Welcome to GrafTech!

EDGE InnoQuest April 30th 2014
Julian Norley, Vice President R&D

GRAFTech International | Redefining limits

Agenda

- Introduction to GrafTech & Innovation “through the ages”
- A case study in innovation – the AET business “from industrial gaskets to heat spreaders for smartphones”
- Innovation tools
  - Technology Roadmapping
  - Idea Records/Patent
  - StageGate Process/Project Database
  - External Interactions/Open Innovation

GrafTech International Today

A Global Company With a History of Innovation

- ✓ Founded in 1886!
- ✓ Headquartered in Parma, Ohio
- ✓ $1.2 billion in annual sales (2013)
- ✓ ~ 2600 team members worldwide (2014)
- ✓ 17 manufacturing facilities throughout USA, Mexico, Spain, France & Italy
- ✓ Sales in over 75 countries; 75% of revenues generated outside of the United States
- ✓ World renowned R&D center
  - ✓ Approximately 80 scientists, engineers & R&D professionals
  - ✓ Approximately 733 patents
  - ✓ Extensive pilot plant and testing facilities
  - ✓ LEAN manufacturing expertise

GrafTech Headquarters & R&D Center
Parma, Ohio

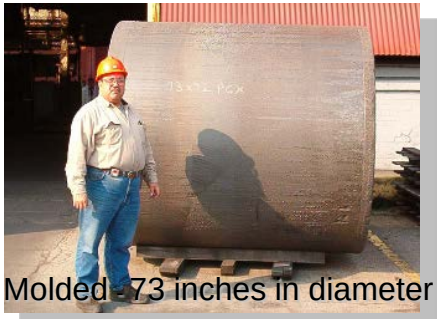
Natural Graphite Operations
Lakewood, Ohio
Founded 1892

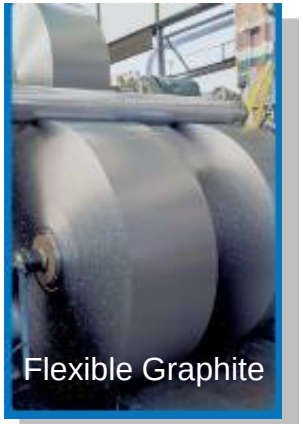
Wide variety of different forms – From Nano to Macro!

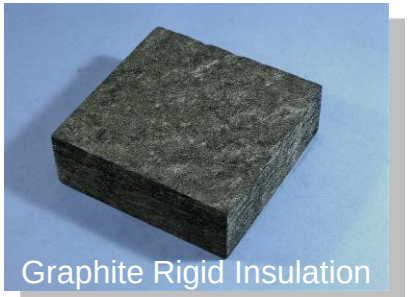

Machined Synthetic Graphite Components


Fibers


Powders


Molded - 73 inches in diameter

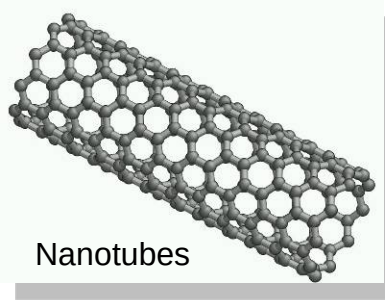

Flexible Graphite

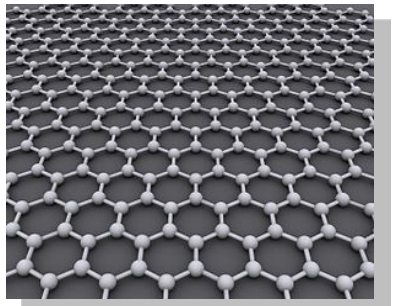

Graphite Rigid Insulation


Felt


Carbon Foam


Carbon/Carbon Composites


Nanotubes


Graphene

GRAFTech International | Redefining limits

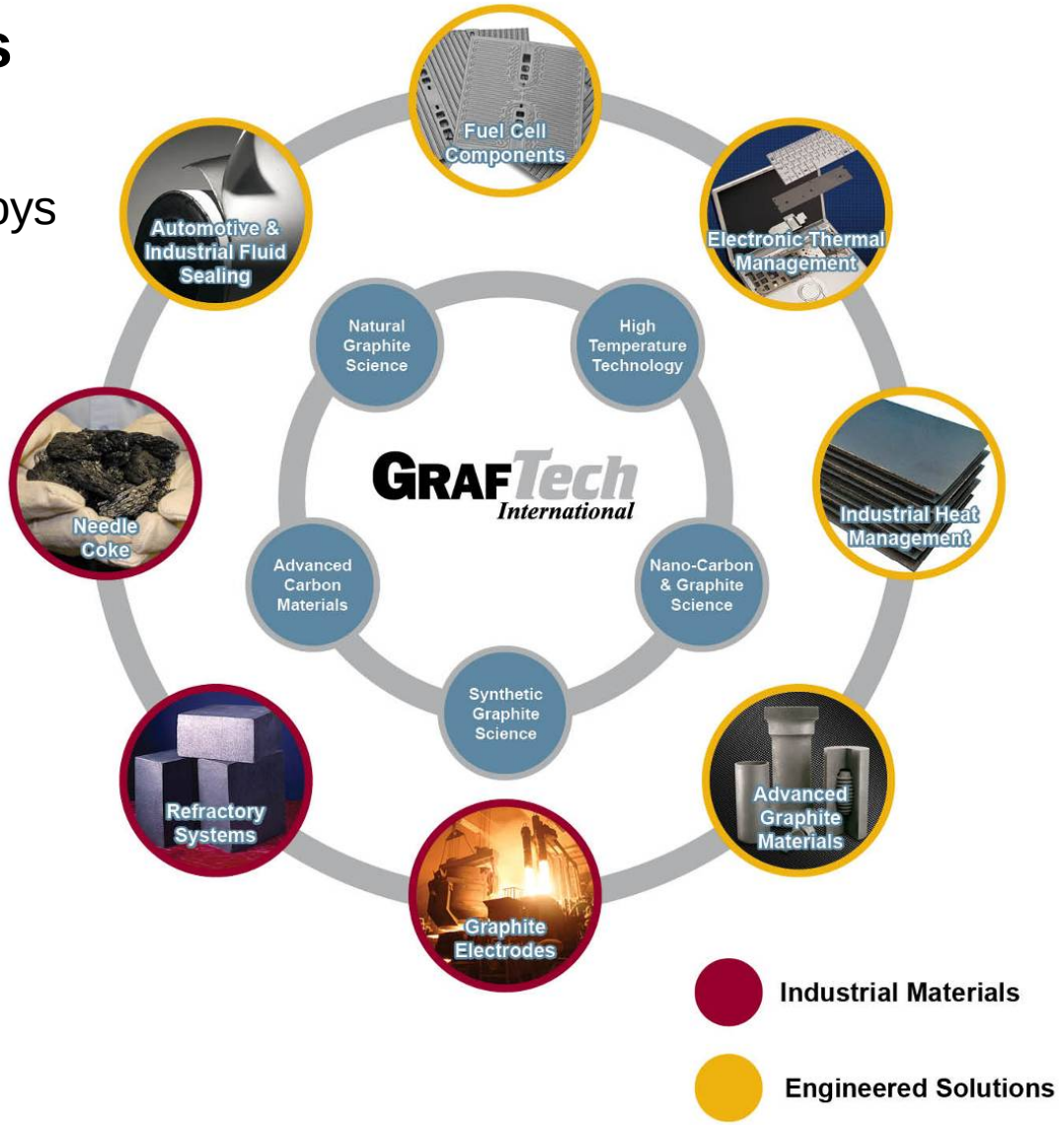
Unique Properties – Tailored over an Extraordinary Range!

