
- Transition from prototype to production
- Process control

Budget

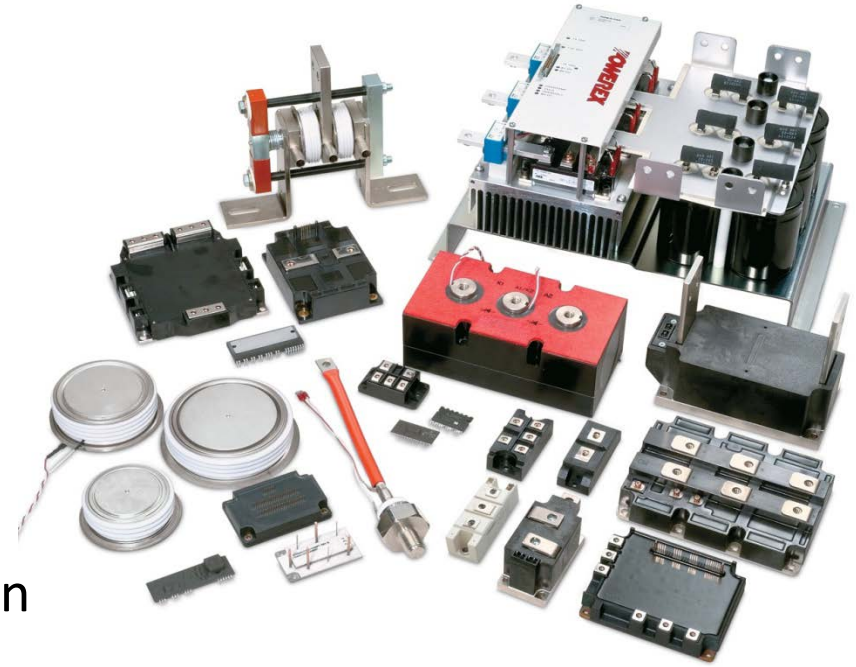
- Total project funding
  - DOE share: $6,049,581.00
  - Powerex share: $2,592,678.00

Partners

- No partners in grant award
- Leveraging existing customer and supplier relationships

Project Overview

- Powerex corporate offices in Youngwood, PA (near Pittsburgh)
- 250+ employees
- 120,000 square feet of facilities
- Design and manufacture
  - Rectifiers and Thyristors
  - Custom Modules
  - Integrated Power Products
- Markets include: automotive/ vehicle, transportation, wind, power generation & distribution, motor control, energy conservation



Project Objectives/Relevance

Objective:

Powerex will modify its existing facility to house an integrated Electric Drive Semiconductor Manufacturing (EDSM) Center capable of producing over 100,000 electric drive semiconductor devices annually.

- **EDSM Facility** - Provide a facility capable of meeting all EDSM project objectives
- **Manufacturing Center** - Provide capability to produce, at a minimum, 100,000 electric drive semiconductor devices annually
- **Reliability Center** - Provide the capability to fully test and qualify semiconductor device performance and reliability
- **Prototype Center** - Provide the capability to develop new semiconductor device concepts through prototyping. This capability will reduce risk associated with new semiconductor device performance and reduce risk associated with high-volume manufacturing of new devices.

Approach – Phases & Milestones

Phased into existing facility

- Maintain continuity of current operations and reduce risk

Phases of implementation

- **Phase 1**
  - Construct 10,000 sq ft class 10,000 clean room
  - Install & integrate manufacturing center equipment and processes
- **Phase 2**
  - Relocate existing prototype equipment into clean room
- **Phase 3**
  - Install reliability center equipment in space vacated by prototype equipment move
- **Phase 4**
  - Demonstrate capability through Low Rate Initial Production

