High Performance Products, Advanced Materials

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NeXolve Holding Company – Jim Moore CEO

- Huntsville, AL

- Aerospace Products – Director: Jim Pearson
  - Engineering Services
    - Design and Modeling
  - Aerospace Products
    - James Webb Space Telescope sunshield.
    - Small spacecraft deployable systems
    - MLI and lightweight systems
    - Thin-film photovoltaics

- Advanced Materials – Director: Brandon Farmer
  - Spacecraft Products
    - Optical Quality Membranes
  - Polymer Products
    - Films, Resins, Powders
  - Analytical Services
    - Characterization and Analysis
NeXolve Capabilities

- **Engineering Heritage (30 Years)**
  - Thin Film Materials and Control of Materials
  - Leader in Thin Film Polymer Material Design and Manufacturing
    - Inflatable antenna’s and concentrators
    - Solar Sail demonstrations
    - Multilayer Insulation
    - Sunshades and Reflectors
  - Expertise in Modeling and Analysis

- **Spacecraft Flight Heritage**
  - On-going commercial flight programs supplying thin film products
  - Key provider to NASA’s JWST program

- **Materials R&D**
  - Strong background in polyimide materials
  - Tailoring of Polymers for Niche Applications
  - Developed ‘tunable’ space durable products similar to Kapton
  - On-going R&D in several markets
  - 3 - PhD Polymer Chemists on Staff

- **Advanced Materials**

- **Spacecraft Blankets and Sunshields**

- **JWST Sunshield Provider**

- **Tailored Polymer Coverings**

- **Inflatable RF Antenna’s and Concentrators**
Space Products - Engineering Services

Computer Simulation Experience
- On-Orbit Temperature Predictions
- Lightweight Optics
- Large Space Structures
- Rocket Engine Thermal Analysis
- Component Stress Analysis
- 3D Solid Modeling CAD/CAM
- Incompressible Flow Modeling
- Orbital Mechanics
- Signatures/Discrimination
- Thin Film Modeling
- Thin Film Thermal Analysis
Aerospace Products

• Space Products Capabilities
  – Design and Modeling of light weight structures
  – Polymers and materials
  – Thin film products – MLI and Shields
  – Metrology – laser scanners, trackers and Lidar.
  – Space qualification and testing
  – System Engineering and Verification
  – Small spacecraft deployable systems – booms, mechanisms

• NASA - Highlights
  – James Webb Space Telescope Sunshield
  – LISA-T – developing unique PV system for Cubesat class missions
  – NEA Scout – providing solar sail and metallic booms

• NeXolve has the unique ability to design, manufacture (10k class cleanliness), and model/analyze large deployable thin film space structures
Current Applications – Small Spacecraft

Capabilities

- Design and development of light-weight deployable spacecraft systems.
- Thin film photovoltaics integrated to membrane systems.
- Large area lightweight systems such as solar sails

➢ NeXolve has a unique track record of developing systems for small spacecraft. Programs have included NASA-Nanosail-D, NASA NEA-Scout and LISA-T photovoltaic system.
NASA – NEA Scout

• NEA Scout Scope for NeXolve
  – Development and delivery of Flight Solar Sail 3 micron CP1 polyimide
  – Development and delivery of sail restraint device.

• NeXolve Current Status
  – MSFC EDU testing completed in fall of 2017
  – Flight Hardware delivered in Feb 2018.
  – NeXolve team also tasked to support on-site integration and testing at MSFC in Summer 2018
NASA – LISA-T Array System

• LISA-T Scope for NeXolve
  – Procurement and integration of SOA solar cells with NeXolve thin-film polyimides
  – Development and design of unique deployable array
  – Mechanical fabrication, testing and delivery for MSFC TRL-6 demonstration
  – Development and delivery of sail restraint device.

