Batteries with Improved Safety Through Thermally Stable Separators

Technology & Features

Microfiber/Nanofiber Technology Overview

Separator Thermal Comparisons

Flame Testing

Applications & Benefits

High Rate Capability: reduce inactive materials

Scale-up Case Study

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What is a lot of energy packed into a small container called?

A grenade?

Or a battery?

Both?

What does a battery fire cost?

787s grounded, batteries cited

Concerns over two recent incidents in Boeing 787 Dreamliners led the FAA to order all the jets grounded until the company can certify the plane's lithium ion batteries are safe.

Burned batteries
Recovered by investigators

Boeing 787s grounded
January 16 – May 20
4 months at $200 million/month

$800,000,000 mistake

are placed below the passenger deck on 787

◄ In-flight problem in 787, Japan, Jan. 15

All Nippon Airways 787 made emergency landing after cockpit monitor indicated battery trouble and a burning smell was detected

Burn marks were later found around main battery in an electrical vault below the cockpit

Source: National Transportation Safety Board, Boeing, McClatchy Washington Bureau

Graphic: Robert Dorrell
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Sony recalls 438,000 Vaio laptops

PC

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Sony Battery Recall Costs $429 Million

BY SUSAN ARENDT OCTOBER 26, 2006 01:53PM EST 0 COMMENTS

Sony's massive battery recall ended up costing the company a whopping $429 million and sent its bottom line screaming into the basement.

All other 2005 2006 2007

*Year ended March 31
*Percentage of sales and operating revenue to outside customers

REUTERS

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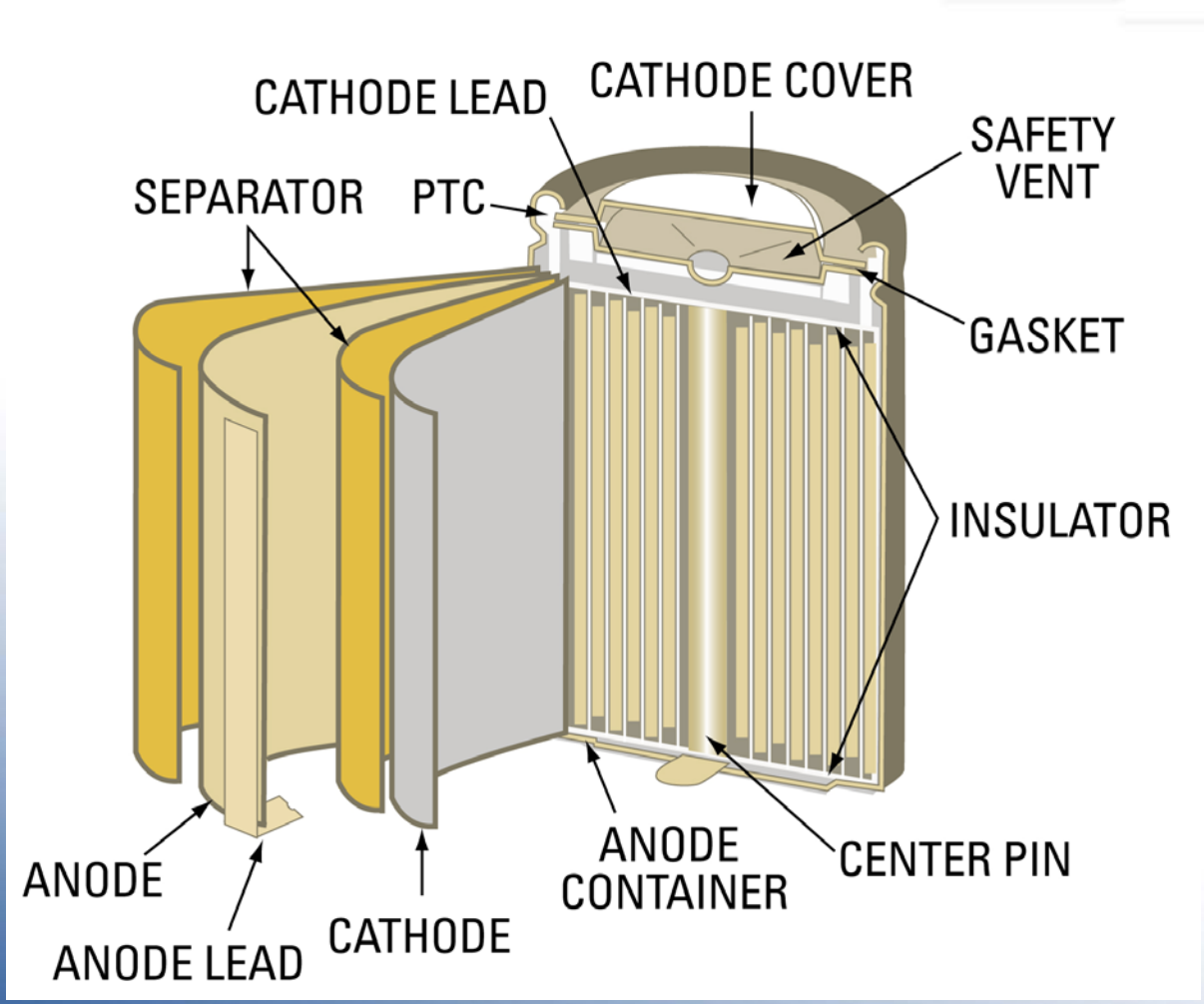
Parts of a Battery