- Operating temperature up to ~ 3300°C in an inert environment, 500°C in air. Strength increases with temperature. Used in many high temperature metals processing applications
- Thermal conductivity 0.1 – 1500 W/mK – used as thermal insulation and as heat spreaders in smartphones
- Low cte; outstanding thermal shock resistance – use in rocket nozzles, graphite electrodes in melting of steel
- High Purity < 5 ppm – use in semiconductor and solar industries
- Chemical stability – used widely in chemicals industry, fuel cells, batteries
- Good electrical conductivity – used as an electrode in fuel cells and batteries
- Surface area 0.1 m^2/g to 2500 m^2/g – used for li-ion battery anodes and supercapactitors
- Readily machinable

GrafTech Businesses and Products

Two Business Segments

- **Industrial Materials (IM)**
  - Services steel and ferroalloys markets
  - Graphite electrodes
  - Refractory materials
  - Needle coke
- **Engineered Solutions (ES)**
  - Engineered synthetic graphite products
  - Flexible graphite products
  - High temperature carbon composites
  - Key markets include electronics, energy and aerospace/defense

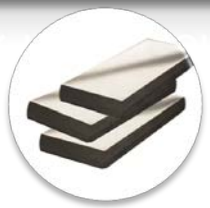


Engineered Solutions Business Segment

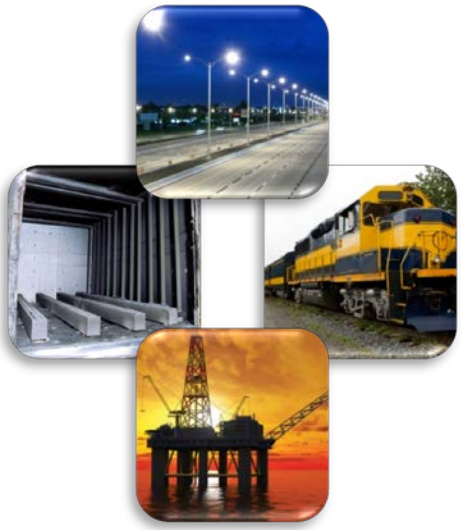
Flexible Graphite

Flexible Graphite
(Smartphones, Tablets, Displays)

Advanced Graphite & Insulation



High Temp Furnaces
(LED, Solar, Sapphire, Industrial)
Diamond Drill Bit Molds
Rail Wheel Molds



Carbon Composites

Rocket Nozzles
Heat Shields
(Aerospace & Defense)

Additive Materials

Lubricants
(Automotive)
Polymer Additives
Friction Material

Poised to Benefit from Significant Growth in Key Markets

Growth We Expect in Key Markets Next 5 Years

+23%

LED LIGHTING
(HIGH TEMPERATURE FURNACES)

+19%

SMARTPHONES
(ELECTRONIC THERMAL MGT)

+14%

AEROSPACE & DEFENSE

+17%

OIL & GAS STRUCTURES

+19%

SOLAR

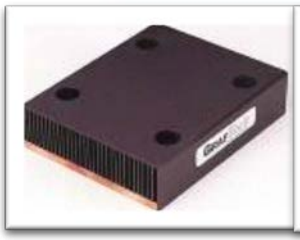
+15%

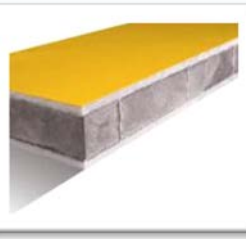
LITHIUM ION BATTERIES

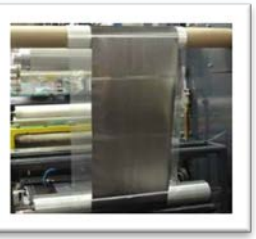
Leverages core competency in graphite materials → new growth engines

Source: GTI Estimates, third party assessments and third party reports

Strong History of Innovation



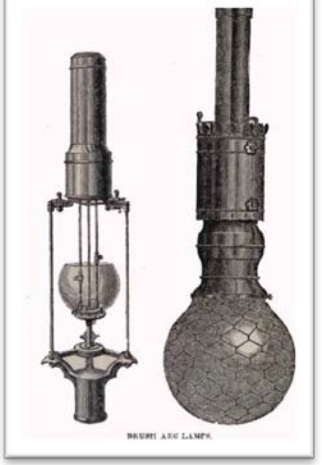
2003 **2004** **2005** **2006** **2007** **2009** **2011**

2003 winner for HS-400 heat sinks
2004 winner for SPREADERSHIELD™ heat spreaders
2005 winner for Apollo® (ALX ™) graphite electrodes
2006 winner for GRAFOAM® graphite foam
2007 winner for GRAFCELL® fuel cell plates
2009 winner for GRAFIHX™ Flexible Heat Exchangers
2011 winner for SS1500 Worlds' Thinnest Graphite Heat Spreaders

+ Awards for Grafoil graphite tape 1963, Refractory metals (1964), **high modulus Thornel graphite fibers (1966)**, Boralloy pyrolitic boron nitride lab ware (1966), porous metal sheet (1966), UCAR graphite monochromator made from pyrolytic graphite for use in x-ray analysis (1968), carbon and graphite foams for use in aerospace applications (1968), code 114 treated graphite which is an anti-oxidation treat (1970), and jet airplane brake discs (1970).

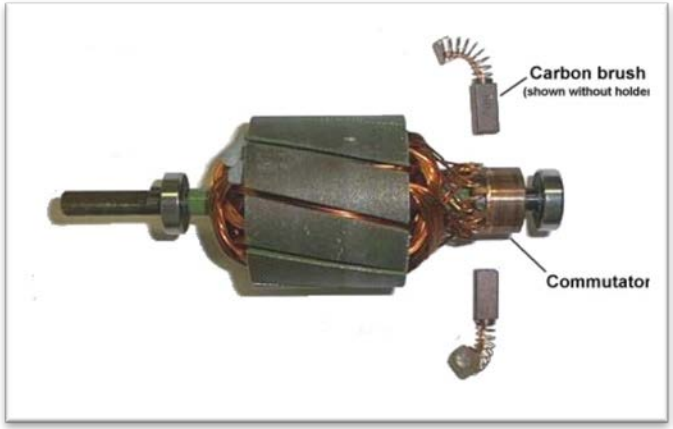
The Carbon Arc Lamp ca.~ 1880's-1890's

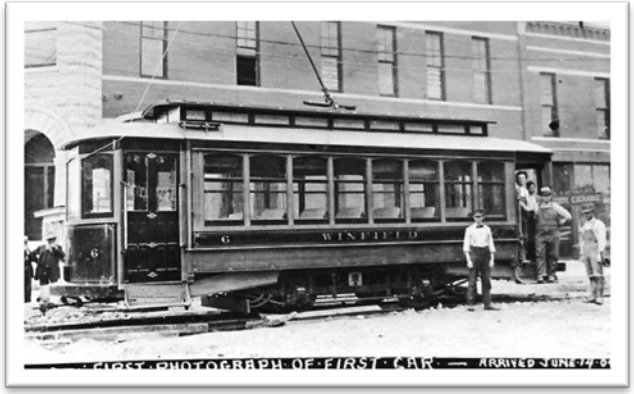
- National Carbon Company's first products were ~ 6-inch long pencil sized carbons for arc lamps for electric street lighting
- Charles Brush is credited for developing the first commercial arc lamps producing public light well into the 20th century.
- Brush may have been one of the first carbon materials scientists?
  - He improved the manufacturing process by molding or extruding the carbons using a mixture of "still" coke, a product of petroleum refining from SOHIO in Cleveland and coal tar pitch which together with his invention of copper cladding significantly improved the strength allowing longer electrodes with longer burn time.
- Carbon arcs peaked in 1899 at 158 million but continued to be used through the next sixty years in military searchlights, UV therapeutic tanning lamps ("sunshine carbons"), and motion picture projectors, culminating in an Oscar in 1956 for development of a high efficiency yellow flame carbon for motion picture color photography