– NeXolve Current Status
  – TRL-6 development completed successfully.
  – Demonstrated both Omni-directional array and Planar array.
  – Array performance metrics exceed current SOA for small spacecraft photovoltaic arrays.
  – NeXolve teaming with MSFC CAN REDI Program for microgravity testing in fall of 2018
JWST Sunshield (NeXolve)

a unique, singular, evolution from invention to practice and Flight delivery

• JWST Scope for NeXolve
  – >10 years support from development through delivery
  – Design, qualification, materials and processes, manufacturing, test, verification, quality control, program management, FEM, and analysis
  – 12,000 sf 10k class manufacturing facility
  – Delivered >10 full-scale prototypes plus 5 flight layers and 4 flight covers and numerous dev models/hardware.
  – Patented Thermal Spot Bonding (adhesive-less seaming), a critical enabling technology
    • One of HSV’s 101 Inventions at USSRC.
  – Numerous other unique process capabilities – adhesive bonding, assembly, measurement etc.

• NeXolve Current Status
  – 5 Layers already delivered to NGAS – Fall 2017.
  – 4 of 4 Covers completed
  – NeXolve team currently tasked to support on-site modifications and sunshield layer integration at NGAS

Flight Layer 2 – completed July 2016
JWST Template Layers in Testing
Sunshield Components

Thermal Welded Kapton Seams
Advanced Materials

We manufacture and develop Advanced Materials for Demanding Applications

- Core competencies
  - High Temperature Polymers
  - CTE matched polyimides
  - Micron gauge film manufacturing and handling
  - Specialty coatings
  - Rapid product development

- Products
  - Raw powder polymer
  - Liquid resin casting or spray polymer solution
  - Unfinished polymer film
  - Finished polymer film

- Markets Served
  - Environmental protection
  - Wire and cable coatings
  - Microelectronics
  - Aerospace
Clear and Colorless Polyimides

Base film
- CP1 polyimide
- CORIN polyimide -- Similar properties as CP1, with AO durability
- Essar Stretch polyimide – Elastic polyimide

Film Grades
- Non-conductive
- Clear conductive grades available, less than 1% difference in optical transparency as compared with base grade

Dimensions
- Thicknesses: 25, 12, 5, 2.5 micron, Other customer-specified thicknesses available
- Lengths: 100 ft and longer
- Widths: Up to 60”

Key Discriminators
- Low Solar Absorptivity (Colorless)
- Ultra-low gauge (0.1 mil) avail.
- Low Moisture Uptake (0.5%)
- Low Dielectric Constant (2.5)
Polyimides for Thermal Control

Conductive Black and White Polyimides

- Thermalbright: $\alpha/\varepsilon=0.23$
- Black CP1: $\alpha/\varepsilon=1.080$
- Electrical resistivities available in white and black – $10^4$ – $10^{11} \, \Omega/\square$
- Continuous production at 1 mil thickness
- Proprietary production process ensures isotropic thermomechanical properties
- Films produced with smooth finish or textured surface for improved adhesion
- Dielectric coatings available
Optinox Films and Coatings

Optinox™ films and coatings are highly UV durable and exhibit excellent weathering including outstanding stability to ozone.

Optinox™ is available in rolls up to 60” wide, or in low-temperature curing liquids for coating applications. Both the film rolls and liquid coatings are available in three grades.

Three Grades:
1. Transparent Clear: UV cutoff at approximately 230 nm for a 2 mil film or coating
2. Transparent UV Blocking: UV cutoff at approximately 395 nm for a 2 mil film or coating
3. Reflective White: Reflective White Film

Optinox™ 200 rolls are provided either as a freestanding film, or permanently bonded to a PET backer. Additional thicknesses are also available upon request.

Optinox™ liquid curing resins are provided as a two-part curing system.
Novastrat® History and Overview

- The Novastrat® series is a patented polyimide series with controlled CTE.
- Novastrat® was initially designed for interlayer dielectrics for CTE matching.
- All Novastrats are high temperature polyimide materials.
- Photodefinable version available for patterning with either the polymer itself or traditional methods.
- Vacuum coating deposition compatible.
- Various methods to introduce custom surface finishes.

