Space Propulsion Systems, Inc.

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MICROCELLULAR SOLID PROPELLANT TECHNOLOGY

Versatile, Cost Effective, and **Green**

Report Documentation Page

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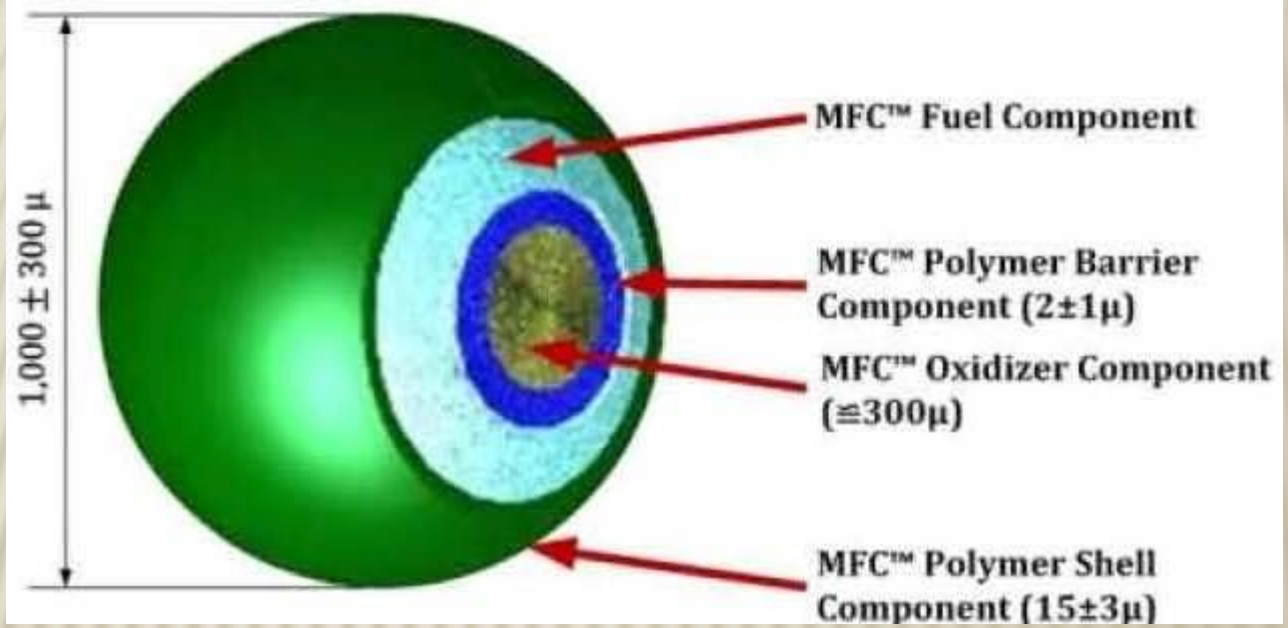
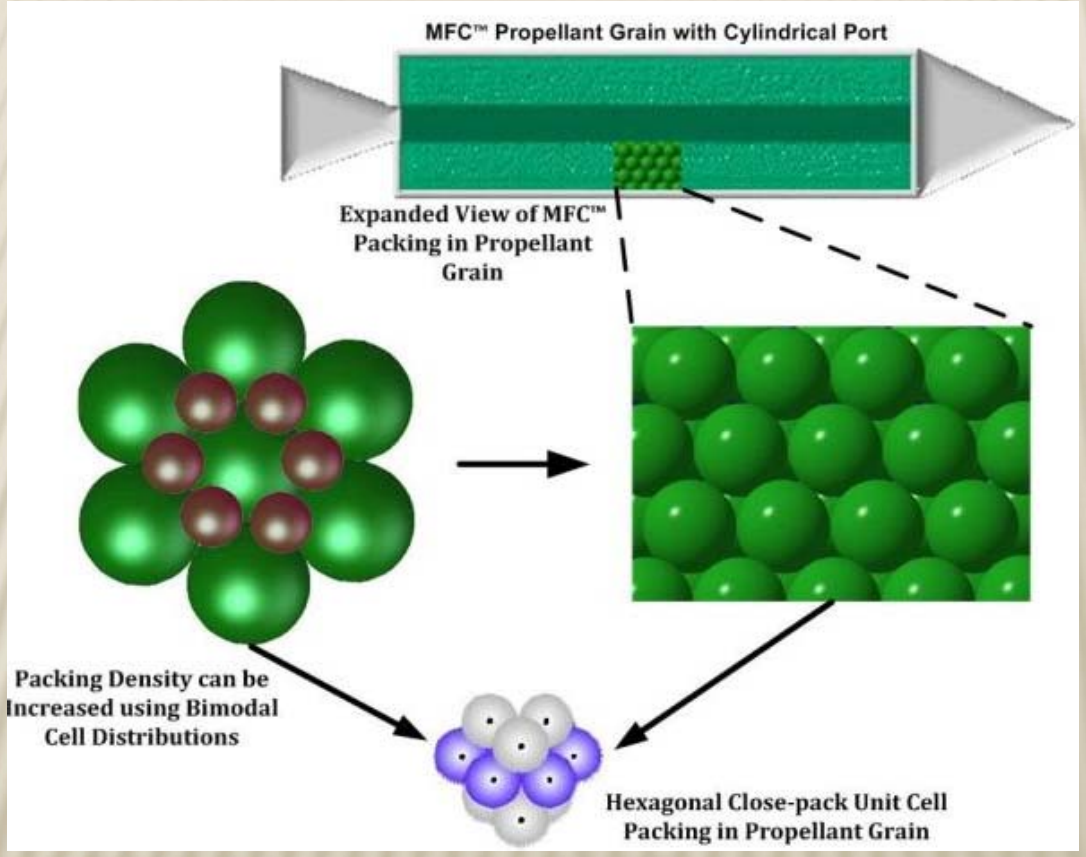
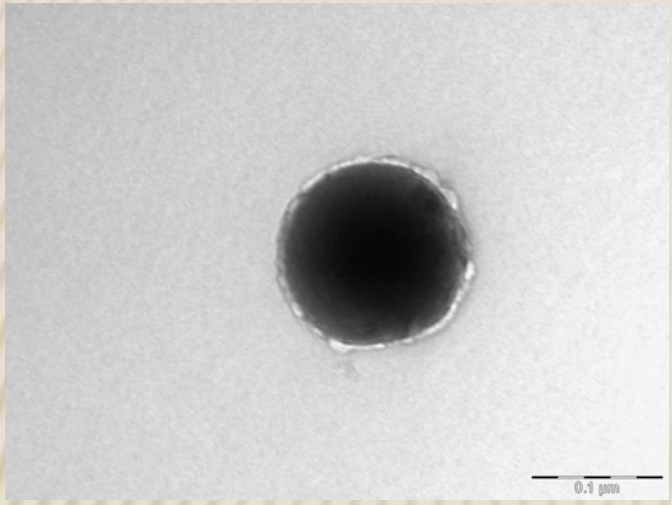
MICROCELLULAR PROPELLANT GRAINS CONTAIN ALL COMPONENTS IN THE PROPER PROPORTION NECESSARY FOR COMPLETE COMBUSTION