MILESTONE	DATE	STATUS
Clean room installation complete	Nov 2011	Complete
Manufacturing Center equipment installed	Nov 2012	Complete
Prototype Center equipment moved to clean room	Dec 2012	Complete
Low Volume production resumes in new clean room	Jan 2012	Complete
Reliability Center equipment installed	Jan 2012	Complete
Manufacturing Center process demonstrated	Jun 2012	Open
Reliability Center capability demonstrated	Jun 2012	Open

Approach – Project Scope

Modifications of existing Powerex facility

- 10,120 ft² (940 m²)
- 40% to 60% relative humidity control
- 22C +/- 2C temperature control
- Class 10,000 manufacturing areas

Manufacturing Center

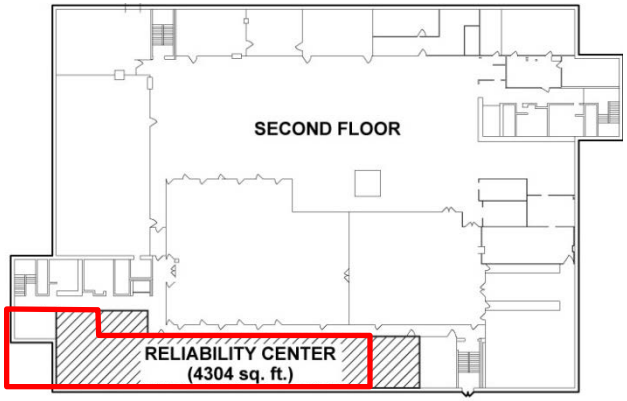
- 6,070 ft² (565 m²)
- Capable of producing 100,000 units/year in 2015