![Un-coated Novastrat in DARPA MOIRE program demonstration](image)

### Dimensionally Stable Polyimides

<table>
<thead>
<tr>
<th>Property</th>
<th>Novastrat® 905</th>
<th>Novastrat® 100</th>
<th>Kapton E</th>
<th>CP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>*CTE (ppm/°C)</td>
<td>0.0</td>
<td>13.0</td>
<td>17.0</td>
<td>51.2</td>
</tr>
<tr>
<td>Tg (°C)</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>263</td>
</tr>
<tr>
<td>*Tensile Strength (MPa)</td>
<td>281</td>
<td>208</td>
<td>262</td>
<td>100</td>
</tr>
<tr>
<td>*Youngs Modulus (GPa)</td>
<td>7.5</td>
<td>6.0</td>
<td>5.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Color</td>
<td>Yellow</td>
<td>Yellow</td>
<td>Orange</td>
<td>Slight Yellow</td>
</tr>
</tbody>
</table>

*Measured at RT
Decades of polymer science and film manufacturing experience have led to unique methods of material formulation and production techniques.
Current Applications - Aerospace

Aerospace Products

- Wide Temperature/Space Durable
- Large Variety of Materials
- Custom Formulations/Properties
- Aerospace Performance

NeXolve materials are ideal for many aerospace applications and can be customized for specific functionality or operating environment.
Current Applications - Electronics

Electronics Grade Materials

- Low Dielectric/Moisture Uptake
- Conductive/Nonconductive
- CTE Matching
- Photodefinable

Material offerings are technology enabling and allow greater design flexibility. Tailor-made solutions for customer specific applications.
NeXolve Analytical Services

• Overview of Analytical Services
  – Contract testing and analysis of customer samples
  – Routinely test samples for Aerospace, Building Material, and other industries
  – Testing to ASTM standards, military standards, or customer designed specifications
  – Design and perform custom experiments
  – Interpret test data
  – Not just another “testing house”

• Testing Capabilities
  – Thermal properties
  – Solar/Optical properties
  – Mechanical properties
  – Profilometry/surface mapping
  – Others

Visit nexolvematerials.com for full list of analytical services capabilities and pricing
Test and Analysis Facilities

- **Analytical Equipment**
  - TA Instruments Q400 EM Thermo Mechanical Analyzer
  - TA Instruments Q200 Modulated DSC with RCS-90 cooling accessory
  - Perkin Elmer Lambda 950 UV/Vis Spectrophotometer with transmission/reflection Spectralon integrating sphere
  - Bruker Tensor 27 FTIR with transmission/reflection gold integrating sphere
  - AZ Technology Temp 2000A - IR Emissometer
  - X-RITE Ci6x spectrophotometer/color meter
  - Instron 5569 Universal Tensile Tester with multiple environmental chambers covering -271 C (2.3K -456 F) to 315 C (600 F)
  - Pneumatic adhesion tensile test instrument (PATTI)
  - Polymer Standards Systems Gel Permeation Chromatography System
  - Stanford Research Systems MPA 100 Melting Point Apparatus
  - Brookfield LVDVE-115 Viscometers
  - Ubbelohde viscometers
  - Multiple Atago Abbe-type refractometers
  - RF reflection inspection equipment
  - Various surface/volume resistivity meters
Quality Control

• ISO 9001:2008, AS 9100C Certifications
• Aerospace programs require tight material specs & stringent manufacturing processes
  – Incoming raw materials specification
  – In-house testing, source supplier inspections
  – Qualified and certified equipment (dedicated and shared)
  – Rigorous process qualification

• Examples of currently supplied products for aerospace, electronics, and medical raw materials and components
  – NeXolve synthesized and formulated liquid resins used in spin-on wafer applications
  – NeXolve processed and assembled thin films on DirectTV, XM Radio, and other flight hardware
  – **NeXolve-synthesized polyimides and NeXolve cast/cured freestanding films used in space flight on commercial satellites (>1000 m² on orbit)**
  – **NeXolve-synthesized polyimides and silicone adhesives, NeXolve cast/cured freestanding films used in flight hardware**