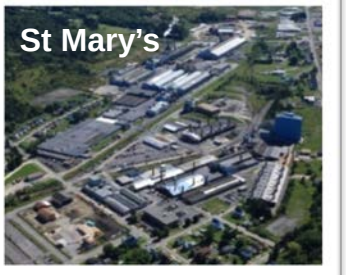
1880's – 1910's Carbon Brushes for Electric Motors

- The carbon brush conducts current between a stationary wire and a rotating shaft in electric motors, alternators and generators.
- In 1888, Charles Van de Poele demonstrated the first carbon brushes in the motors of Street Cars.
- 1892 saw the construction of a new National Carbon Factory (Factory "A" in Lakewood, a suburb of Cleveland) and in 1899 Speer Carbon was founded in our St Mary's, Pa plant to make carbon brushes for electric motors and generators.
- Factory "A" included maybe the first carbon R&D lab - conducting research on brushes, arc carbons and batteries. In 1905 they developed Electro-graphite carbon brushes followed in 1908 by metal graphite brushes.



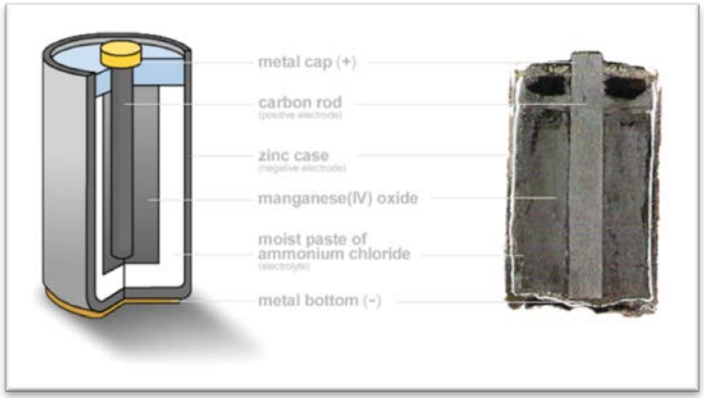



Factory "A" 1892



1896 - Columbia Dry Cell Battery

- In this new era of electrification, batteries were fast becoming essential to power a number of new devices such as telephones and igniters for cars
- Our history in energy storage began In 1896 when the National Carbon Company (corporate predecessor of Eveready/Energizer) developed the six-inch, 1.5 volt Columbia battery, the first **sealed dry cell** successfully manufactured for the mass market. The Columbia, a carbon-zinc battery with an acidic electrolyte, was a significant improvement over previous batteries, meeting consumer demand for a maintenance-free, durable, no-spill, inexpensive electrochemical power source.
- The carbon electrode serves as the current collector; carbon powder was added to the MnO_2 cathode to improve electrical conductivity
- Dry cells were made at Factory “A” until 1920. The Columbia launched the modern battery industry by serving as the basis for all dry cells for the next sixty years. In 2005 the Columbia Dry Cell battery was designated an American Chemical Society National Historical Chemical Landmark



1900’s – 1940’s The Dawn of Electric Steel, Graphite Electrodes

- GrafTech’s largest market is graphite electrodes used to melt scrap steel in electric arc furnaces.
- Electric steel represents ~ 30 % of global steel production with over 1 million tonnes of graphite electrodes consumed annually.
- The first steel made in the United States with electric power was in 1906 by the Halcomb Steel Company in Syracuse, New York.
- Many companies got into the electrode manufacturing business, mostly using carbon electrodes, but Acheson with its graphite electrodes was in the lead technologically. In 1909, the Acheson Company patented the improvement of the strength of electrodes using impregnation by pitch.
- Carbon and graphite use was also critical as anodes for aluminum and calcium carbide production. Union Carbide and Carbon Company was formed in 1917
- In 1922, the AGX electrode brand was introduced, a brand that is still in use today. The largest size available was 14” in diameter
- By the end of the 1920’s, 16” diameter graphite electrodes were being produced.
- In 1944, National introduced 24-inch diameter graphite electrodes, just in time for the post World War II economic recovery in Europe which caused a dramatic increase in the number of electric arc furnaces, mainly for production of alloy steels from recycled scrap.
- Today GrafTech is the World’s largest graphite electrode manufacturer with a capacity of 255,000 tonnes. Electrodes now up to 30-inch (750 mm) in diameter x 9.5 feet (2.87m) long

First electric arc furnace in the US

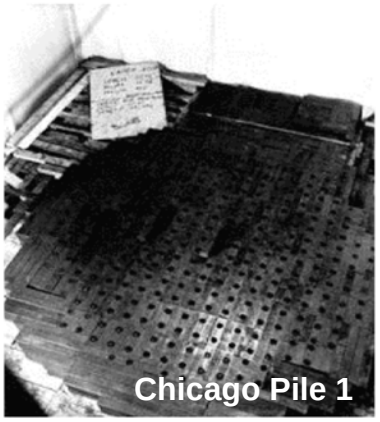
UCAR

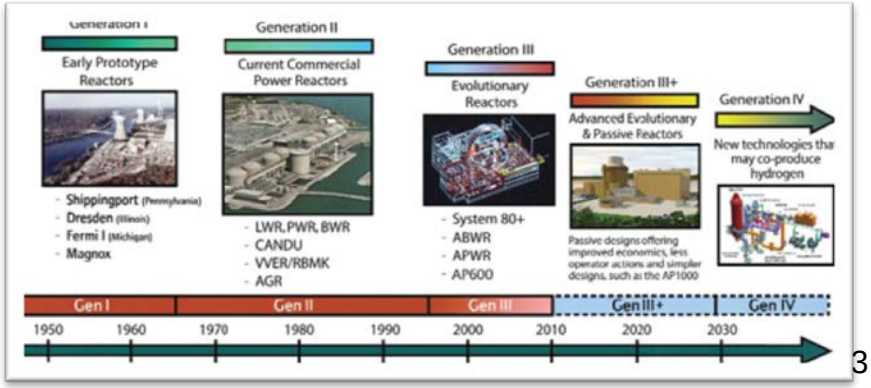
UCAR® GRAPHITE ELECTRODES

AGX™

(1940's-1980's) Nuclear Graphite

- In 1942, National's graphite grade AGOT was used as the neutron moderator in the first atomic pile built under the University of Chicago's Stagg Field, part of the revolutionary Manhattan Project. This high purity grade was easily machined into the intricate shapes required for reactor construction. National Carbon Company delivered 225 tons of AGOT and 30 tons of AGX for the Manhattan Project.
- The company received a "Chemical Engineering Achievement" award from the US government in 1946 in recognition of the work accomplished for the Manhattan Project.
- National Carbon provided graphite for Magnox, and AGR reactors in the 50's-80's for commercial electricity production; some reactors are still in operation today although are being gradually phased out.
- Graphite is now back in consideration for next generation combined heat and power Gen IV very high temperature reactors


