The Science Behind Xplorlabs: Extraction to E-waste

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Outline of Presentation

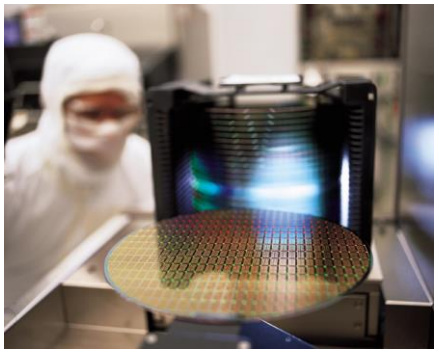
- Introduction and Background
- The Grand Challenge
- Design Cycle and Design for Environment (DfE)
- Supply Chain Complexity
- Q&A

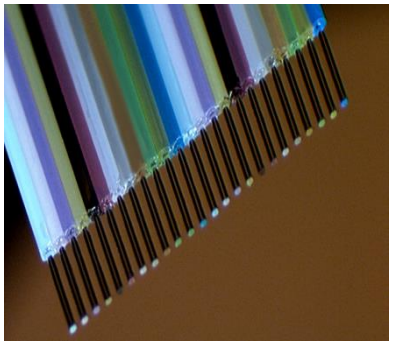
Currently

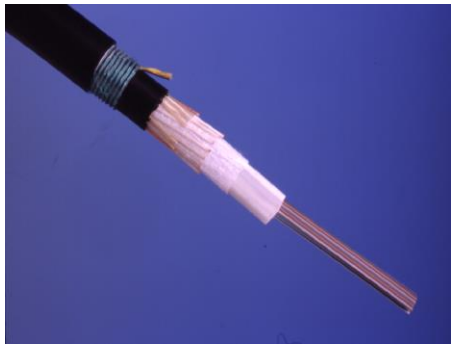
- UL Vice President of Research
- Strategic Advisor UL Not for Profit Safety Research
- 40-year Career PhD in Chemistry and Materials Science:
  - Upjohn Company: 1977-1980 (industrial chemicals)
  - AT&T Bell Laboratories: 1980-2001 (product development)
  - UL: 2001-present (safety)

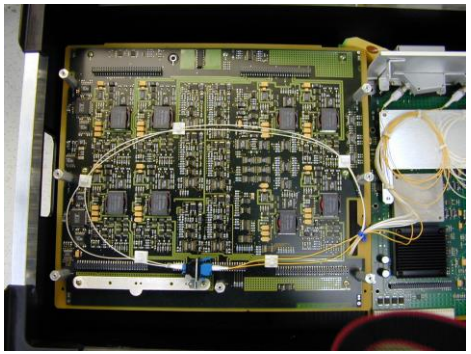
AT&T Bell Laboratories Experience

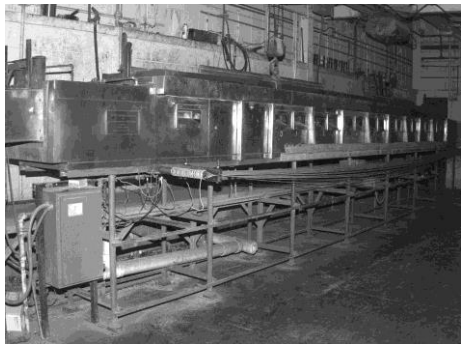
AT&T Bell Labs Research

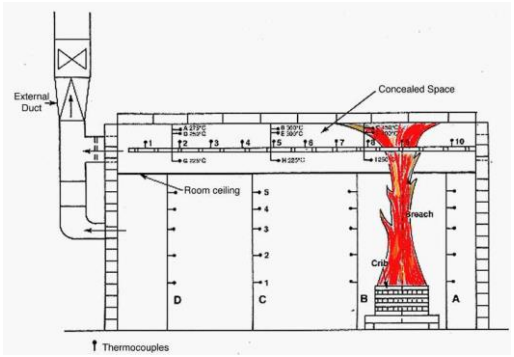












The Grand Challenge

How do we responsibly advance societal needs, promote product innovation, protect the planet and create a sustainable future?

