Facility Vision & Roadmap
… Integrated Operations & Future Expansion

2nd Floor Engr, Admin, & Special Mfg

1st Floor Manufacturing & Laboratories

60,000-sqft: COMPLETE

23-Acre Master Building Layout

Company Overview
NGST Cryogenic Deformable Mirror

... Cryogenic Deformable Mirrors with Cofired Actuators

Cryoceramic Materials

349-Ch Cryogenic Discrete Actuator DM
Weighs 13 lbs

349-Ch Cryogenic Modular DM
Weighs 3 lbs

Discrete, Cofired Actuator Set

XiMUX Set and Forget Electronics

Advanced Materials
Conventional versus Modular Designs

... 1-mm Actuator Spacing with Increased Reliability

Transverse Module

Discrete Array
SBIR Based 42 x 42 Mirror
Pathfinder Mirror Towards Space Qual Mirror
SBIR Funded High Density 42 x 42 Mirror

Evolution of Module Towards Integrated Arrays

• 1764 Actuators in Four Modules
  Aligned within Rows and the Facesheet Plane

• Addressed with Custom Interconnect
  • Expected population of defects due to reuse of flex cables

• Successfully Polished Square Optic
  Using Custom Polish Fixturing
  • Concerned about affect of conductive epoxy properties on stability of figure

• Unprotected Gold Coating Applied without Affecting Figure
Lessons Learned Applied to Next Generation

... Roadmap Towards Space Qualifiable Component

• Epoxy Effects
  • Conductive epoxy has significant disadvantages compared to structural epoxy for attaching the facesheet
    - Thicker, nonuniform, bond joint
    - Weaker than structural epoxy and more moisture sensitive
    - Potential shorting path

• Flex Circuits
  • First generation interconnect was reworked, with considerable thermal cycling
  • Defects exist at several points in two of the flex cables due to the repeated bonding and removal of the flex from the BGA and underfill

• Module Effects
  • Dicing debris leads to low parallel resistance and potential shorts
1,764 Channel 1-mm Deformable Mirror

Modular Mirror Technology for Future Space Instruments

• 1764-Channel Deformable Mirror
  • Significant advance in demonstration of module technology for correction of stray light in coronagraph applications.

• 21 x 21 1-mm Module Format
  • Modular Actuator Arrays Allow Scaling to Large Channel Counts
  • PMN-Based Electroceramic Enables Angstrom Level Dimensional Control.
  • Conductive Adhesive Enables Integrated Ground of All Actuators
  • Multiple Layer Flex Circuit Replaces Thousands of Individual Wire Leads
ECLIPSE Based 64 x 64 Mirror
Engineering Model Towards TRL 5
Greenware Processing at 4 x 4 Level
... Enables Production Yields

- Larger greenware format allows increase in number of modules produced
- Baseline binder composition being used for parts while transition to more favorable binder system is in progress

2 Modules per Block
Transitioned to 10 Modules per Block Format
Flexible circuits are a highly reliable, single layer design with 500 micron trace width—fully tested before attached to a module.

- Replaces 8 layer single flex with 75 micron traces.
- Attach process developed and characterized.

**Diagram Notes:**
- Module with 32x34 connections
- 32x34 Header
- 32x32 Module
- Conductive Epoxy Bond
- Flex Cable
- Connection to electronics
- 0.050 inch pitch
- Approx. 7.5 cm length
• Grounds out the back design allows structural epoxy, the baseline on all Xinetics deformable mirrors, to be used to bond the facesheet to the modules.
  • Modules can also be tested before incorporation into a mirror
  • Structural epoxy will provide thinner, more uniform, more reliable and moisture resistant bond joints than conductive epoxy.

• Facesheet fabrication demonstrated on facesheets with 15,000+ pusher pads.

• Polishing Pathfinders Built from Pyrex Developed to Advance Polishing Process
High Authority Demo At Elevated Fields

... Proof Test, Cycle Life & Bandwidth

Cycle Testing Parameters

• 70 V DC, ± 16V AC, 500 Hz, 30 minutes (900,000 cycles)
• 120 V DC, ± 30V AC, 500 Hz, 30 minutes (900,000 cycles)
• 70V DC, ± 2V AC, 4 kHz, 30 minutes (7.2 million cycles)

Results:

• No noticeable change in Stroke, Capacitance or Parallel resistance after several million cycles
• No visual sign of degradation
• Only 1 degree temperature increase during most intense testing.

1mm Module Reliability Testing

• Flex – qualify continuity of all connections in flex and confirm that no shorts exist.
• Module – confirm that all actuators are active and individually addressable.
• Flex to Module Interface – establish integrity of bond between flex and module, confirm that no shorts exist between actuators or from signal to ground.
1,024-Channel Single Module Mirror
... Delivery in December 2002

1024 Channel Mirror Heath Kit

Preparation for 4,096 Channel Mirror in Spring 2003
4,096-Channel 1-mm Deformable Mirror

... Delivery in May 2003

• 4,096-Channel Deformable Mirror
  • Enables Phase Correction in both Coronagraphic Instruments and High Resolution WFOV Telescopes; Establishes Component and System Technology to TRL Level 5/6 in JPL Test Bed Simulations.

• Roadmap Towards ECLIPSE & TPF: Pre-Planned Product Improvements
  • Modular Array Size Increased to 32 x 32 Format to Enable Direct Scaling to 64 x 64 Array
  • Structural Adhesive Replaces Conductive Adhesive and Enables Angstrom Level Dimensional Stability
  • Ground Connectivity at Modular Interconnect Enables In-Process Testing
  • Large Format Interconnect Allows Simple, Actuator Line Addressing
Xinetics XiMUX Driver Electronics
Enables High Density Mirror Control
40 Channel Hybrid Power Mux

Size reduced by 86% with Hybrid XiMUX

The Hybrid is functionally 21 Sq. in. of a XiMux board space.

112 Ch. XiMux Driver

40 Ch. Hybrid First Article

6.0” x 3.5”

1.2” x 2.4”
100 Channel Low Noise High Resolution

... Proof-of-Concept Circuit Board

Low Power and Being Tailored for Vacuum Operation
16-Bit High Resolution Multiplex Driver

... Proof-of-Concept

Lab Setup

Sw. Leakage Current ~ 0.22 μA

1-LSB Between adj. Channels

LSB = 0.305 mV

3X

LSB = 0.915 mV

10.09X

LSB = 9.23 mV

Low Pass Filter

16 Bit Data

Mode Control

Programmable Digital Controller

Power Mux Control

Digital Controller

Feedback

A

Σ

D

Low Pass

Filter
1,024 Channel XiMux Driver System

… Integrated Hybrid Components

Connectors for:
Actuator Drive
Digital Commands
Power

1024
High Voltages
Switches

Cold Plate

16 Power Amplifiers

16 Digital Controllers