MICROCELL PROPELLANT GRAINS CAN BE PACKED TO MINIMIZE VOIDS BY USING VARIOUS GRAIN SIZES



Actual Nanoparticles with Tailored Uniform Coatings



Encapsulated particles via Supercritical Technology
Nanoscale particle: 150nm
With 5-10 nm thickness

Uniform Surface: 2-4 Nanometer

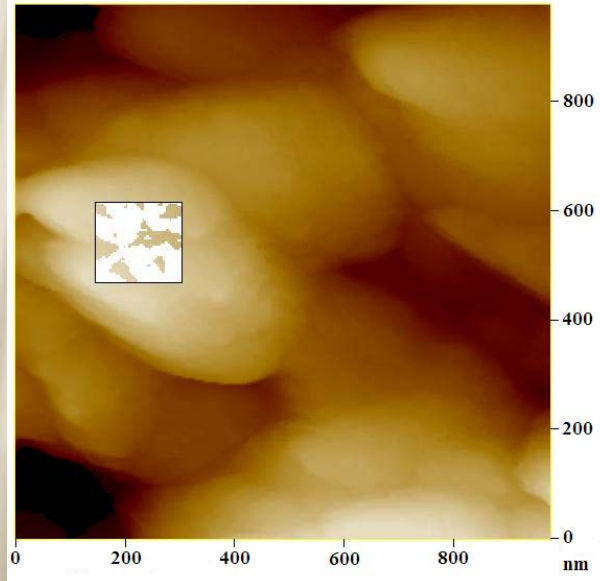


Image Statistics

Img. Mean	0.099 nm
Img. Rms (Rq)	96.153 nm
Img. Ra	74.559 nm

Box Statistics

Raw mean	3.290 nm
Rms (Rq)	3.378 nm
Mean roughness (Ra)	2.660 nm

NUMEROUS PROPELLANT MATERIAL COMBINATIONS CAN BE FORMULATED INTO MFC'S PROVIDING A SELECTION OF ISP'S...(CON'T)

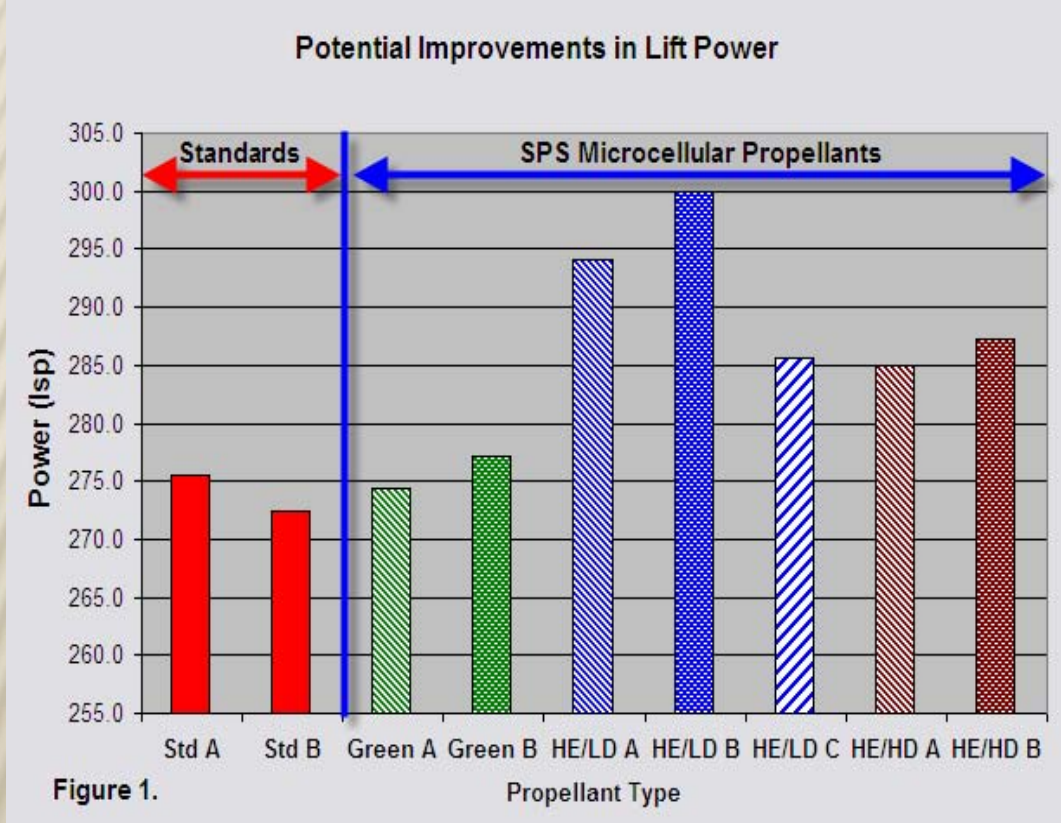


Figure 1.

