



## Plenary Session: Forecasting Key Ceramic Markets to Understand Industry Trends

Charles Miller, Jr.  
President – Harper International Corp.

April 25, 2017

# Today's Agenda

## Forecasting Key Ceramic Markets to Understand Industry Trends

"It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so."

- Mark Twain



# Today's Agenda

## Forecasting Key Ceramic Markets to Understand Industry Trends

- About Harper
- Focus: Feasibility and Scale Up Engineering
- Relationship to Forecasting Industry Trends
- Conclusion



# About Harper

- Headquartered in Buffalo, NY
- An Employee-Owned Company
- Technology & Piloting Facilities
  - Harper / Buffalo, NY - Particulate Processing Pilot Plant
  - Partner Facilities – Carbon Fiber lines (ORNL – USA & Portugal), UHT 2500C Pusher furnace (UDRI-USA)
- Manufacturing Facility
  - System assembly, Automation & Cold Function Testing
- Multi-Disciplined Engineering Talent
  - Chemical
  - Ceramic
  - Mechanical & Design
  - Electrical
  - Industrial
  - Process & Integration
  - Process Cost Modeling



# About Harper

- > Established Leader in Thermochemical Processing Systems
- > Precision High Volume Net Shape Sintering Systems
- > Key Partner in Carbon & Ceramic Fiber Pilot and Production Plants

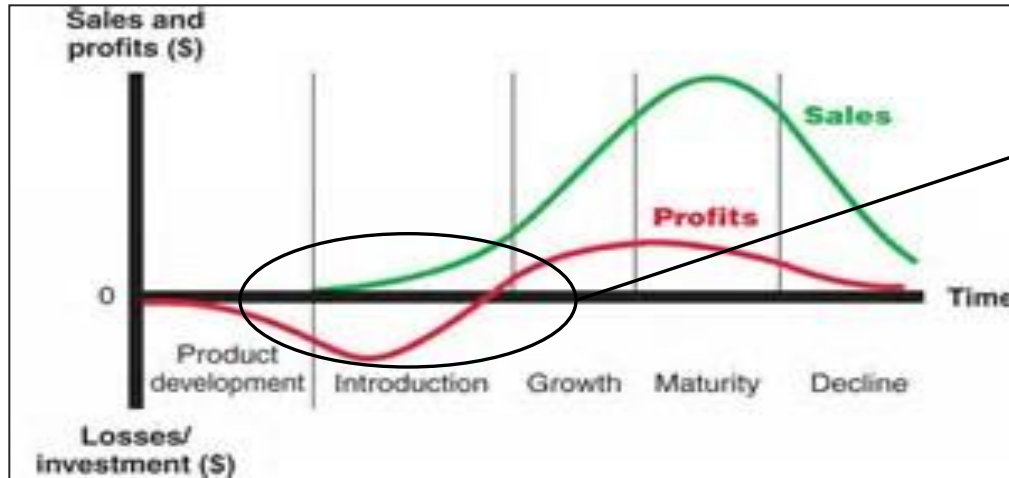
## Primary Technical Focus:

- New / Challenging / Advanced Material Processing
  - 300°C – 3000°C
  - Batch and Continuous processing
  - Precise atmospheric controls
  - High purity requirements
  - Complex gas-solid interactions



Fiber Synthesis Pilot Line: Demonstrated significant (50%) OPEX enhancements for composite fiber processing.

# Challenges in Commercialization of Materials



- Technical success
  - Application
  - Material
- OPEX appropriate for return
- Time for deployment



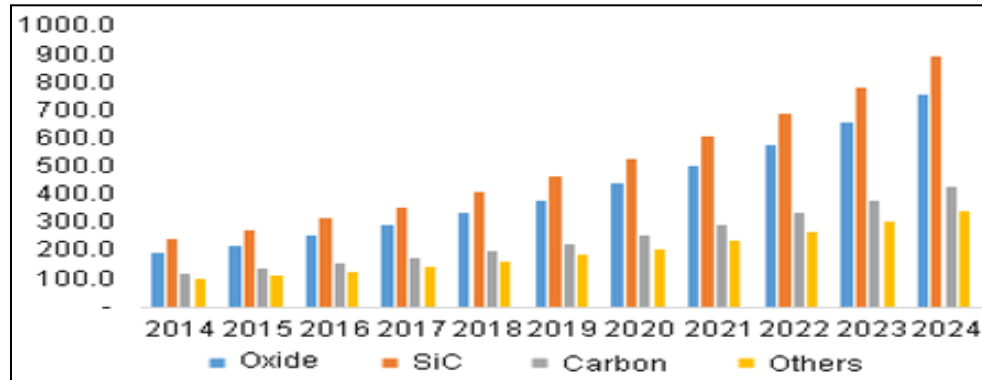
# Challenges in Commercialization of Materials