Chicago Pile 1

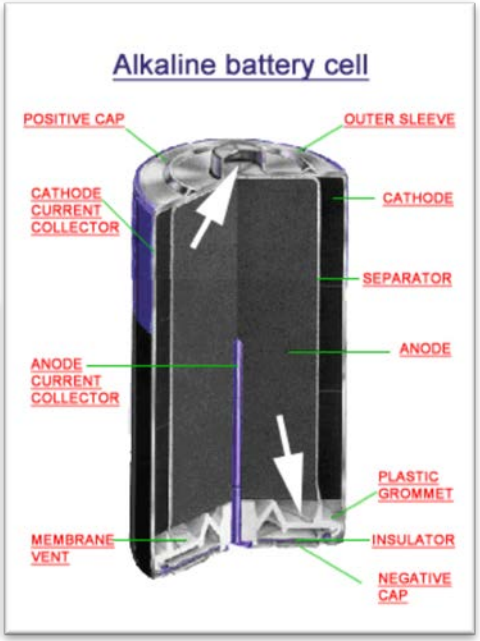


1950's -1980's – Fibers, Alkaline Batteries & Fuel Cells

- In 1956, the new "National Carbon Company Parma Research Laboratory" located in Parma Ohio, near Cleveland, was opened. The $6 million facility contained 158 laboratory modules.
- The facility was designed primarily for basic research in chemical and solid state physics. The building has been expanded several times, most notably in 1965 when a pilot plant was added and the name changed to "Parma Technical Center".
- 575 employees at its peak in the early 80's
- Cutting edge research was performed in the areas of **alkaline batteries**, **carbon fibers** and **fuel cells.**
- Nine R&D 100 Awards

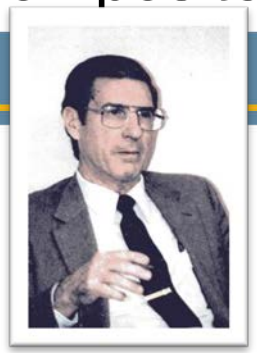
1957 - Alkaline Batteries

- Eveready Battery (purchased by National Carbon in 1914) revolutionized the battery industry in the 1950's, introducing alkaline battery technology, a giant step toward longer battery life in portable, battery-powered devices.
- The original patent for alkaline batteries was filed by Lewis Urry (pictured), Karl Kordesch and P.A. Marsal in 1957.
- Used an **alkaline** electrolyte of potassium hydroxide instead of the acidic ammonium chloride or zinc chloride electrolyte of the zinc-carbon batteries.
- Urry is considered "the father of the alkaline battery" and had 57 patents to his name. In order to sell the idea to his managers, Urry put the battery in a toy car and raced it around the Parma Research Laboratory cafeteria against a car with conventional dry cell batteries. His invention had many times the durability.
- An Ohio historical marker was erected in 2011 at the Parma facility to recognize his contributions to the alkaline battery.



1958-1970 – Early Carbon Fibers & Composites

- The modern era of carbon fiber development started at the Parma Research Laboratory in 1958 when Dr. Roger Bacon vapor deposited graphite whiskers while performing high pressure arc carbon research
- "I found all these whiskers," he says. "They were up to an inch long, and they had amazing properties. They were only a tenth of the diameter of a human hair, but you could bend them and kink them and they weren't brittle. They were long filaments of perfect graphite." Bacon demonstrated fibers with a tensile strength of 20 GPa and Young's modulus of 700 GPa. By comparison steel is 1-2 GPa tensile strength with a Modulus of 200 GPa and 5x heavier!
- In 1959 researchers at Parma patented a process for making carbon fibers and cloths from rayon precursors by heat treating at temperatures up to ~ 3000°C –National began to commercialize carbon fiber cloth and felts for use as rocket nozzle exit cones and high temperature insulation
- In 1963, Union Carbide began the first commercial production of continuously processed carbon yarn, permitting for the first time the development of carbon fiber composites made by filament winding or by lay-up of prepreg tapes. This was the initial entry of carbon fibers into the "advanced composites" industry which had previously been dominated by glass and boron fibers. In the mid-1960s, a range of graphite-reinforced epoxy composite parts such as wing tips, nose cones, tail caps, trailing edges of wings, and air-inlet ducts were developed for military jets.
- Until 1965, all commercial carbon fibers were relatively low strength and low modulus until the introduction of Thornel 25 (25 million psi modulus , ~ 172 GPa) high modulus rayon based yarns from the work of Dr. Roger Bacon et al. who discovered that "hot-stretching" of the fibers to > 2800°C oriented the graphite layers. R&D 100 Award 1966



Dr Roger Bacon

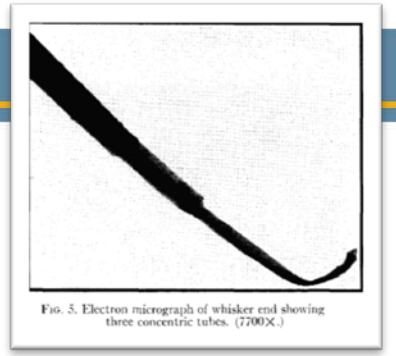
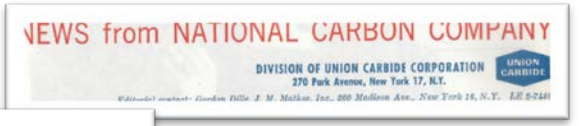


Fig. 5. Electron micrograph of whisker end showing three concentric tubes. (7700×.)

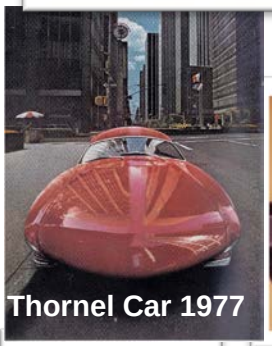


August 1966 3000 lb Mustang supported by a loop of carbon fiber reinforced resin

Mid-1960's Starfighter with carbon fiber/epoxy parts

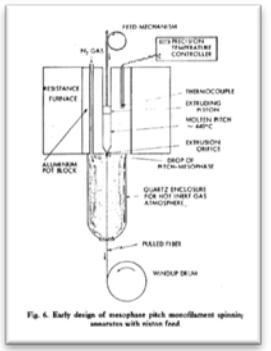
1970's to Today - Carbon Fibers

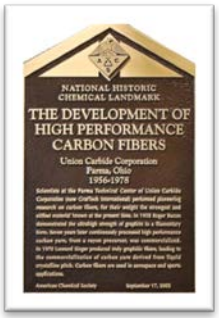
- The 70's saw the positioning of carbon fibers and composites for commercial applications as golf shafts, fishing poles, tennis rackets, skis and boat hulls
- Work at Parma by Singer and Lewis in the 1970's on the melt spinning at ~ 400°C of liquid-crystal-like mesophase pitch created highly-oriented graphitizable carbon fibers with extremely high Young's modulus (approaching 1000GPa) and thermal conductivity (> 1000 W/mK). They were commercialized in 1975 finding use in military, space and aircraft brake applications.
- Union Carbide licensed the Toray PAN fiber manufacturing technology in 1978 completing the portfolio of rayon, PAN and pitch based fibers.
- In 2003, the American Chemical Society designated the development of high performance carbon fibers as a National Historic Chemical Landmark. The plaque reads: "Since Roger Bacon discovered "graphite whiskers" in 1958 at Union Carbide's Parma Technical Center, carbon fibers have been used in high performance applications from airplanes to automobiles and from satellites to sporting goods. Bacon's research, along with a host of other scientists at Parma over the years, set the stage for the exploding field of carbon fiber-based composite materials technology."
- Today GrafTech manufacturers/uses fibers in graphite electrode products, insulation packs and carbon/carbon composite rocket nozzles and nose tips