Figure 1. Legend

Std A (Red) - **Peacekeeper Propellant**

Std B (Red) - Shuttle Propellant

Green A - ADN Based Propellant (Single Phase Flow, No Pollutants)

Green B - HNF Based Propellant (Single Phase Flow, No Pollutants)

HE/LD A- High Energy, Low Density ADN Formulation

HE/LD B - High Energy, Low Density HNF Formulation

HE/LD C - High Energy, Low Density AN/CL-20 Formulation

HE/HD A - High Energy, Compact Engine ADN Formulation

HE/HD B - High Energy, Compact Engine HNF Formulation

.....AND BURN RATES

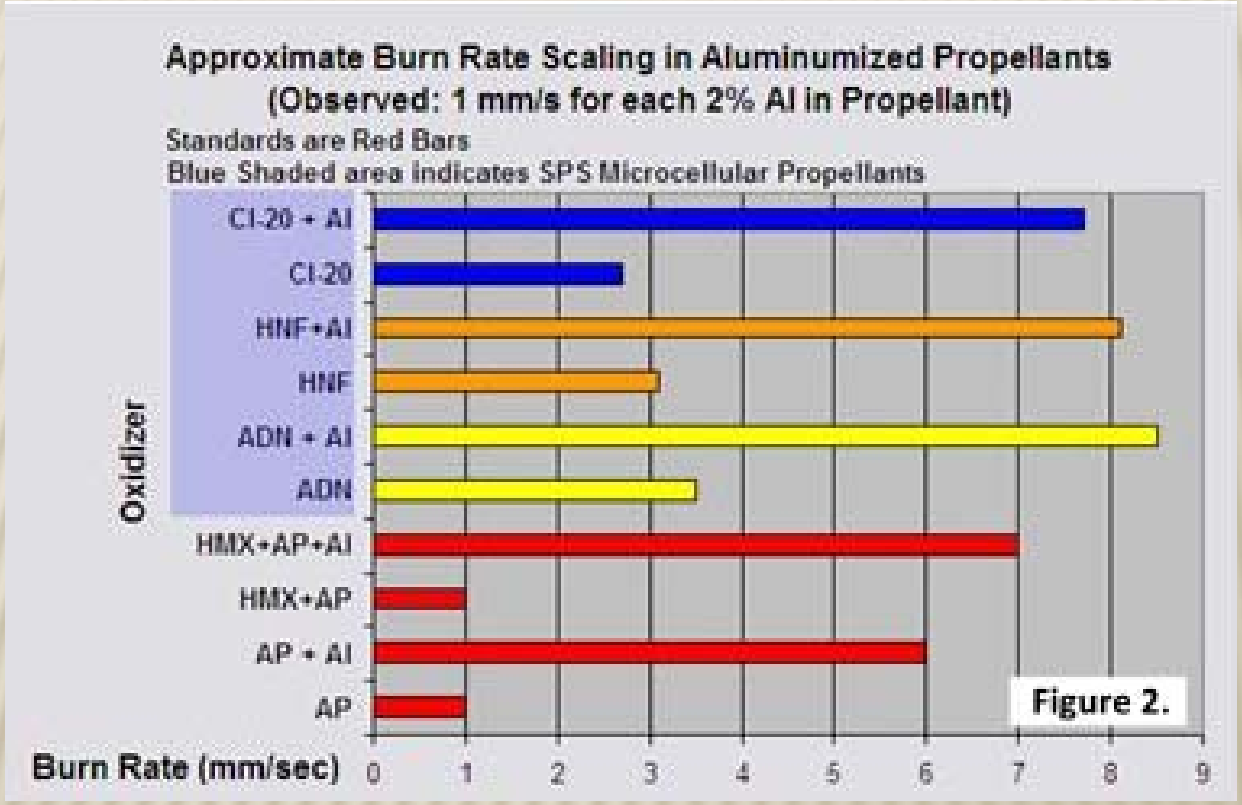
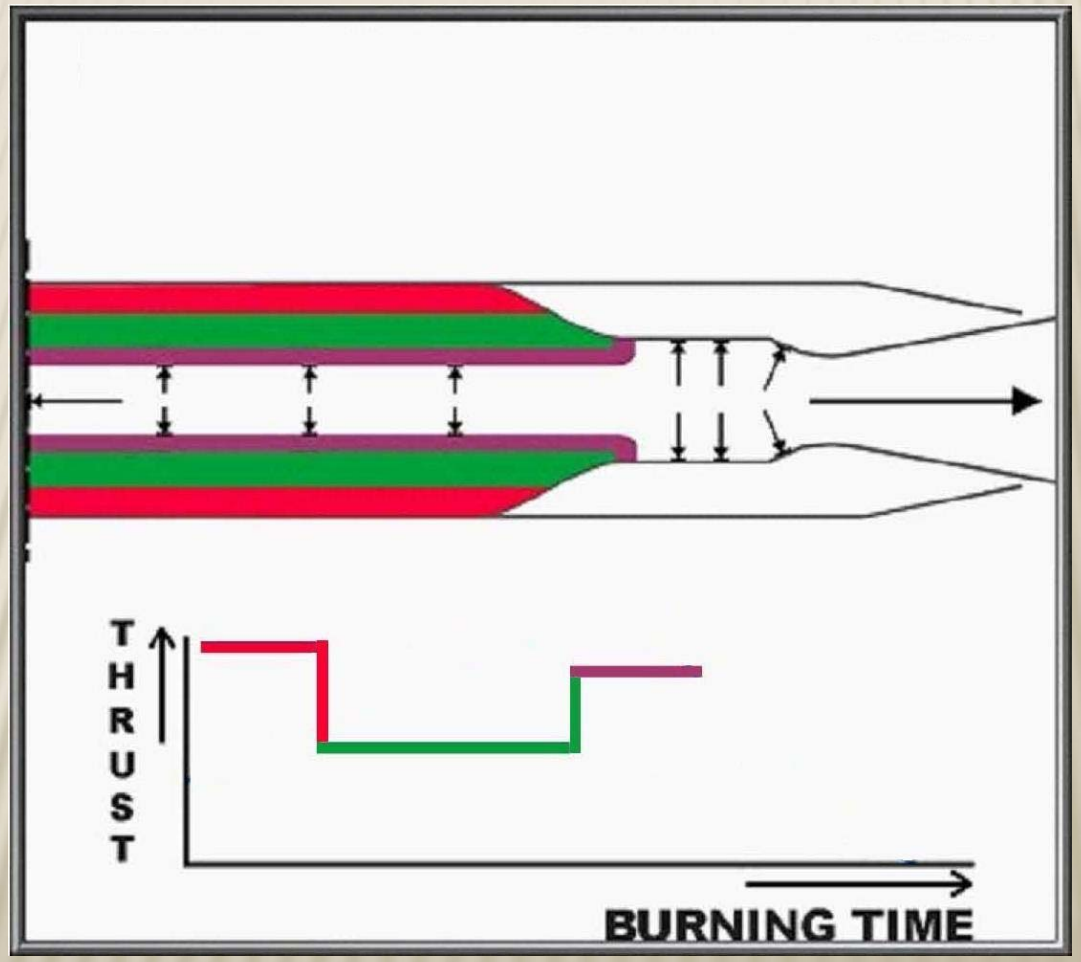


