

Toxic Substance Replacement in Industry: Drivers, Challenges and Opportunities

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The Fire Retardant Dilemma: Part III

Michael Kirschner

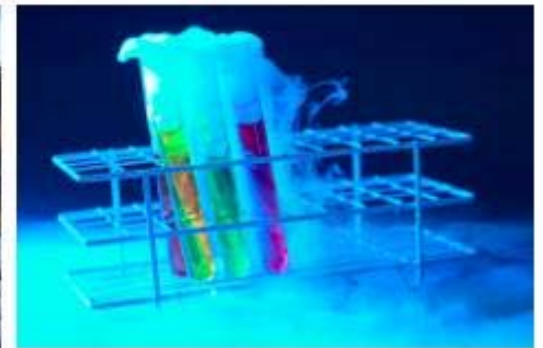
President, Managing Partner

Design Chain Associates, LLC

www.DesignChainAssociates.com

+1.866.DCA.7676

mike@DesignChainAssociates.com



Agenda

- DCA Intro
- Toxic Substance Replacement Drivers
- Case Study
- Product Design Today
- Challenges
- Opportunities
- Observations

DCA Intro

- DCA helps manufacturing clients understand, comply with, track, and develop profitable strategies around and beyond emerging environmental regulations like RoHS, WEEE, EuP, and REACH
- For more information visit our website:
www.DesignChainAssociates.com

What Makes Industry Change Substances?

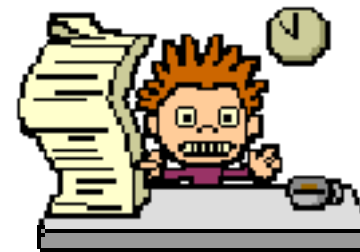
- Availability of Less Hazardous Substances or Methods that Achieve Similar Properties to Replace Known Hazardous Substances that Employees can be Exposed to
 - Beryllium Oxide
- Disasters
 - Hydrogen for dirigibles
- Regulations
 - Lead in solder, PBBs, PBDEs
- Peer/NGO Pressure
 - Dell, HP, Sony, etc...all have self-laudatory environmental websites
- Business Strategy/CEO Awareness
 - Cost Reduction (e.g., reduce regulatory cost burden)
 - Attract/Retain Employees
 - Opportunity to Expand Market-Share

Electronics: Incorporation of Flame Retardants

- Primarily to achieve safety performance
 - TV's bursting in to flames in the mid-'70s
- Bromine (and Antimony Trioxide, to a lesser degree) added to microelectronic device packaging and PC Boards
 - TBBPA
- Bromine in plastic enclosures (DecaBDE, TBBPA), wiring, and other high-temp/high-power circuitry
- Goal: Comply with UL94V-0 *without impacting other technical performance properties*

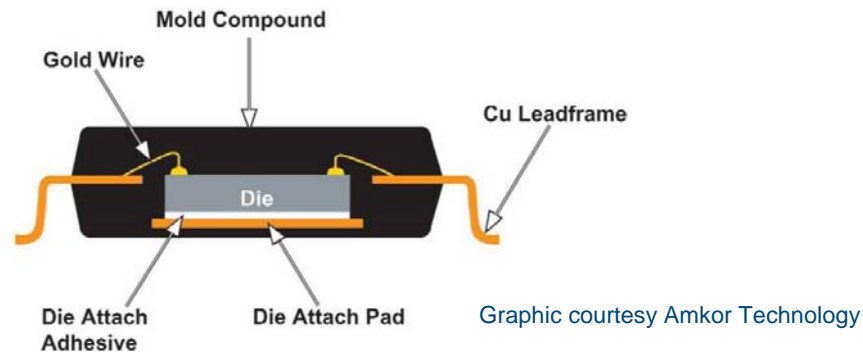
What's It Take To Add A Substance?

- Nothing is easy...



Case Study 1: TBBPA in IC Packaging

TSSOP Cross Section



- Bromine added to mold compound in '80s
- Reliability testing results: increased Au/Al intermetallic growth at high temp (175°C – 200°C)
 - Increased bond wire resistance → open circuit
 - Proportional to bromine concentration
- Solutions: increase Tg of mold compound; add antimony oxides

Sources: Blish, et. al., "Effect of Bromine Concentration in Molding compound on Gold Ball Bonds to Aluminum Bonding Pads", IEEE 1986 Electronics Conf; National Semiconductor "Package Reliability – August 1999"

Case Study 2: Red Phosphorus

- Sumitomo Bakelite replaces bromine with “red phosphorus” in mold compound
 - “Environmentally Friendly”: no Br or Sb
 - Similar flowability, curability and electrical properties
 - Better reliability in high temperature operating/storage life (no Br or Sb!)
- Early field failure rate increased
 - Fujitsu saw a 0.8% failure rate in 6-12 months
 - High temp/humidity environment → shorts in ICs



Sources: Deng & Pacht: FAILURES IN SEMICONDUCTOR DEVICE ENCAPSULATED WITH RED PHOSPHORUS FLAME RETARDANT - <http://www.glue.umd.edu/~yuliangd/publications/C2005-SMTA-RP.pdf>. Nakao, Fujitsu HDD (Hard Disk Drive) Defect <http://shippai.jst.go.jp/en/Detail?fn=2&id=CA1000624>

Case Study 2: Red Phosphorus

- Root Cause: Red phosphorus was “sealed” in $\text{Al}(\text{OH})_3$, but seals were poor/inconsistent
 - Created phosphoric acid in temp/humidity
 - Dissolved Cu and/or Ag, which flowed and caused internal pin-to-pin shorts
- Sumitomo stops making the product
 - After 1000 tons is produced
 - Lawsuits ensue...
- Root cause:
 - Poor process control
 - Inadequate reliability testing regimen and control thru multiple levels of supply chain



Rin Kagaku Kogyo Co., Ltd

Sumitomo Bakelite

Amkor

Cirrus Logic

Fujitsu

HP? Dell? IBM?