Dr Len Singer

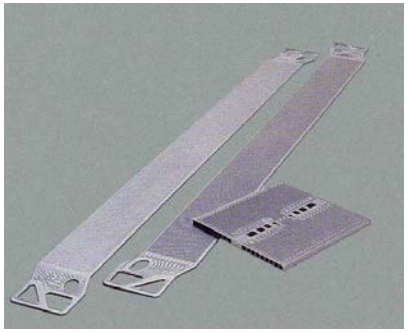
Dr Irv Lewis





1950's to Today - Fuel Cells

- National Carbon's involvement with fuel cells started in 1955. The most well known researcher in this area was Dr. Karl Kordesch, who started his career with National Carbon by contributing to the basic patents for the alkaline battery. He then branched out to alkali fuel cells with carbon gas-diffusion electrodes.
- He demonstrated fuel-cell-powered mobile radar sets for the U.S. Army, a fuel-cell-powered motorbike, and drew up plans for an undersea base that would run on fuel cells. Dr. Kordesch developed hydrogen fuel cells for the US Space program, the US Navy and the General Motors Electrovan.
- In the early 70's he built a fuel cell city car (an Austin A 40, designed as a hybrid vehicle with rechargeable batteries) for his personal use and operated on public roads for several years.
- GrafTech's legacy in fuel cells continues today with the manufacture of natural graphite flow field plates in PEM fuel cells for the automotive, bus and fork lift industries through its collaborations with Ballard Power, Plug Power, the DOE and Ohio's Third Frontier Fuel Cell Program.
- Technology expanded into flow batteries for grid storage



1990's to Today – Semiconductor/Solar

- GrafTech first started manufacturing graphite materials for semiconductor and solar industries in the 1990's
- Graphite is used extensively in the furnace hot zones in the manufacture of polysilicon, single crystal and multicrystalline silicon ingots, quartz and fiber optics
- Includes seed chucks, molds, susceptors, heating elements, heat shields and insulation materials
- Critical attributes are high temperature resistance, chemical resistance, purity, tailorable thermal conductivity (low and high) and machinability

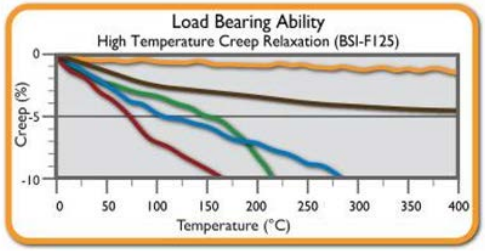
GRAFSTAR™

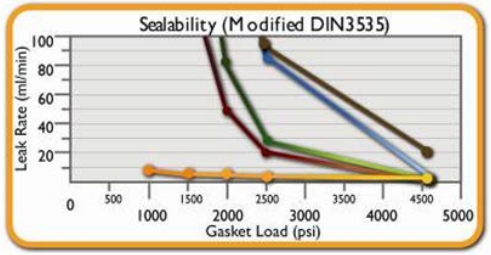
GRAFSHIELD™

Case Study In Innovation – The AET business

From industrial gaskets to smartphones

- In 2000 AET was a manufacturer of natural-graphite based flexible graphite materials GRAFOIL® for industrial fluid sealing and automotive gasket applications
- Top customers were automotive and chemical companies
- Measured properties such as compressibilty & recovery, sealability, creep, oxidation resistance
- Business was starting to decline as product became commoditized; our customers were becoming gasket houses who would select the material that maximized their profit and influence!
- Business & R&D groups began looking for new opportunities – highlighted fuel cells, electronic thermal management as emerging **megatrends** where we could exploit our **core competency** in flexible graphite materials science

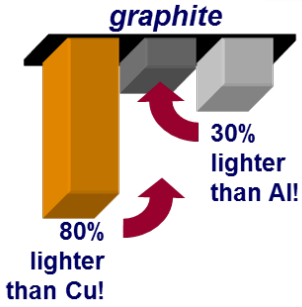


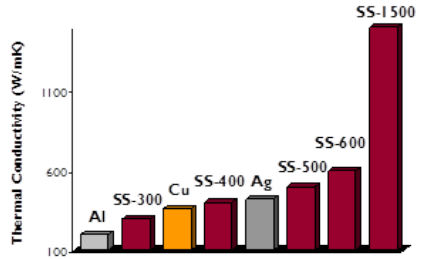


Case Study In Innovation – The AET business

From industrial gaskets to smartphones

- In 2014 AET is the World's largest manufacturer of synthetic and natural graphite heat spreaders for consumer electronics
- Solving **unmet thermal challenges** in ultrathin devices such as smartphones, tablets, flat panel displays
- **Challenged the orthodoxy** that only metals could work!
- Top customers are major names in consumer electronics
- Measure properties such as thermal conductivity
- Business booming – new facility opened in Sharon Center, Ohio
- Fluid sealing and automotive gaskets are < 10% of our business today
- Without this innovation the AET business would have died!





eGRAF® SPREADERSHIELD™ heat spreaders

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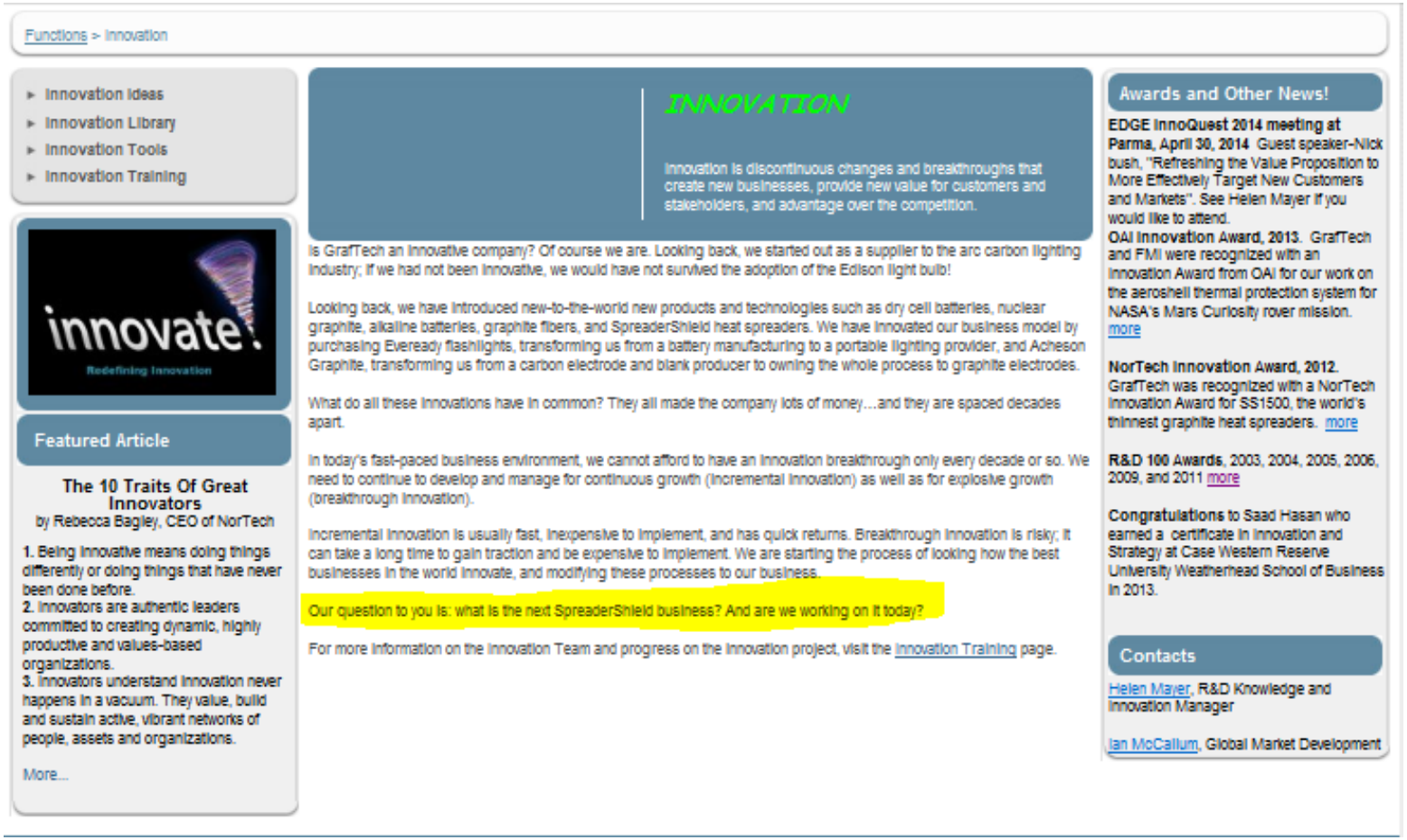
Current Innovation Thrusts



Functions > Innovation

- Innovation Ideas
- Innovation Library
- Innovation Tools
- Innovation Training

innovate!
Redefining Innovation

Featured Article

The 10 Traits Of Great Innovators
by Rebecca Bagley, CEO of NorTech

1. Being innovative means doing things differently or doing things that have never been done before.
2. Innovators are authentic leaders committed to creating dynamic, highly productive and values-based organizations.
3. Innovators understand innovation never happens in a vacuum. They value, build and sustain active, vibrant networks of people, assets and organizations.