Figure 2.

MULTI-LAYERING OF DIFFERENTLY FORMULATED MFC'S CAN BE USED TO ESTABLISH A MISSION SPECIFIC TRUST PROFILE



OPERATIONAL BENEFITS OF USING MFC'S IN ROCKETS, MISSILES, AND SPACE LAUNCH VEHICLES

- Enables A Seven Day Pour and Launch Using Precast "Stackable" Motors
- Predictive Modeling Enables Mission Specific Motor Design Selection, Propellant Blending, and Mission Launch Vehicle Configuration Tailoring
- Mission Specific "Throttle" Profiles Can Be "Hardwired" Into the Launch Vehicle Motors
- Propellants Can Meet Differing Critical Mission Requirements Using The Same Launch Vehicle Configuration
- Reduces Launch Operations Manpower Requirements
- Various MFC Formulations Can Be Stored for Rapid Grain Casting
- Potential for Both Significant Reductions in Cost of Operations and Significant Enhancement in Capabilities

.....CONT

- Solution for Critical Launch Vehicle/Motor Performance Issues Like Destructive Harmonics/Vibration
- Microcell Solid Propellants Can Be Used For:
  - Motors Using Conventional Grain Casting
  - Experimental Motors/Engines
- Allows a New Approach to Development of Combined Cycle Engines for Aerospace-planes, Hypersonic Vehicles, and Fly-back Booster Applications, JATO, Aircraft Cruise Assist
- Allows for “Pre-programmed” Smart Thrust Sequences for All Types of Missiles.