Prototype Center

- 4,050 ft² (375m²)
- Utilizing existing Powerex equipment

Reliability Center

- 4,300 ft² (400m²)
- Capable of testing to automotive standards

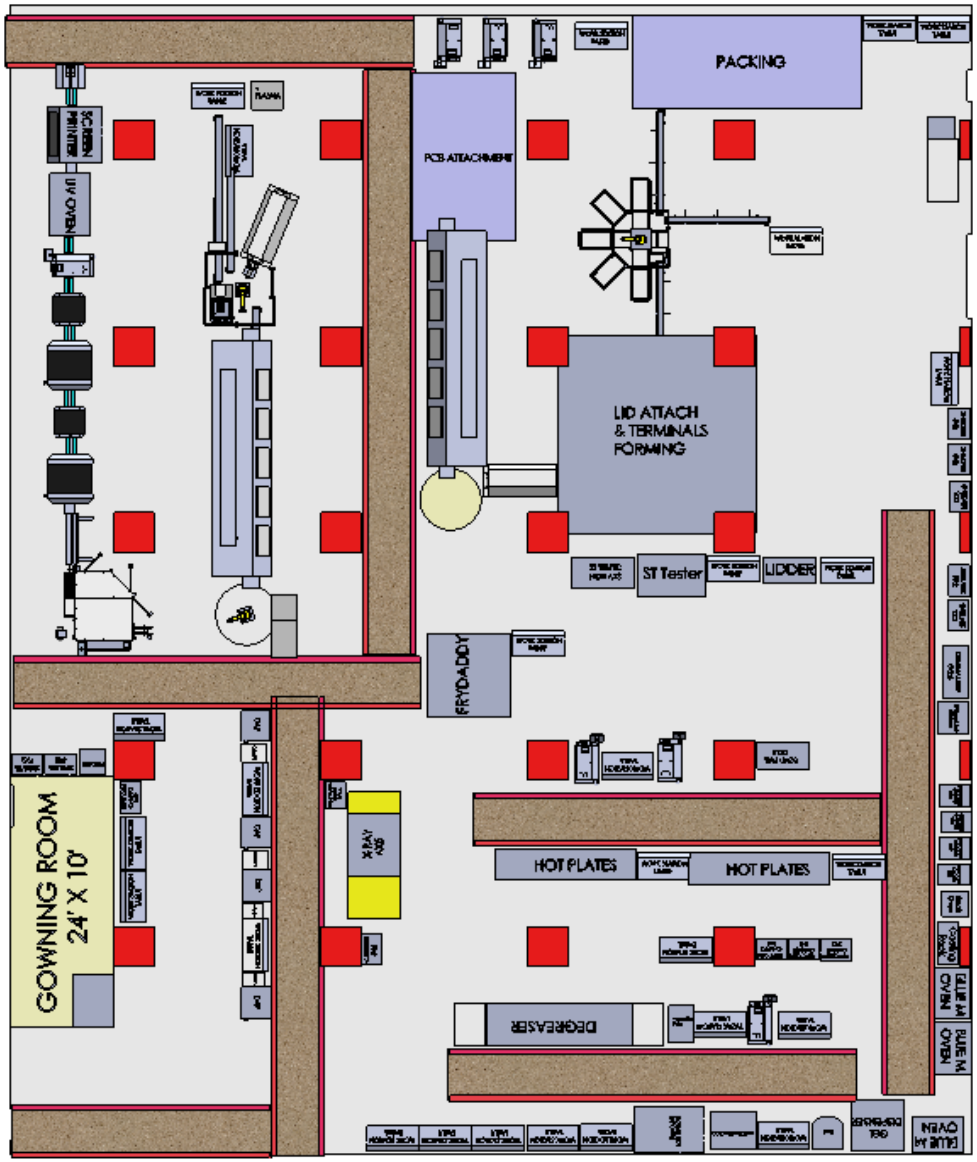


Accomplishments – Manufacturing Center

- Finished Steel City room Nov 3, 2011
- Equipment moved in Nov 4, 2011

- Production moved to clean room Dec 19-30, 2011
- Production started Jan 4, 2012

Approach – Process & Equipment

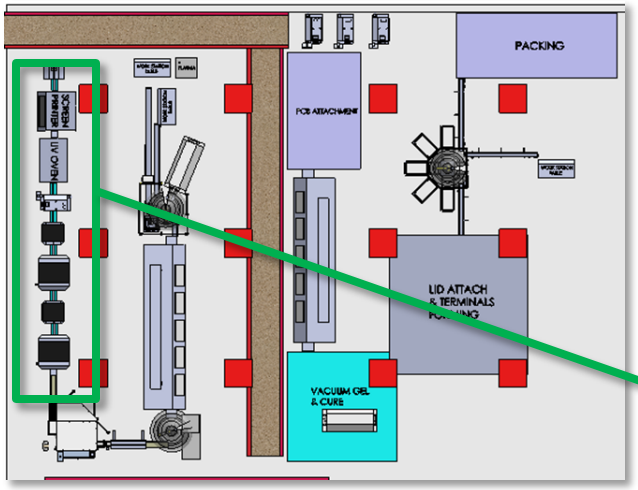


Steel City Clean Room Layout

Manufacturing Center in same room with Prototype Center.

This concept will allow us to better utilize all machines and cells.