More...

INNOVATION

Innovation is discontinuous changes and breakthroughs that create new businesses, provide new value for customers and stakeholders, and advantage over the competition.

Is GrafTech an innovative company? Of course we are. Looking back, we started out as a supplier to the arc carbon lighting industry; if we had not been innovative, we would have not survived the adoption of the Edison light bulb!

Looking back, we have introduced new-to-the-world new products and technologies such as dry cell batteries, nuclear graphite, alkaline batteries, graphite fibers, and SpreaderShield heat spreaders. We have innovated our business model by purchasing Eveready flashlights, transforming us from a battery manufacturing to a portable lighting provider, and Acheson Graphite, transforming us from a carbon electrode and blank producer to owning the whole process to graphite electrodes.

What do all these innovations have in common? They all made the company lots of money...and they are spaced decades apart.

In today's fast-paced business environment, we cannot afford to have an innovation breakthrough only every decade or so. We need to continue to develop and manage for continuous growth (incremental innovation) as well as for explosive growth (breakthrough innovation).

Incremental innovation is usually fast, inexpensive to implement, and has quick returns. Breakthrough innovation is risky; it can take a long time to gain traction and be expensive to implement. We are starting the process of looking how the best businesses in the world innovate, and modifying these processes to our business.

Our question to you is: what is the next SpreaderShield business? And are we working on it today?

For more information on the innovation Team and progress on the innovation project, visit the Innovation Training page.

Awards and Other News!

EDGE InnoQuest 2014 meeting at Parma, April 30, 2014 Guest speaker-Nick bush, "Refreshing the Value Proposition to More Effectively Target New Customers and Markets". See Helen Mayer if you would like to attend.

OAI Innovation Award, 2013. GrafTech and FMI were recognized with an innovation Award from OAI for our work on the aeroshell thermal protection system for NASA's Mars Curiosity rover mission. more

NorTech Innovation Award, 2012. GrafTech was recognized with a NorTech innovation Award for SS1500, the world's thinnest graphite heat spreaders. more

R&D 100 Awards, 2003, 2004, 2005, 2006, 2009, and 2011 more

Congratulations to Saad Hasan who earned a certificate in innovation and Strategy at Case Western Reserve University Weatherhead School of Business in 2013.

Contacts

Helen Mayer, R&D Knowledge and Innovation Manager

Ian McCallum, Global Market Development

Joel Hawthorne GrafTech CEO Q1 Worldwide GrafTech meeting 4/30/2014!

Overview of Innovation Tools

EDGE InnoQuest April 30th 2014

Helen Mayer R&D Knowledge and Innovation Manager

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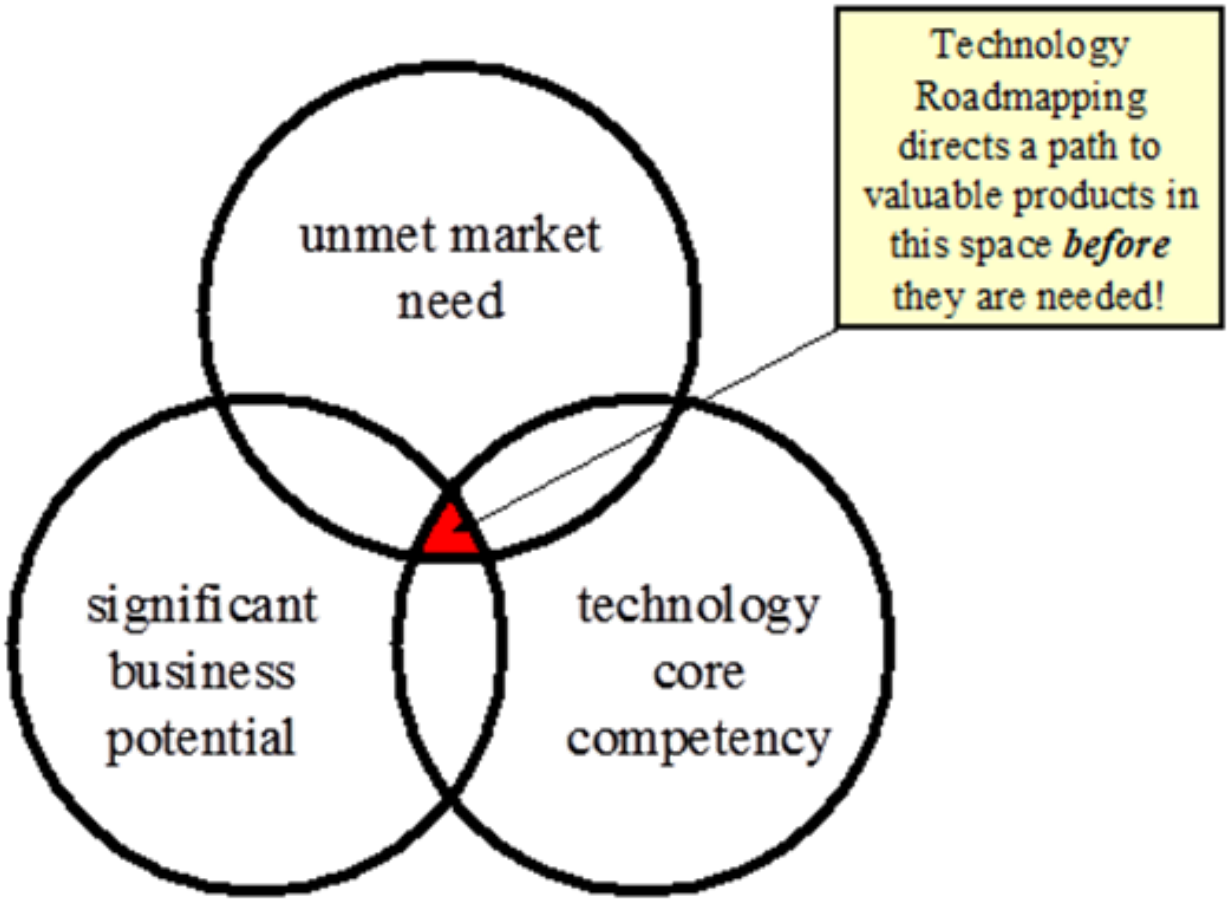
Agenda

- Innovation Tools
  - Technology Roadmapping
  - Idea Records/Patent
  - StageGate Process/Project Database
  - External Interactions/Open Innovation

What is Technology Roadmapping?