- Electrodes
  - Store Energy
- Current Collector
  - transfer electrons
- Electrolyte
  - transfer ions
- Separator:
  - Keep electrodes isolated
  - Allow ions to pass through

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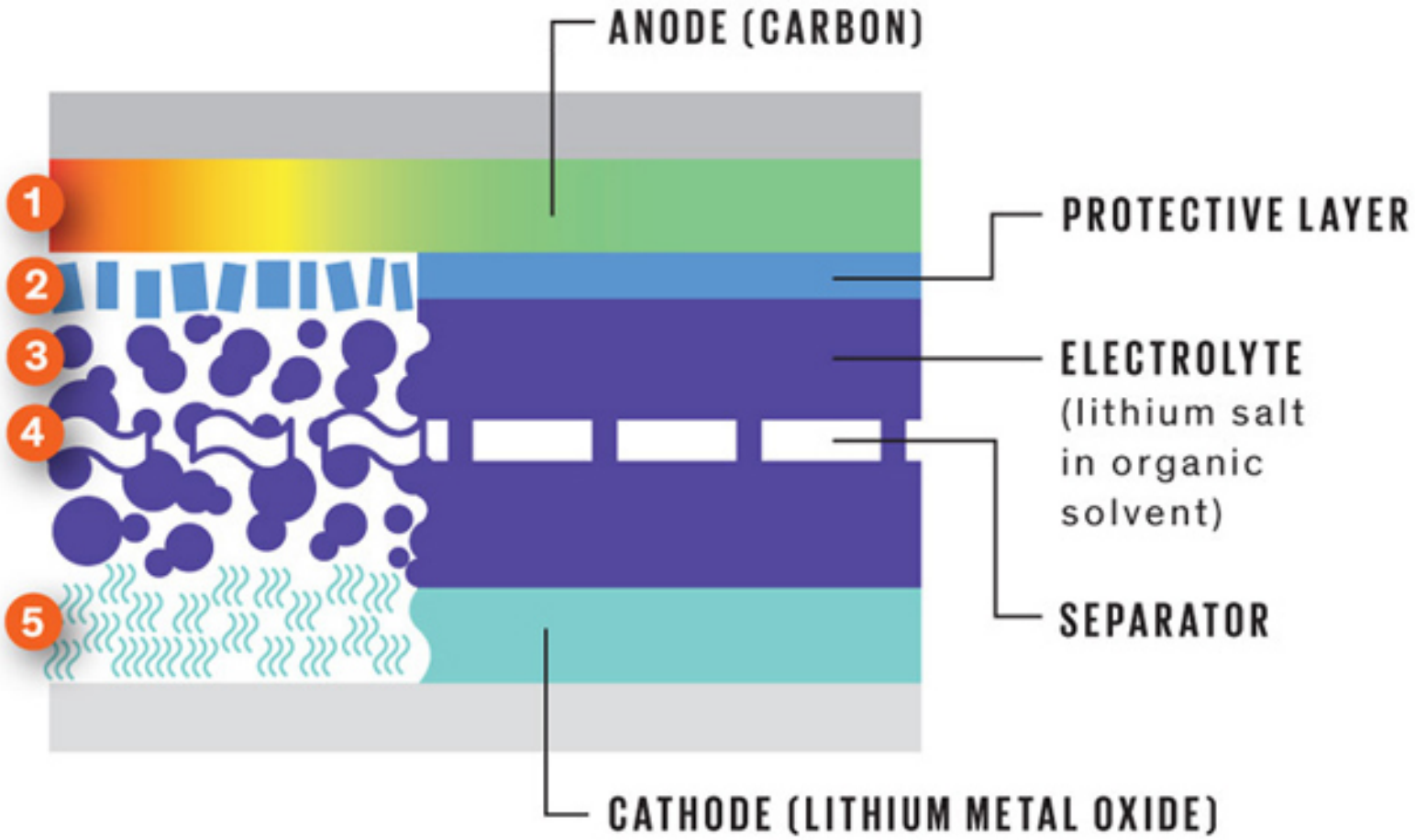
Thermal Runaway in a Lithium-Ion Battery