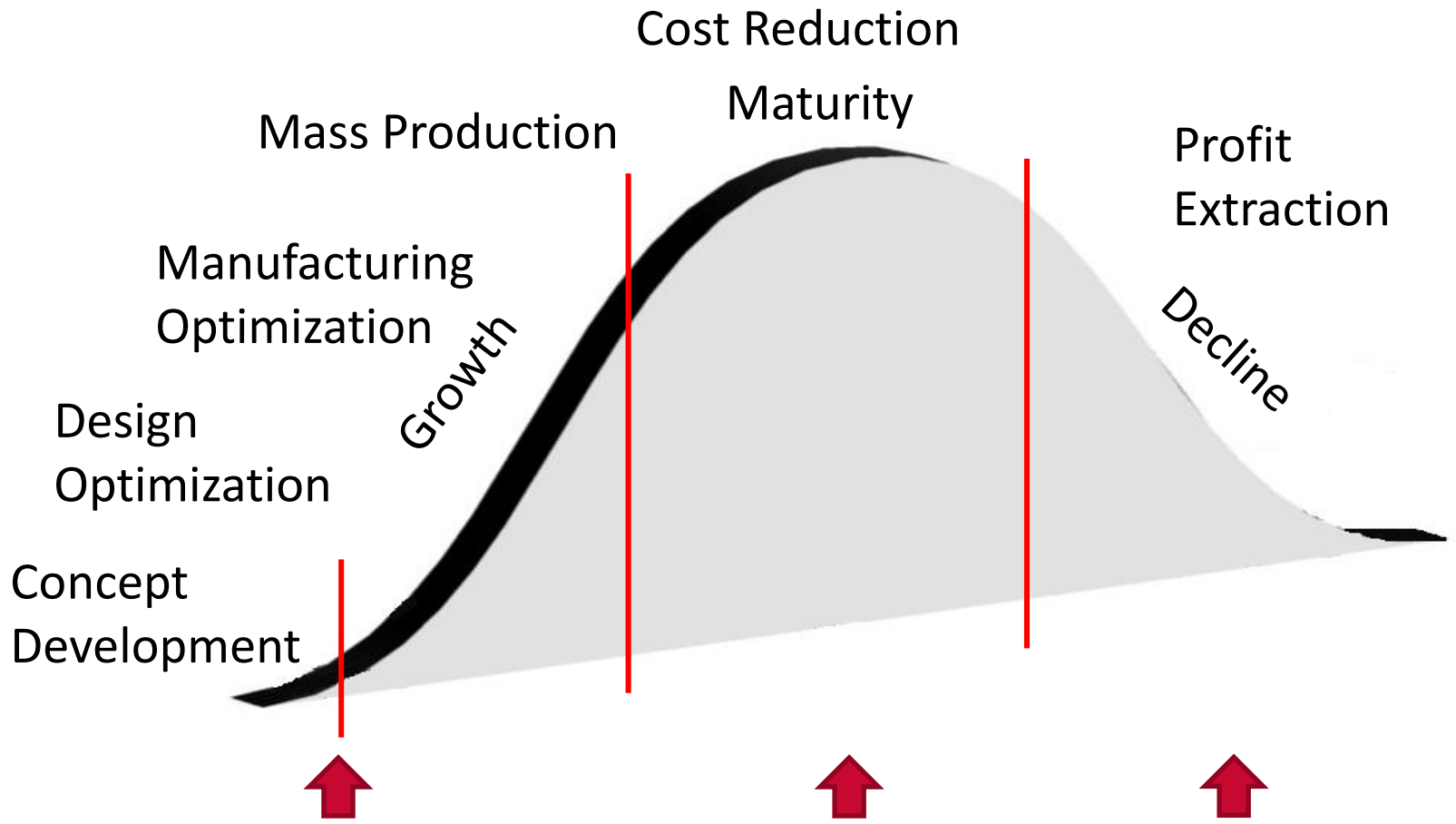
- Everyone has a role to play in this challenge
- It requires an understanding of technology, global trade and commerce and the product design cycle
- Nothing will change until we take action!

Every year, according to the United Nations, the world belches out 20 million to 50 million metric tons of waste from electronic and electrical equipment *— more than the weight of every single commercial airplane ever built combined. Of that, only 20% is properly recycled. Only 10% of the cellphones ever bought in the US are recycled. The other 130 million … are simply tossed in the trash.*[1]