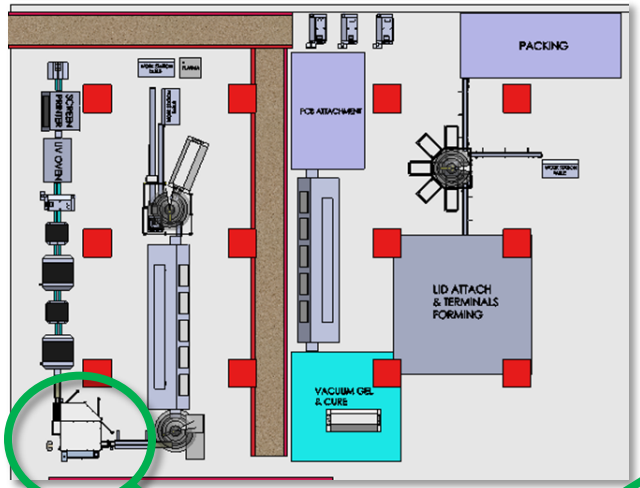
Accomplishments – Manufacturing Center

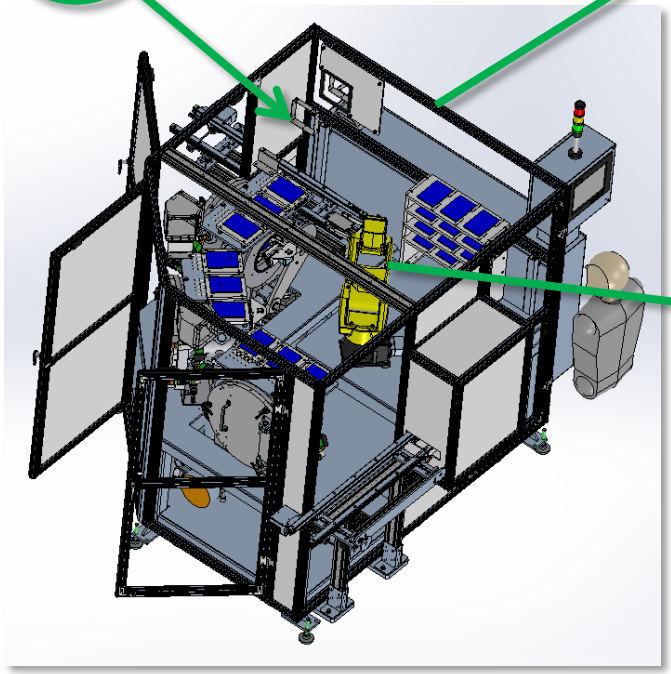


First equipment moved to Powerex Cleanroom:

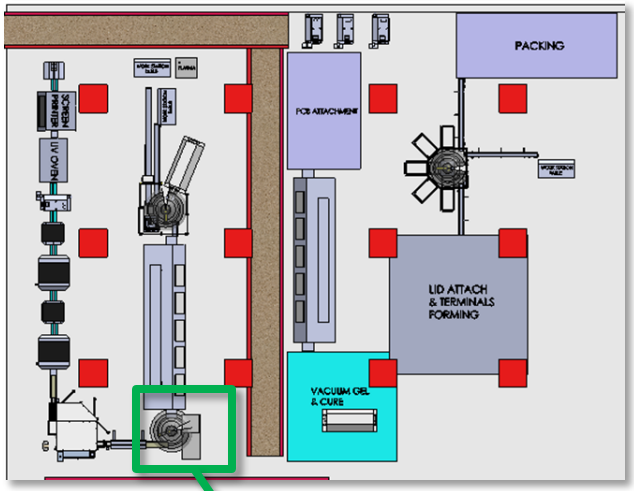
- Base plates de-stacker
- Solder mask printer
- UV curing oven
- Wire bonder
- Solder paste dispensers (2)
- Components pick & place (2)