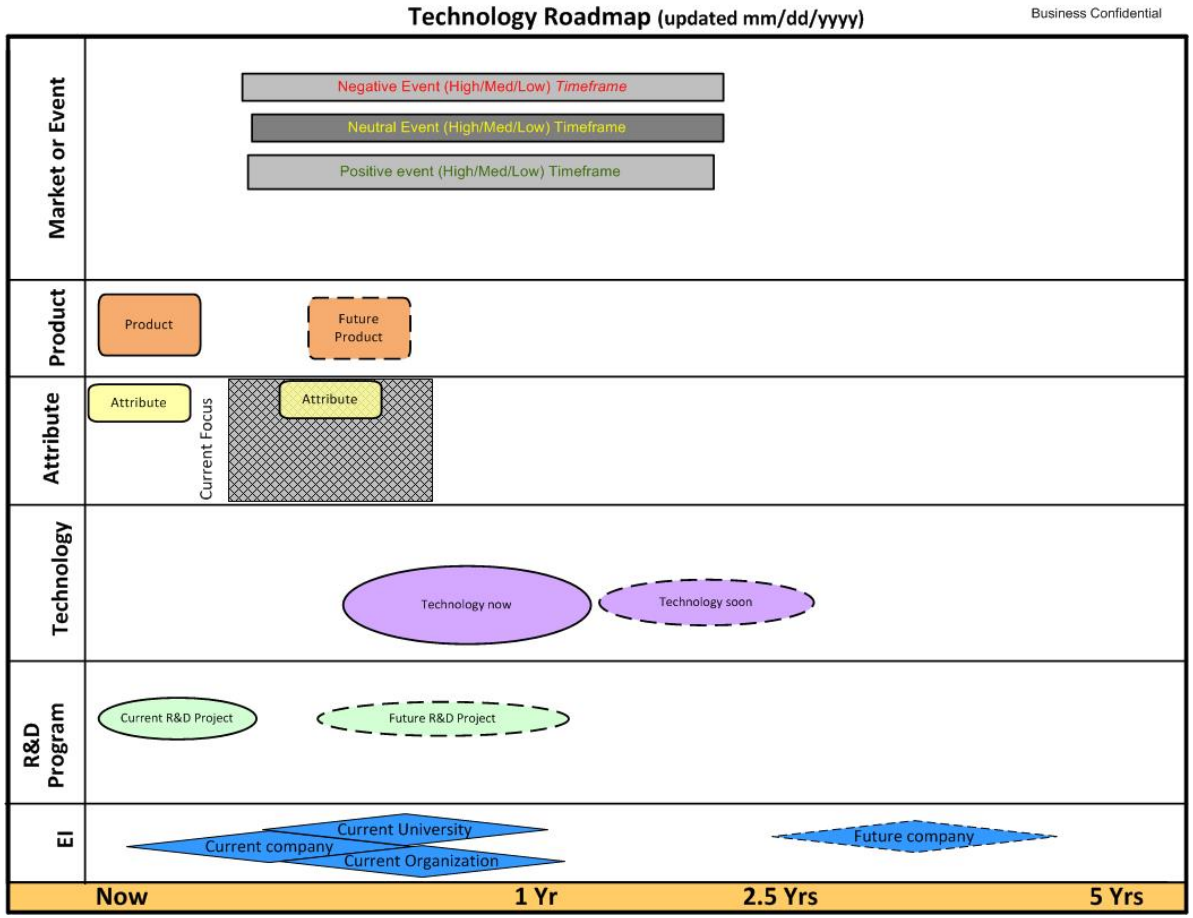
Technology Roadmapping

Why: determine whether or not our R&D efforts are aligned with business strategy, product needs, and market demands or changes. What needs to change?

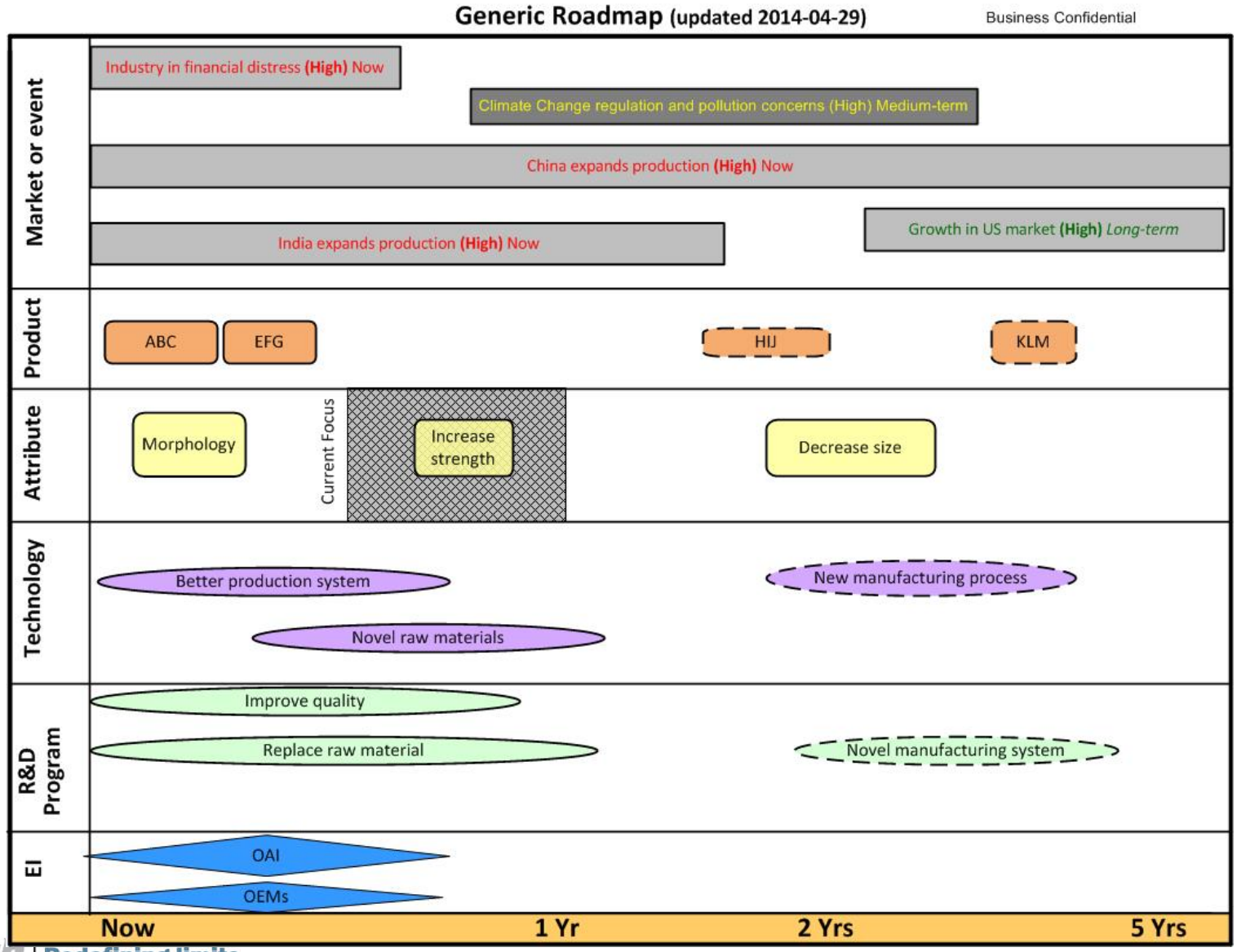
Who: cross functional team, including R&D, marketing, sales and senior leadership

What: 1-2 hour roadmapping session where we collectively discuss what's *"out there"* and what's *"in here"*