[1] ***According to Declutr***

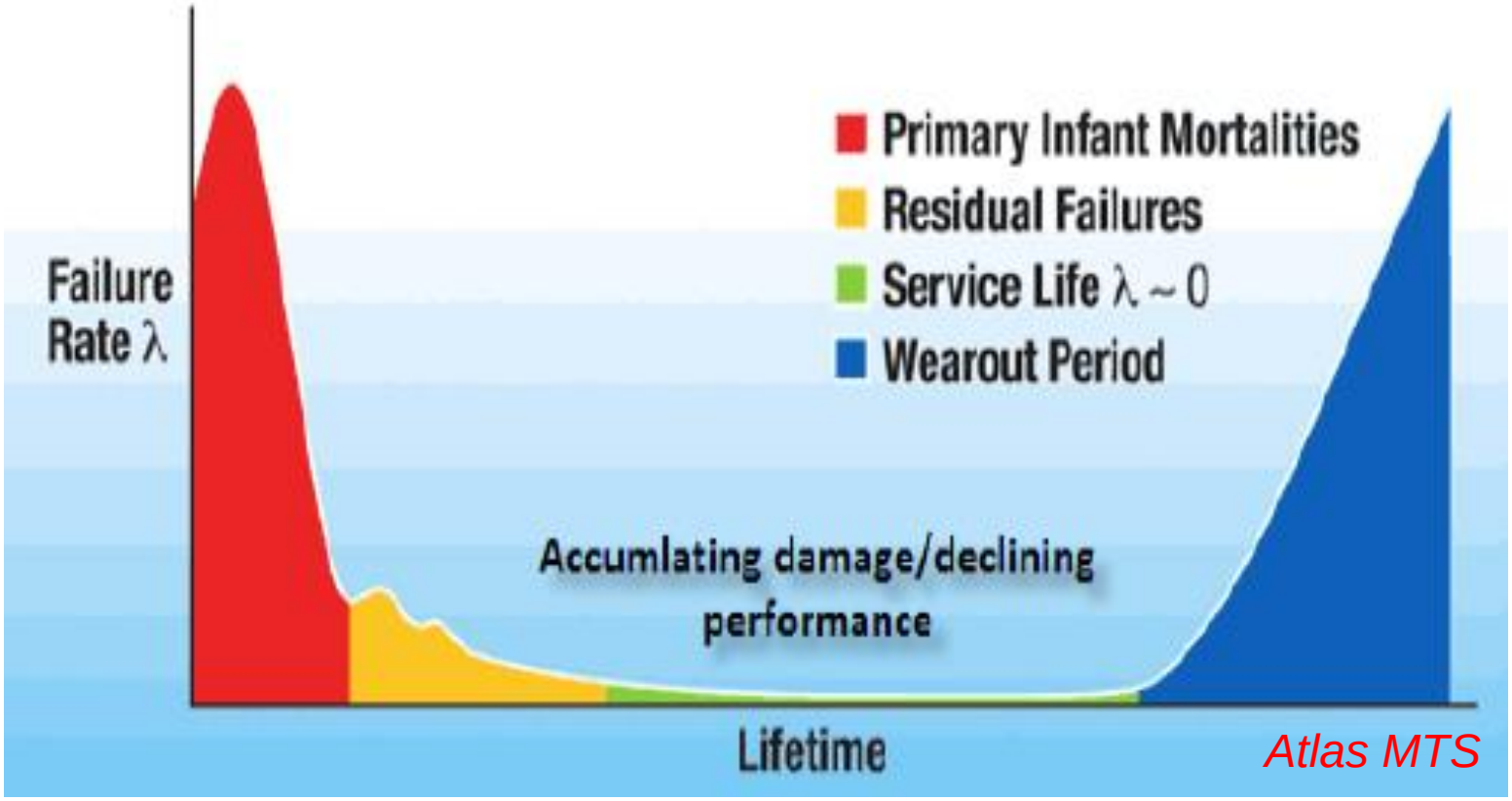
Product Development & Design Cycle

Linear Product Design & Life Cycle

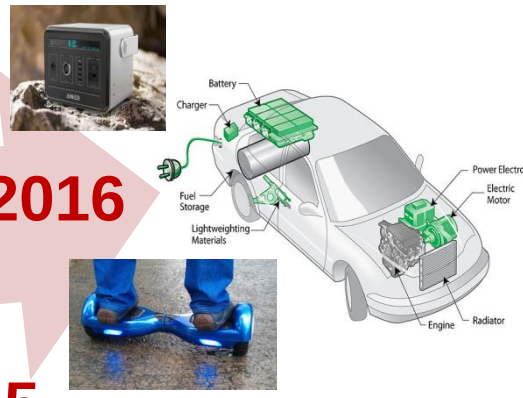


How Long Does a Product Last?