UNIQUE CHARACTERISTICS/FEATURES OF SPS'S MICROCELLULAR PROPELLANTS

SPS Microcells-

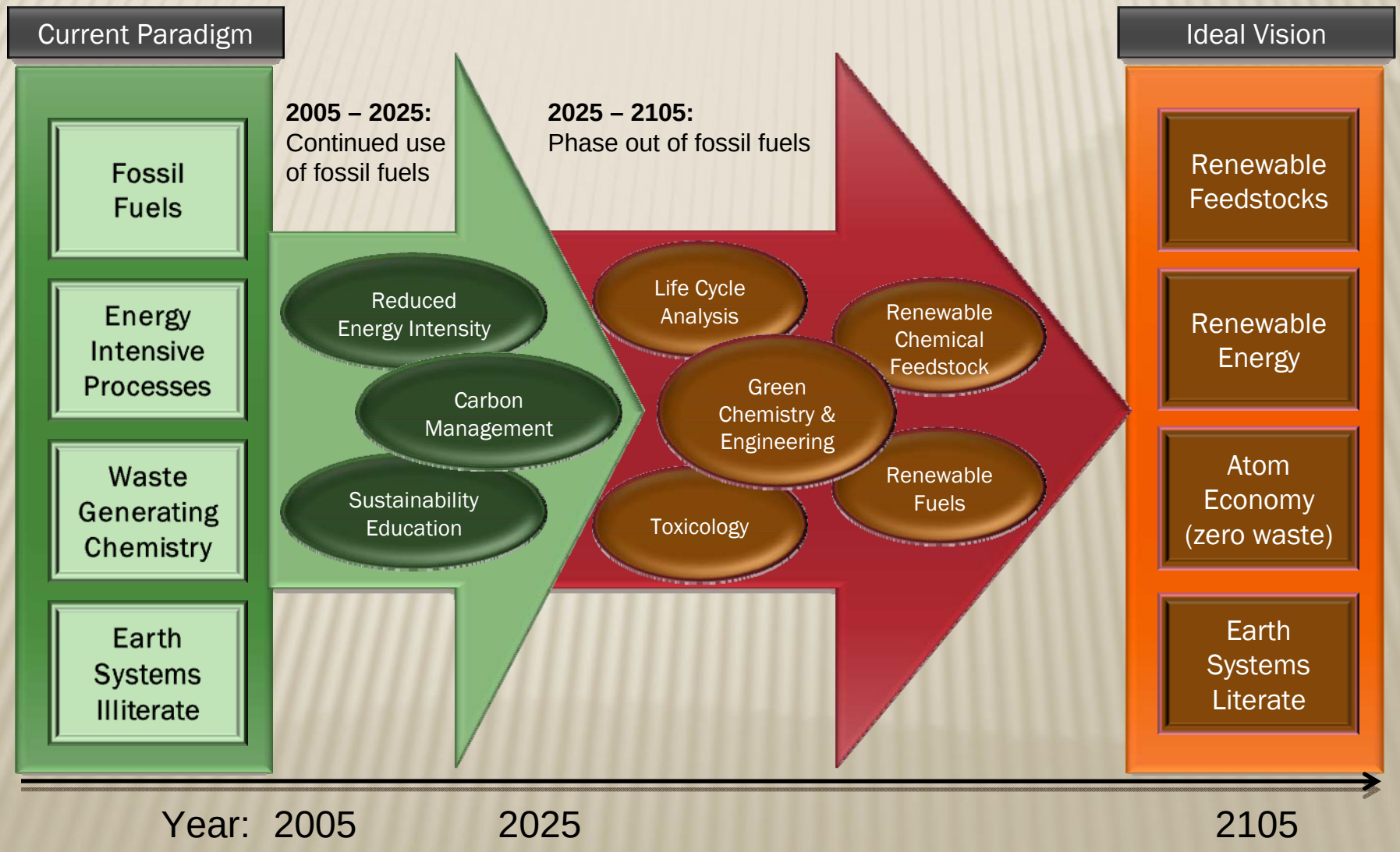
- Allow for the safe combination of a large variety of highly energetic oxidizers and fuels
- Allow for balancing the chemical ingredients with high accuracy to optimal performance on a per microcell basis
- Possess a perfect micron thin protection barrier of low energy polymer fuel, integral to the Microcell, which prevents the highly energetic ingredients from mixing and destabilizing the propellant prior to controlled ignition
- Control the ignition temperature of the Microcell, and maintain that temperature by restricting Microcell ignition to the barrier/oxidizer reactions
- Provide a “thick” shell or rind of outermost layer polymeric (fuel) material which can strongly chemically bound to neighboring Microcells, polymeric propellant binder, and rocket motor casings
- Standardize the chemical identity of the Microcell outer rind polymeric (fuel) material so that all completed Microcells are externally identical
- Provide the ability to pre-produce and “stockpile” microcells in safe and secure storage facilities
- Provide the ability to ship the protected environment and safe, essentially insensitive, Microcellular propellants to offsite storage facilities using conventional hazardous chemical shipping procedures
- Allows production of Green Propellants for all uses