Accomplishments – Manufacturing Center

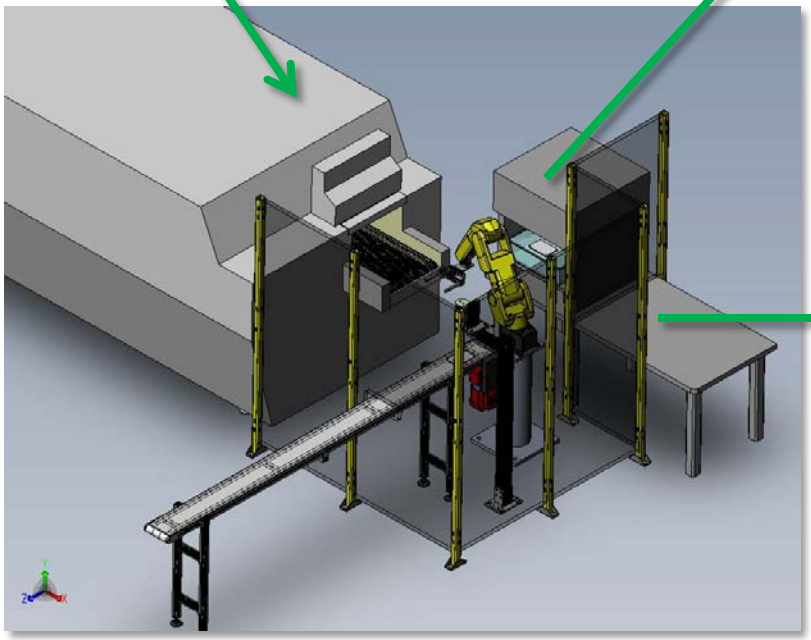




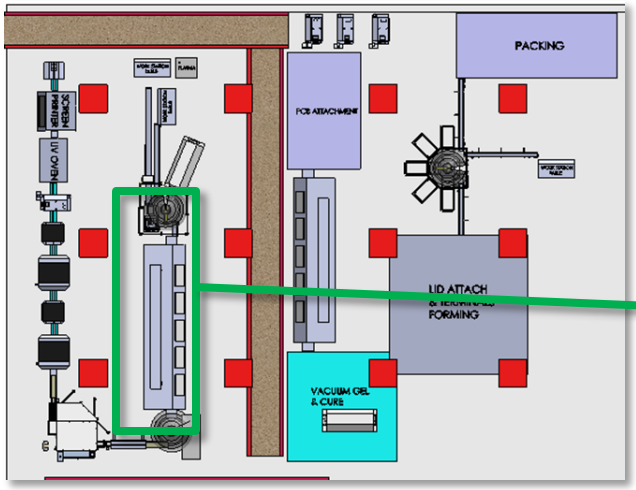
Accomplishments – Manufacturing Center



100% acoustic microscope inspection after reflow soldering

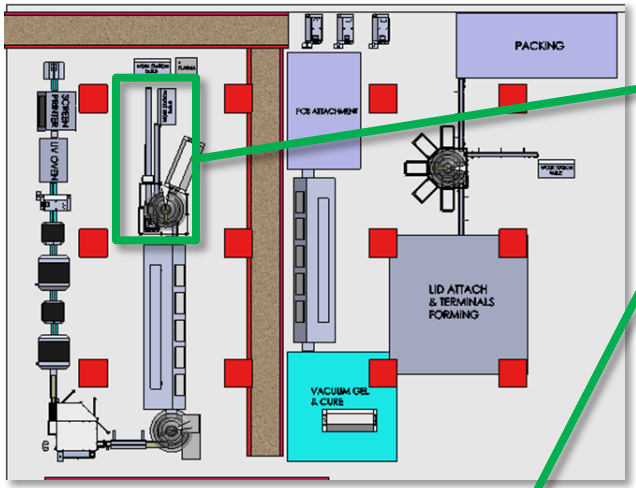


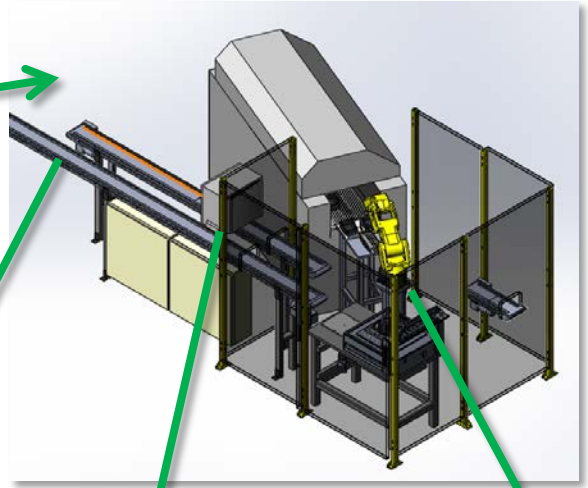
Accomplishments – Manufacturing Center