UL and IEC tests design and manufacturing processes and determine the potential for "infant mortality", but *currently* are not predictors of end-of-life



Evolution of Battery Technologies



Batteries in end products require independent, third party certification

- Formats: button, cylindrical, prismatic, pouch
- Laptops (Required)
- Cell Phone Batteries
- Appliances, Power Tools and Consumer Products
- Light EV Batteries and Systems
- Commercial / Industrial Transportation / EVs
- Stationary Batteries / Energy Storage

Lithium Ion Technology

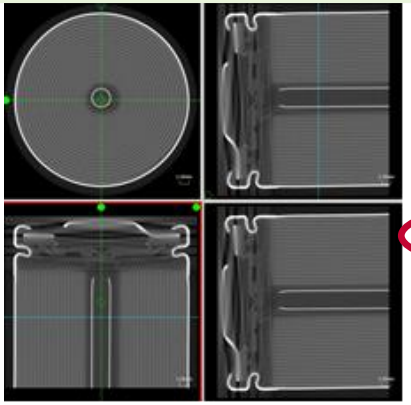
Electrochemical cell

Device which generates electrical energy from chemical energy via redox reactions

Battery

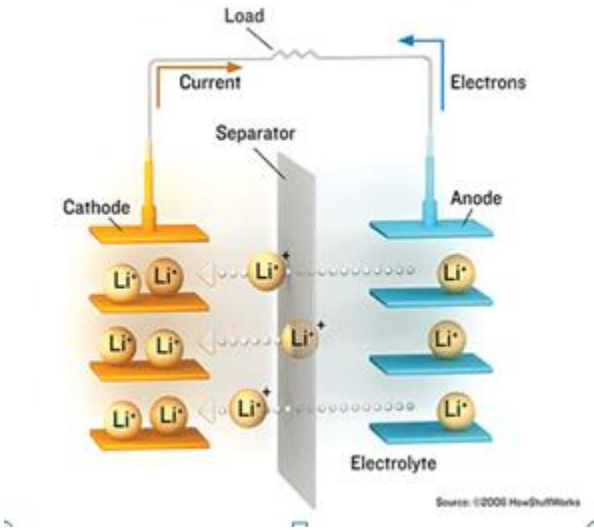
One or more electrochemical cells

- *-Primary or non-rechargeable (Lithium cell)*
- *-Secondary or rechargeable (Lithium-ion cell)*



Cell Components

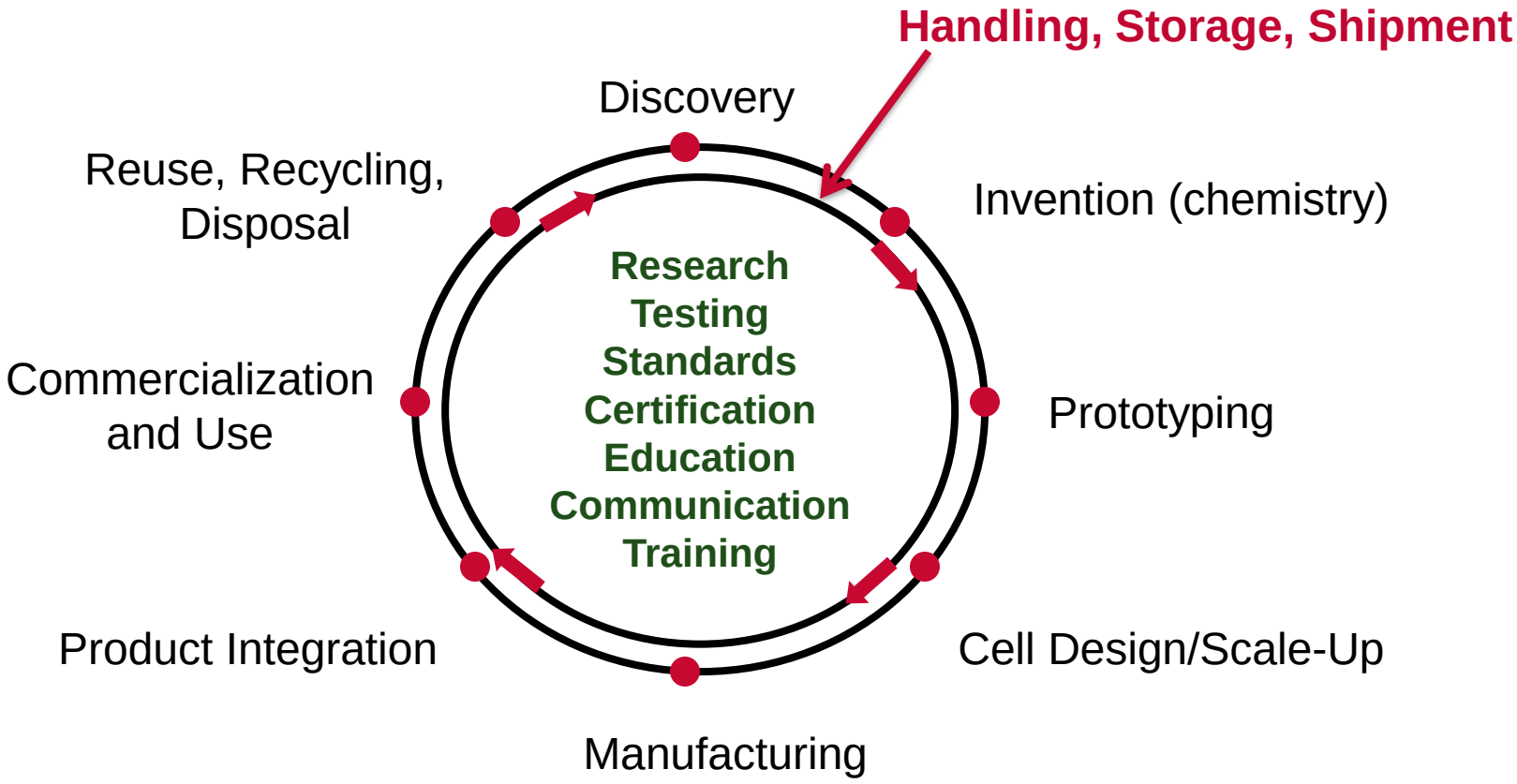
- *Electrodes (Cathode, Anode)*
- *Separator*
- *Electrolyte*
- *Housing*
- *Passive safety mechanisms*