Moral of the Story

- In a holistic, functioning system, changing one seemingly minor material in a seemingly minor way can and will have unforeseen consequences

Or...

If Anything Can Go Wrong, It Will

Murphy's Law

“It Should Be Easy for the Electronics Industry to Change Materials!”

- So Says Greenpeace, based on superficial observation...
- Can RAPIDLY improve products/performance ONLY BECAUSE we understand the materials we use so well
- Changing a substance = a whole new learning curve

For Example...

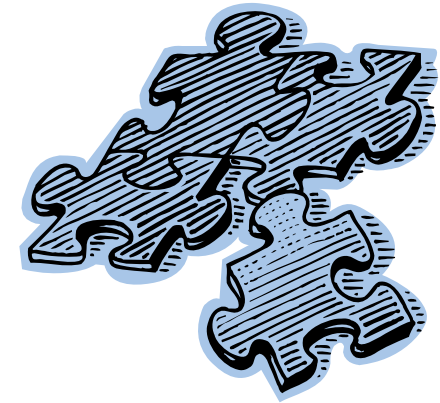
- | | |
|--|---|
| <ul style="list-style-type: none">• Lead in solder<ul style="list-style-type: none">• 60+ years of experience• Excellent reliability models• Well-understood performance | <ul style="list-style-type: none">• Pb-Free solder<ul style="list-style-type: none">• ~4-5 years of experience• No reliability models yet• Unknown performance• Mandated by EU (RoHS Directive – 2002/95/EC) |
|--|---|

- without impacting other technical performance properties
 - Not a holistic approach...

NO OBSERVATION!

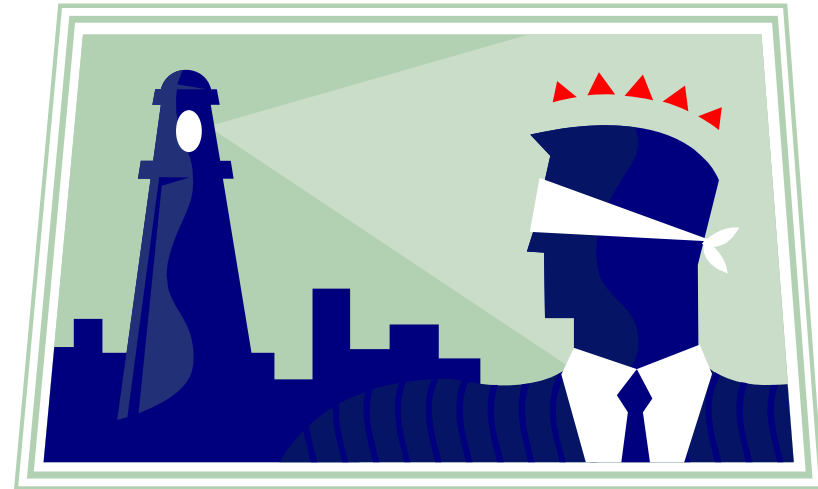
Product Design Today

- Technical Product Design fundamentally focuses on a few attribute classes for components
 - Form/Fit/Functional
 - Including quality/reliability attributes
 - Mechanical
 - Thermal
 - Electrical
 - (Optical)
- Over the past 2 decades we've incorporated business attributes for suppliers and components
 - Cost
 - Leadtime
 - Strategic Roadmap
 - Ramp capability
 - Etc.



The Industry Blind Spot

- Environmental Attributes
 - Impact of products on the environment
- Including
 - Toxicity Attributes
 - Energy Attributes
 - Waste Attributes



KEY POINT!

Ignored until now, these are **RIPE** for optimization and competition

Industry Challenges



- Much of the data needed is unavailable
- Little understanding of what lifecycle data is needed
 - And how to compare/weigh/trade-off, e.g. eutrophication, global warming, etc. properties of different plastics
 - Standards will be needed
 - So will toxicologists, chemists, etc.
- No process for inter-industry collaboration
 - This is a cross-industry challenge
- No coherent process to engage industry technologists in legislation development
- **FLASH!** ANSI & NAM Teaming up to create a Manufacturer's Network

Concluding Observations

- Environmental attributes have *typically* not been considered in the material selection process
- Suddenly they are critical/primary
- Changing materials piecemeal is extremely difficult
- The trajectory of product-focused environmental regulation is quite clear:
 - ALL chemicals that are toxic/ecotoxic OR where toxicity is unknown risk being restricted
 - Energy use through the entire lifecycle is of growing concern
 - Keeping products out of the waste stream as long as possible is becoming a requirement
- Industry needs to take a holistic, standards-based approach to achieve an effective and efficient result

Thank You For Your Attention

Michael Kirschner
President & Managing Partner
Design Chain Associates, LLC
5 3rd Street
San Francisco, CA 94103

Mike@DesignChainAssociates.com
866.DCA.7676 x2