UNIQUE ADVANTAGES OF SPS'S MFC MANUFACTURING PROCESS

SPS Supercritical Fluid Production Technology for Microcells Features

- Process a wide variety of solid, liquid, insoluble nanoparticulate, or in situ produced fuels, oxidizers, and burning moderators
- Simultaneously "grow" the Microcells and purify the components used in the production of the Microcell
- "Grow" balanced composition Microcells to extremely small target dimensions with both high accuracy and reproducibility
- Simultaneously control the solubility of multiple components in the manufacture of Microcells to allow compounding of oxidizer and fuel components providing intimate and uniform mixtures of different oxidizers, oxidizers and burn rate modifiers, or other propellant
- Exclude moisture during the manufacturing process of Microcells
- Produce solid rocket propellants using a completely "green" manufacturing technology in commercial quantities

Non-Aerospace Commercial Applications



NON-AEROSPACE APPLICATIONS

- Non-petroleum based replacement for jet fuel in commercial and military Aviation
- Emergency inflation devices – such as safe, programmable, automobile airbag restraint systems
- Rechargeable hydrogen storage devices
- Ordnance – Water resistant explosives and gun propellants
- Pharmaceutical Applications - Controlled Release drug delivery systems for drug therapy
- Agricultural Applications – Combined time release fertilizer/pest control
- Electrical storage devices – Spherical capacitors

SUMMARY

SPS Microcell Grain Casting Technology Features

- Standardize grain casting procedures, regardless of Microcell internal composition
- Maximize the amount of highly energetic materials in cast solid propellant grains
- Fill and pack the bi-modal distributions of Microcells to maximum packing density in solid propellant grain molds before casting
- Chemically fuse the Microcells, and Microcells and binder, by pressure infusion of a low viscosity energetic pre-polymer binder which fills the empty spaces between particles
- Enhance strength of case-to-grain bonding
- Multi-layer externally identical Microcells with different lifting powers (Isp and Thrust) and burn rates, thereby producing propellant grains with built in burn profiling (throttling)
- Provide propellant grains that will demonstrate exceptional reproducibility in performance due to the exceptional uniformity of energetic materials distributed within the grain
- Allow casting of propellant grains at a processing facility at the launch site
- Can be used in existing solid rocket engines as a current propellant replacement and for either expendable or re-usable launch vehicle boosters with little or no changes to the motor design /hardware
- Could potentially allow casting of very large rocket engines without segmentation of the engine at a launch site as is currently required