Li-Ion Chemistries and Complexity

Chemical name	Material	Abbreviation	Notes
Lithium Cobalt Oxide	$LiCoO_2$ (60% Co)	LCO	High capacity; for cell phones laptops, cameras
Lithium Manganese Oxide, Spinel	$LiMn_2O_4$	LMO	Lower capacity than LCO, high specific power and long life; power tools, medical devices
Lithium Iron Phosphate	$LiFePO_4$	LFP	e-bikes, automotive, medical, hobbyist.
Lithium Nickel Manganese Cobalt Oxide	$LiNiMnCoO_2$ (10–20% Co)	NMC	Automotive, power tools, medical devices
Lithium Nickel Cobalt Aluminum Oxide	$LiNiCoAlO_2$ (9% Co)	NCA	Automotive, powertrain and grid storage, niche applications
Lithium Titanate	$Li_4Ti_5O_{12}$	LTO	Niche applications

Incidents in the Battery Lifecycle



The world has experienced battery fires at each step of the lifecycle. The estimate for the journey of Li from mineral to installed product is 25,000 miles

The Big Picture…..

Materials Research - Creating a Reliable Infrastructure

Materials	Components	Products	Systems	Structures
• Chemicals	• Connectors	• PV Modules	• Small Devices	• Residential
• Thermoplastics	• Enclosures	• Batteries	• Large Devices	• Commercial
• Thermosets	• Wiring	• Fuel Cells	• Energy	• Retail
• Minerals	• Raceways	• Flow Batteries	• Data/phone	• High Rise
• Metals, alloys	• Switches	• Transformers	• Security	• Industrial
	• PWB/PCB	• Controllers	• HVAC	
	• Power supplies	• AFCI/GFCI	• Cargo	
	• Capacitors	• Wire & Cable		

Small-scale tests
Materials characterization
Performance
Aging/Reliability

Intermediate-scale
Safety
Performance
Aging/Service life
Modeling

Real-scale simulations
Field Tests (performance)
Reliability studies
First responder safety
Electrical safety
Code compliance
Environmental compliance

Summary and Conclusions

1. eWaste is a massive challenge to society and requires innovation and collaboration to address and mitigate
2. It requires knowledge and understanding of the technology and the design cycle to develop impactful solutions
3. The circular economy can create massive new opportunities for education, awareness and commercial growth while protecting the planet
4. eWaste has distinctly different challenges than traditional recycling programs and requires customized focus
5. Everyone has a role and interest in the outcome of this effort!

THANK YOU