Personal Experiences & Lessons Learned in 30+ Years of Industrial R&D

OSU Lowrie Lecture April 3, 2014

What is your Greatest Fear?

1. Speaking to a group 41%

- 2. Heights 32%
- 3. Insects and bugs 24%
- 4. Financial problems 23%
- 5. Deep water 22%
- 6. Sickness 20%
- 7. Death 19%
- 8. Flying 18%





Leadership Speaking Tips

Presentation Skill is Vital

"All the great speakers were bad speakers first."

- Ralph Waldo Emerson





Introductions



Leadership Speaking Tips-

First 60 Second Crucial



Body Language Maters

(perception and your mind set)







http://www.ted.com/talks/amy_cuddy_your_body_langu age_shapes_who_you_are



Leadership Speaking Tips

- Know your audience
- Never agree to give someone else's presentation
- Develop your Key Point
- Come prepared
- Always dress for success
- End before your allotted time





Leadership Speaking Tips

- First draft presentations are too long.
 Second and third drafts are also too long
- Never say you're the last speaker
- Never admit you're nervous or inexperienced at speaking
- Never make references to physical or human characteristics



Your Call to Action

- Two, of many good resources
- Practice, Practice, Practice.

"Every time you get up to speak you are auditioning for leadership."

> — James Humes Author, Speaker, Attorney



Stealth Material Development



Problem

- Exhaust engine nozzle increases radar cross section.
- Normal Radar Absorbing Materials deteriorate in exhaust ambient

Approach



Results/Key Learning

- Don't let prior failures deter you
- Solving hard problems is what distinguishes us

Safe is mediocre at best



Disruptive Technology: CVD Diamond - Bulk





Space Plane Leading Edge



CVD Diamond

Gas outlet



Problem

 Low-pressure route to diamond threatens current products and offers new opportunities

Approach

 Apply standard engineering efforts to explore and optimize

Results/Key Learning

- Great new product BUT not cost effective = business miss
- Follow Scientific Process

Know when to STOP



Disruptive Technology CVD Diamond - Films

CVD Diamond Tools & 3D Shapes/Coatings



Issues

- Cost
- Adhesion
- Quality
- Investment Cost

CVD Diamond



- Kinetic experiments confirm importance of atomic hydrogen
- Cost modeling dominated by energy costs, and investment costs
- Adhesion difficult

Kill Project When You Run out of Hypothesis to Test

Single Crystal Growth



Thermal Conductivity vs. Isotopic Composition



Lattice Constant vs. Isotopic Composition



Lattice Constant for Diamond as a Function of Isotopic Composition

Properties vs. Isotopic Composition



Problem

 Quantify effect of isotopic impurity on limiting intrinsic material properties

Approach

 Grow high quality crystals with varying isotopic properties and measure properties

Results/Key Learning

 World record for highest thermal conductivity, and bond energy density

World-Class Science Doesn't Necessarily Lead to Business Success!





Saw Diamond Product



Diamond Crystals

Application

Photos taken from Diamond Innovations Brochure http://www.abrasivesnet.com/en/product/mbs/uncoated/down/DI%20MBS%20Uncoated.pdf

Diamond Synthesis

Diamond Synthesis Conditions

 $C_g \longrightarrow C_d$ $r_{diamond} = 3.5 \text{ g/cm}^3$ $r_{graphite} = 2.2 \text{ g/cm}^3$



Problem

• Decrease cost, and improve quality of diamond grit products

Approach

• New cell design

Results

>50% reduction in variable cost

Pressure >750,000 psi, temp >1300°C (yield strength of tungsten carbide ~ 500,000 PSI, M.P. Stainless Steel = 1370°C)



Manufacturing Process

High Pressure Apparatus

"Bell" apparents.

How to define P, T, t trajectory for new reaction cell?



Figure 6. The "Belt" high-pressure, high-temperature apparatus, "aspladed" view.



P,T Profile Development







Yield Variable





Summarizing My Lessons Learned

- Take on hard problems. Playing it safe means that at best you will be mediocre. Wayne Gretzky said, "You miss 100% of the shots you don't take."
- Follow the scientific process. Just because something is important doesn't mean you should work on it. You have to have a hypothesis. "Optimism is admirable - but hope is not a strategy."
- Failure comes with taking risk. Make mistakes as fast as you can but never make the same mistake twice. (*Note this does not apply to safety*).
- Understand what people will pay for. Great science is not sufficient for commercial success.
- Take initiative & be accountable. Don't wait to be told what to do.
- **Document your work.** You must institutionalize the knowledge you create.

Some Thoughts on Your Career

- Never run <u>from</u> something; always run <u>to</u> something.
- Never take a job to get another job.
- Treat every job as if it is your last and as if your performance in that role will be your legacy.
- Have fun and do not take yourself or your position too seriously.
- Leadership is determining what you DO NOT have to do.
- End every meeting asking what you can do to help.
- <u>Remember: How</u> you communicate is just as important as <u>what</u> you communicate.



Thank You

Possible versus Practical

The key to industrial research

"Engineers need to be the vanguard, providing practical solutions that will address future problems. We should not be wasting our resources on solutions that, while possible, will never be practical."



William F. Banholzer and Mark E. Jones; Perspective: Chemical engineers must focus on practical solutions, AIChE Journal, Volume 59, Issue 8, August 2013, pages 2708–2720. William Banholzer

Important Points to Consider as Scientists:

Sound engineering principles are forgotten in the hype around the energyclimate-water-food problem

- Engineers must be more involved in channeling efforts toward practical solutions
- Thermodynamics is a lost art
- Society doesn't understand energy
- Energy transitions take time There are no silver bullets
- We've consistently wasted effort on over-hyped alternative energy technologies
 - we've forgotten thermo and engineering principles
 - scale <u>does</u> matter
- Sunlight has got to be part of the solution, but photons are troublesome reagents
- Thinking holistically means atmospheric CO₂ will never be a practical feedstock