Solder flux cleaners placed in clean room

Accomplishments – Manufacturing Center

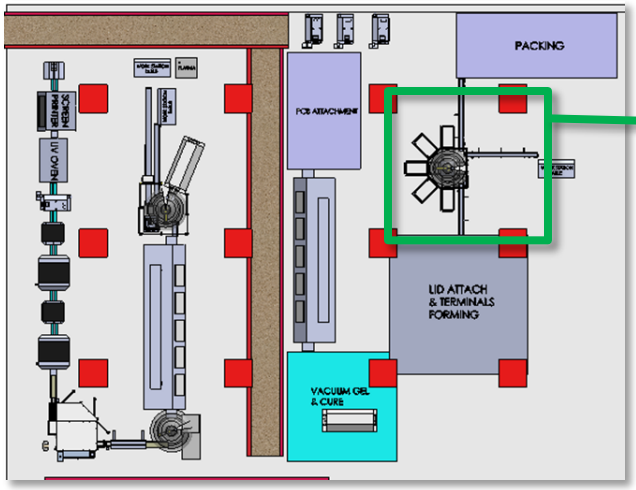


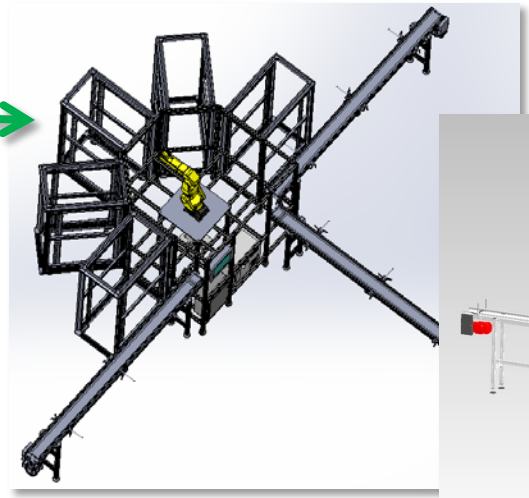


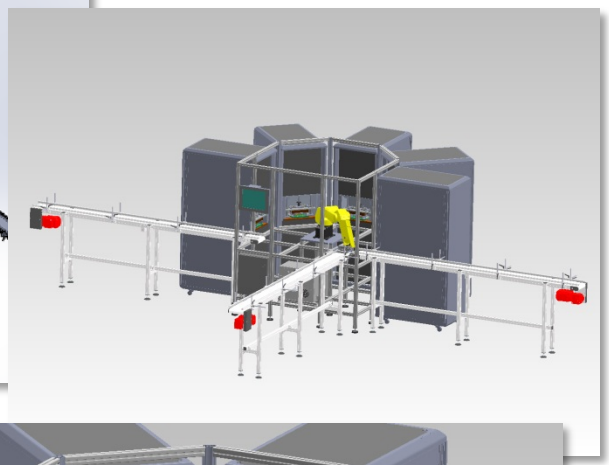
Housing Assembly Cell

- Cleaner unloading
- RTV dispensing
- Housing placing
- Screws attachment
- Placing on the curing oven belt