- OPEX Year on Year enhancement appropriate for return
- Scale-Up
- Additional adopters
- New related applications

# CMC Market Outlook

- CMC projected to reach \$7.51B by 2026 - **CAGR of ~9.5%** 2016 to 2026
- GE Huntsville to produce up to 20 mt/yr of CMC parts in '17, **20x greater than in '07**
- One CFM Intl. LEAP engine uses ~1 kg of CMC, expanding on demand for Boeing 737 MAX aircraft and other jets
- CMCs also a significant element of the design of the forthcoming GE9X engine, which will power Boeing's 777MAX in 2019



Source: Grandview Research



# Challenges in Commercialization of Materials

## ➤ OPEX Appropriate for Return

- Input materials cost
- Labor
- Utility consumption
- CAPEX depreciation

## ➤ Time for Deployment

## ➤ Technical Success

- Product quality
- Transition from 1 → 100's kg/hr
- Yield of in-spec. product
- Handling of products and wastes



# Objectives in Thermal Processing Scale-Up

- ✓ Define the "process window"
  - Stable zone
  - Push to failure
- ✓ Reduce and retire risks
- ✓ Validate data for OPEX model
- ✓ Develop a safe process that will meet environmental regulations
- ✓ Innovate and Optimize
- ✓ Model and validate under industrial conditions



An alignment problem...

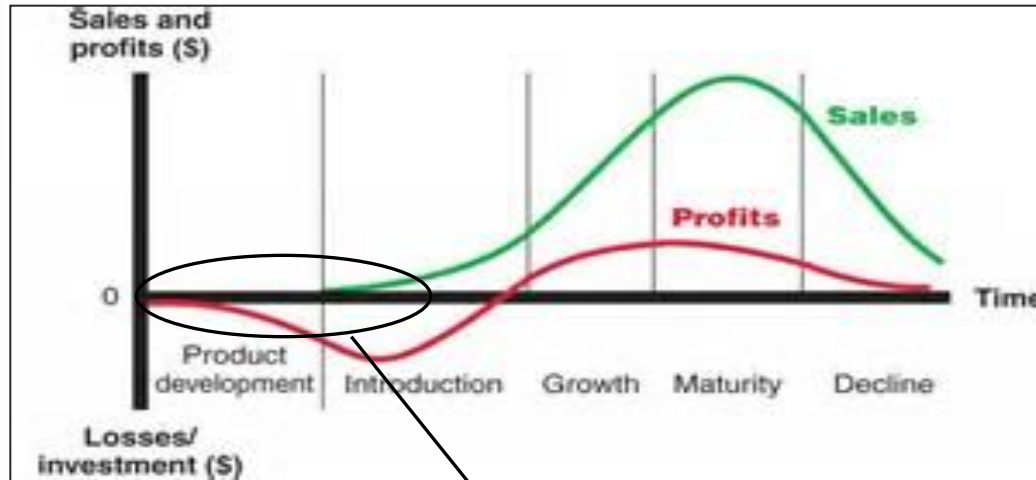
# Ignite™

The Ignite™ program aims to enable the progression of a discovery, an invention or a concept from a small, batch scale to a commercial stage.

- Helping customers turn the next generation of material innovations into profitable new markets
- Utilizes Harper's depth and breadth of experience in advanced thermal processing
  - ✓ Reduce Risk - Scaling factor 1:10, 1:100, 1:1000
  - ✓ Control OPEX
  - ✓ Parallel Development
  - ✓ Controlled Scale-up
  - ✓ Successful Commercialization



# Discovery / Invention of Materials



15-40 years

- Carbon Nano
  - 1996 Nobel prize
  - ~5,000 T/yr demand
- Graphene
  - 2010 Nobel Prize
  - 3,800 T/yr 2026
- Carbon Fiber
  - Late 1950's Inventions
  - Early 1990's wide use Golf Shafts
  - Mid 1990's Commercial Aerospace
  - ~70,000 T/Yr Demand 2016
- Optical Fiber
  - 1970's invention
  - Mid 1980 into Growth
- Gorilla Glass
  - 1960, revived 2005
  - 2010 in ~20% mobile handsets

# Summary

- Focus: Feasibility and Scale Up Engineering
  - Pilot & Production Plants
- Relationship to Forecasting Industry Trends
  - Business Dev. Staff Engaged in Development and Introduction Phases
  - Exec. Team linked to Program Sponsors in Introduction, Growth and Maturity
  - Consultancy, Market Analysis/Research, Sales Staff → Central Data Base & Strat. Planning



Visit us at Booth 530  
and at [harperintl.com](http://harperintl.com)