1. Heating starts.
2. Protective layer breaks down.
3. Electrolyte breaks down into flammable gases.
4. Separator melts, possibly causing a short circuit.
5. Cathode breaks down, generating oxygen.



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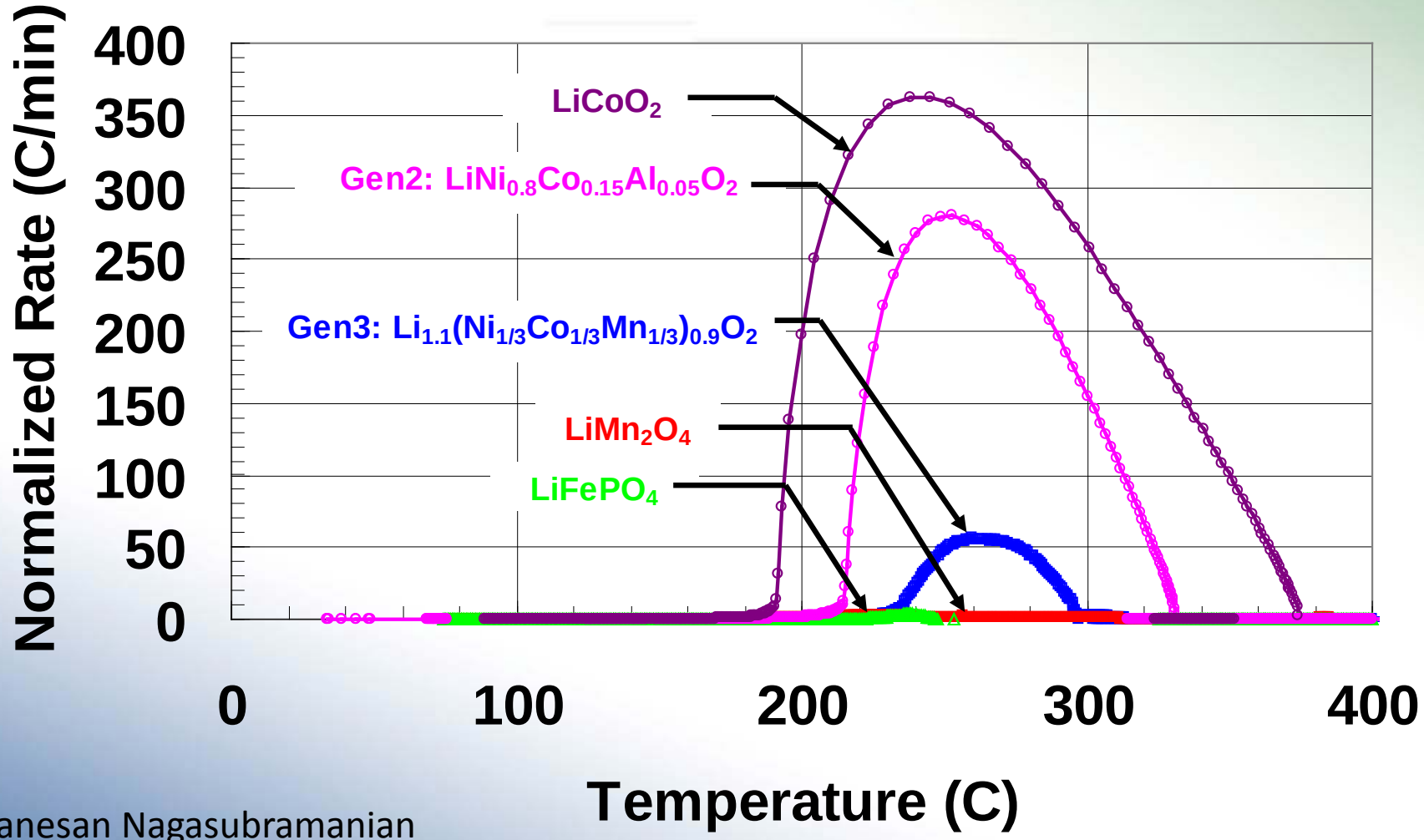
LIB Cathode Thermal Runaway: 180 – 240 C