Accomplishments – Manufacturing Center

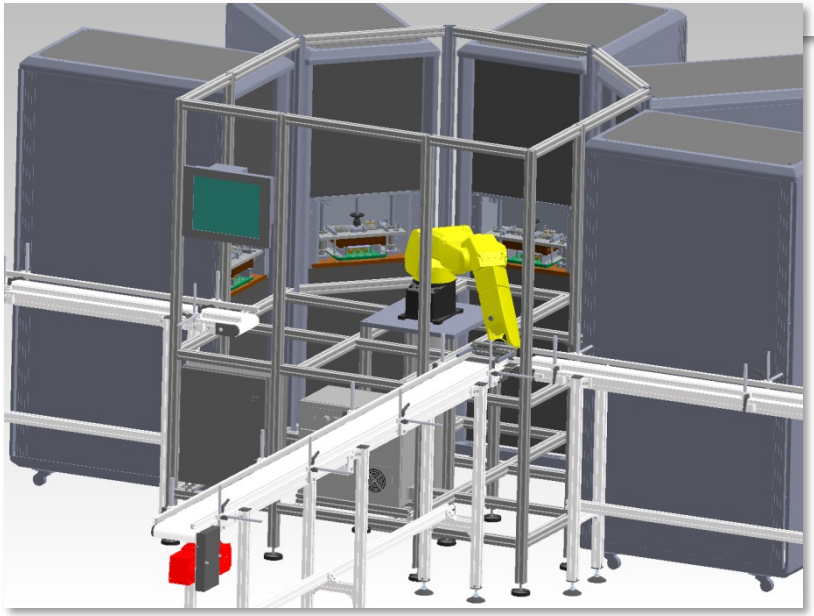






Acceptance Testing Integrated Cell

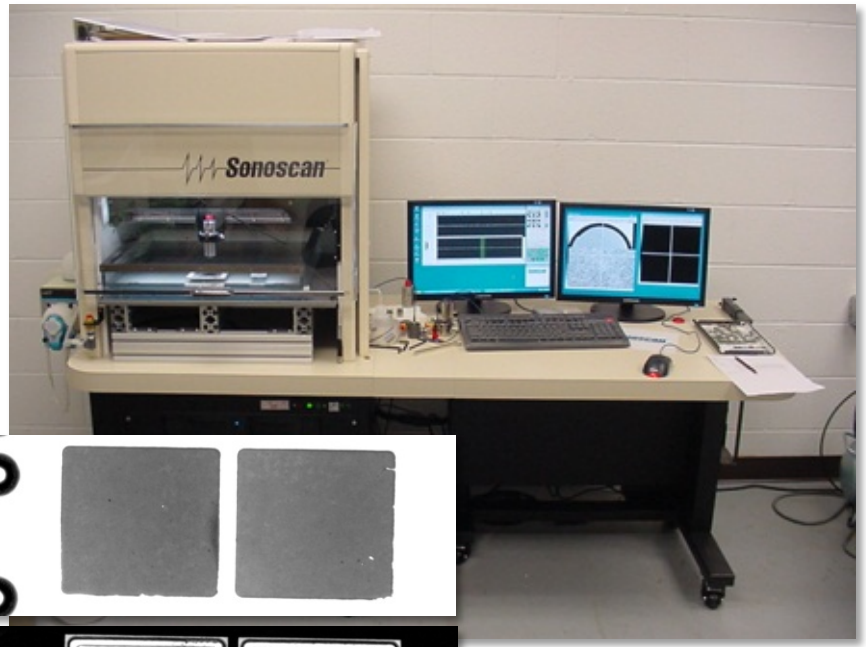
- 5 or 6 testers in individual racks
- Standardized (exchangeable) contacts fixtures installed by robot
- Tested devices placed on hotplates plus in and out contact fixtures by robot
- Testers controlled by PC
- Data automatically collected and stored

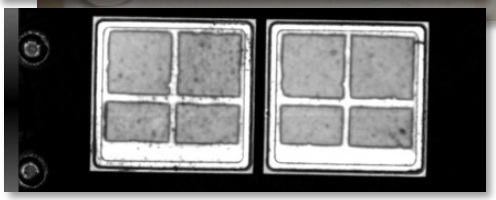


Reliability Center Objectives

- Equipment to perform 27 tests for automotive reliability including
  - Electrical testing
  - Environment testing
  - Lifetime testing
  - Mechanical testing
- Analytical equipment to troubleshoot and control processes