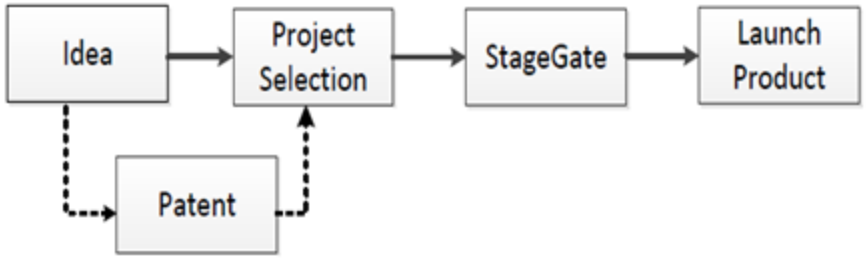
When: depending on the particular market, technology platform or raw material, could be bi-annually, or annual



Sample Technology Roadmap



Innovation Process—Idea Record

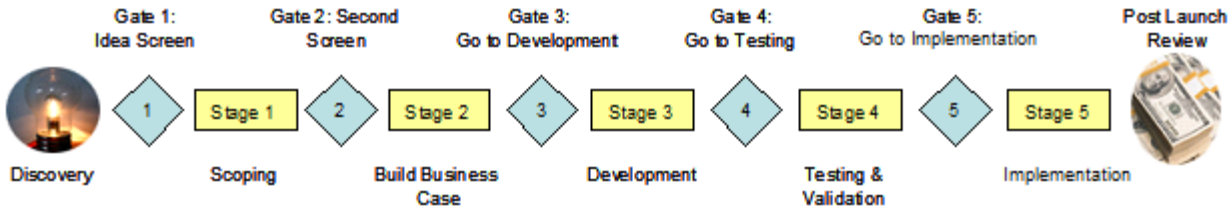


- Idea records can be submitted by anyone in company
- Submitted on standard form
- Recorded in Idea Record database
- Reviewed quarterly by team of R&D managers, product managers, marketing managers, and legal
- Idea categorized as:
  - File patent
  - Trade secret
  - Review again
  - Publish
  - Shelve

Stage-Gate Project Management

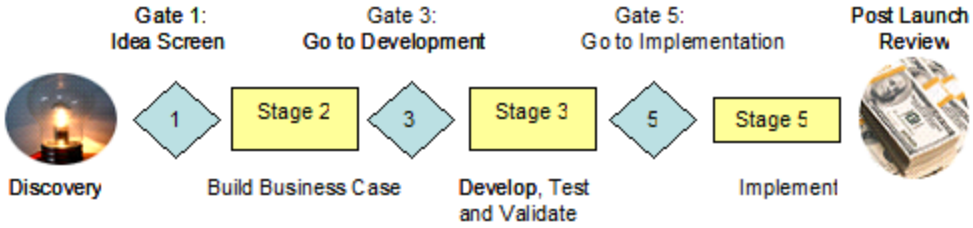
- Advantages
  - Manages project portfolio
  - Evaluates project for opportunity, feasibility, risks, rewards and alignment with strategy
  - Provides communication tool within and outside R&D
  - Facilitates speed to market
  - Facilitates handoffs between R&D and other groups
- Types of Projects
  - New Business Development (5-Stage)
    - New-to-us market, product, material, process, raw material or service
    - Change to an existing process, product, raw material or service that requires significant capital or resource, or involves significant financial, legal, operational or health or safety risk
  - Supply Chain (3-Stage)
    - Low risk changes such as extension to existing products made within a Best Practice, made-to-order products, changes to equipment, processes or products made within a Best Practice, or continuous improvement activities

New Business Development Projects (5-Stage)



- Before each stage is a gate, which requires a review meeting to decide whether to go, hold, recycle or kill the project.
- The gates are where poor projects are weeded out, and where resources are allocated to the best projects
- Gatekeepers vary by project type and gate, but by Gate 3 involve the President of the line of business
- Project leaders are assisted by a Project Management Tool
  - Discovery can involve idea record
  - Stage 1 is a short (<1 month) paperwork project
  - Stage 2 starts to commit technical resources and requires a formal business case
  - Stage 3 is a serious R&D commitment, both in people and spend, often involves pilot plant trials
  - Stage 4 is a validation step; often, the project leadership changes to a business focused group (e. g. Product Management), often involves plant trials
  - Stage 5 is product launch
  - Post launch review occurs 6-12 months after launch and is led by the President of the line of business

Supply Chain Projects (3-Stage)



- Like 5-stage projects, the Supply Chain Projects go through gate reviews with gatekeepers
- No scoping is necessary; solution should be evident
- Develop, Test, and Validation is all one stage
- Project Leaders are not necessarily R&D
- Project Leaders are assisted by a Supply Chain Project Management Tool

Stage-Gate Project Database

- Repository for all active projects
  - Summary of relevant Stage-Gate information
  - Links to project plans

Stage Gate Projects Master Database edit

a database created by Tracey Bradshaw on 24 Jun 03

new entry | show search | (all 52 entries shown)

Use the "Group by" feature to view selected sets of information. You can further sort the selected group by clicking on a column name.

	Priority	Title of Project	Product Line	Project Type	3 or 5 stage?	Current Stage	Project Health	Last Gate Date	Last Gate Score	Last Gate Decision	Next StageGate review	Post Launch Review	Project leader
	Group by	Project Owner											
⊞	Kaschak 1												
⊞	Norley/Albers 10												
⊞	Norley/Chang 16												
⊟	Norley/Mayer 1												
	H	Example Project 1	ES AGM	Material	5 Stage	Stage 1	On Track	1 Apr 2014	70	Go	1 May 2014		Mayer
⊞	Norley/Segger 12												
⊞	Norley/Wayne 4												
⊞	Reynolds 7												
⊞	Karleskind 1												

External Interaction/Open Innovation

Capture maximum value from external partnerships:

- ✓ Build a network of synergistic collaborators
- ✓ Obtain external funding for GrafTech
- ✓ Meet growth objectives through leverage of external organizations' spend
- ✓ Gain access and insight to trends in relevant industries & organizations
- ✓ Create new intellectual assets using external $
- ✓ Leverage prior success to bring the next opportunity
- ✓ Build a positive reputation as a partner of choice
- ✓ Utilize new tools to do "Technology Scouting"
- ✓ Support M&A activity

Our External Interaction system within GrafTech determines which external information to bring inside, and which information to share outside.

External Interactions – R&D

Capturing Maximum Value from External Partnerships

Green dollars to GTI:

For R&D Programs:

- $17,570,789 Awarded since 2002
- External resource leverage is at least 2 to 3x

Focus	Examples of Partners
Carbon Fibers	Oak Ridge National Laboratory; Plasan Carbon Composites; Lignol; Mascoma; UDRI University of Dayton Research Institute; National Composites Center; Zoltek; 3M
Energy Storage	U.S. Department of Energy; OFCC Ohio Fuel Cell; NorTech; nexergy; Ashlawn Energy; TU/e; fumatech Funktionelle Membranen und Anlagentechnologie
Solar	AIT Austrian Institute of Technology; SENER; Fraunhofer; Elkem; NASA; The Ohio State University
Fuel Cells	Huntsman Enriching lives through innovation; Ohio Department of Development; cellimpact Morphic Group; UltraCell High Power Micro Fuel Cells; EnerFuel; Ion Power, Inc; Case Case Western Reserve University; Ballard; Daimler
Nuclear	INL Idaho National Laboratory; Westinghouse; General Atomic; EWI Joining Innovation; NGNP Industry Alliance Limited; AREVA

How We Measure External Interac**tions**

Within R&D:

- Our EI Rating System allows us to define, measure, control and improve external interactions.

- Projects are rated quarterly on a scorecard which includes:
  - ✓ Level of external funding received
  - ✓ Recognition (e.g., R&D 100 award)
  - ✓ Scope and depth of network of collaborators (e.g.: industry, government, academia)
  - ✓ Alignment with Business and Corporate strategy
  - ✓ Innovation

This system has become ‘how we work’ today!

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