Accomplishments – Reliability Center



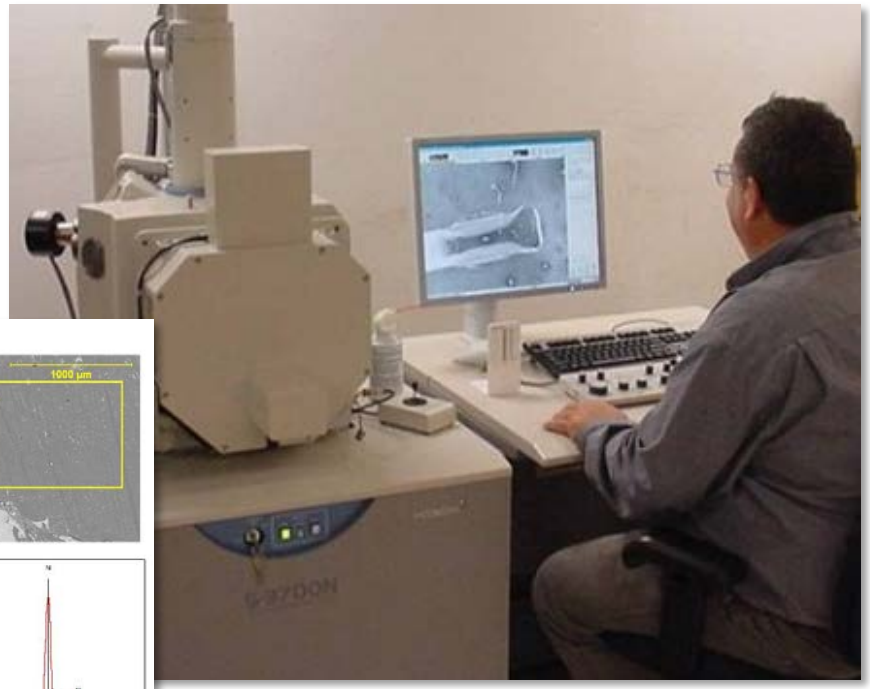


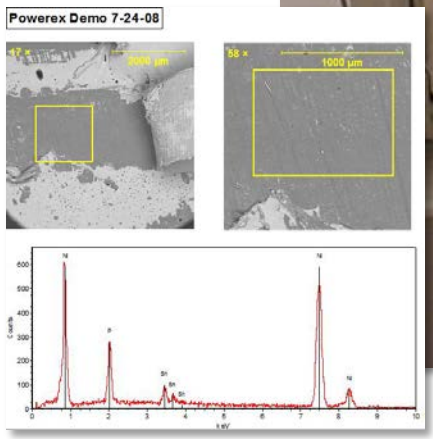
Acoustic Microscope

- Ultrasound imaging
- Solder void and lamentation analysis

Electron Microscope

- Micro imaging
- Micro Elemental Analysis (EDS)





Accomplishments – Reliability Center

- Single-Axis Vibration (Sinusoidal and Random)
- Burn-in (High Temp Reverse Bias, High Temp Gate Bias)
- Highly Accelerated Stress Testing (HAST)
- Intermittent Operating Life (IOL)
- Temperature Cycling
- Moisture Resistance
- Low Temp Storage
- Partial Discharge
- Wire Bond Pull
- Doe Shear

Collaboration & Coordination

- No partners are directly involved in execution of grant
- Strong, collaborative partnerships with many critical material suppliers and service providers
- Long-standing relationships with many customers in electric drive industry
- Long-standing teaming arrangements with universities, federal agencies and companies engaged in state-of-the-art power module research

Future Work

In 2012

- Complete Manufacturing Center equipment integration and process demonstration
- Demonstrate full capability of Reliability Center
- Complete and close out project

Project Summary

- Grant awarded in March 2010
- Objective: create capacity to design through prototyping, produce and test 100,000 semiconductor power modules annually
- 2-year phased approach to permit risk reduction and implementation in existing plant without impacting on-going production operations
- Project is meeting all technical goals on schedule and within budget
- Clean room complete, equipment installed, working on final process demonstration