Ganesan Nagasubramanian
Sandia National Laboratories.
SAND # 2009-7319P

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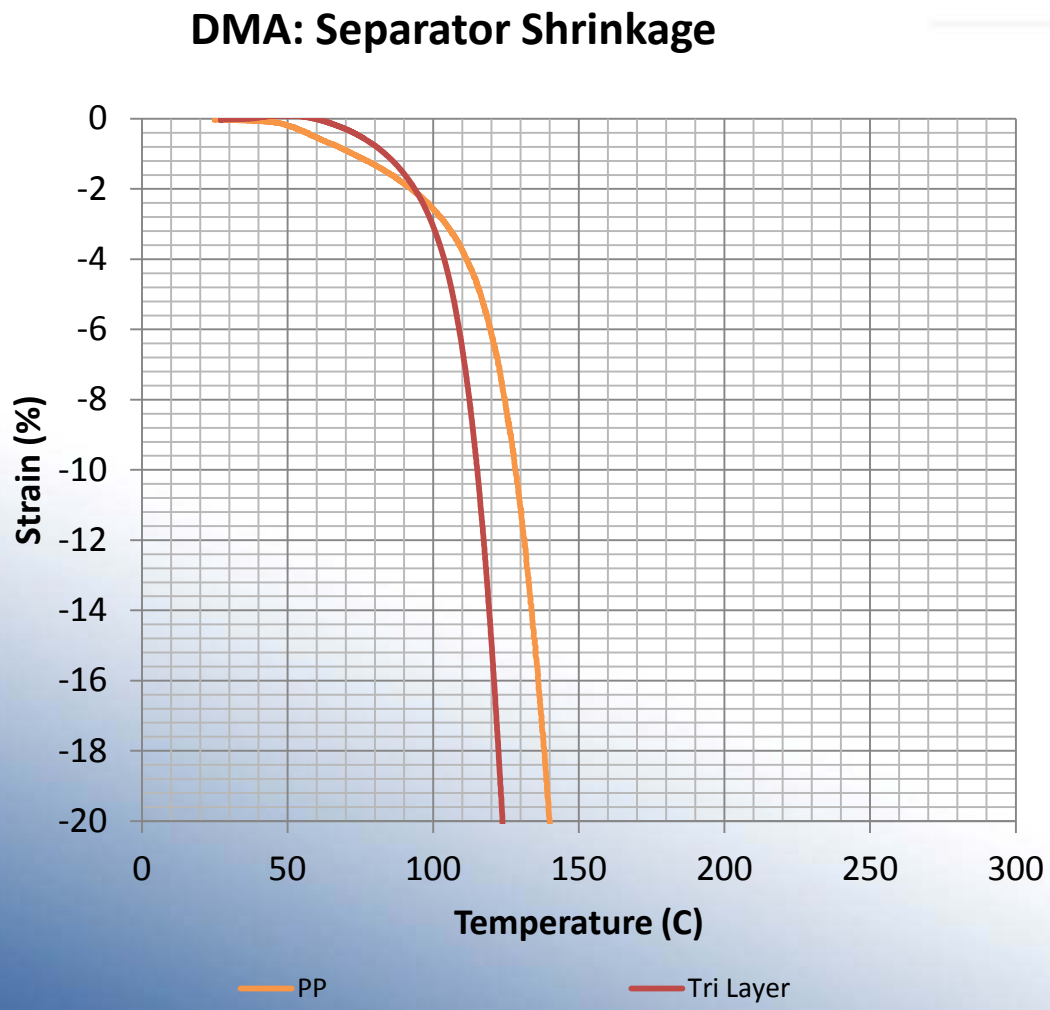
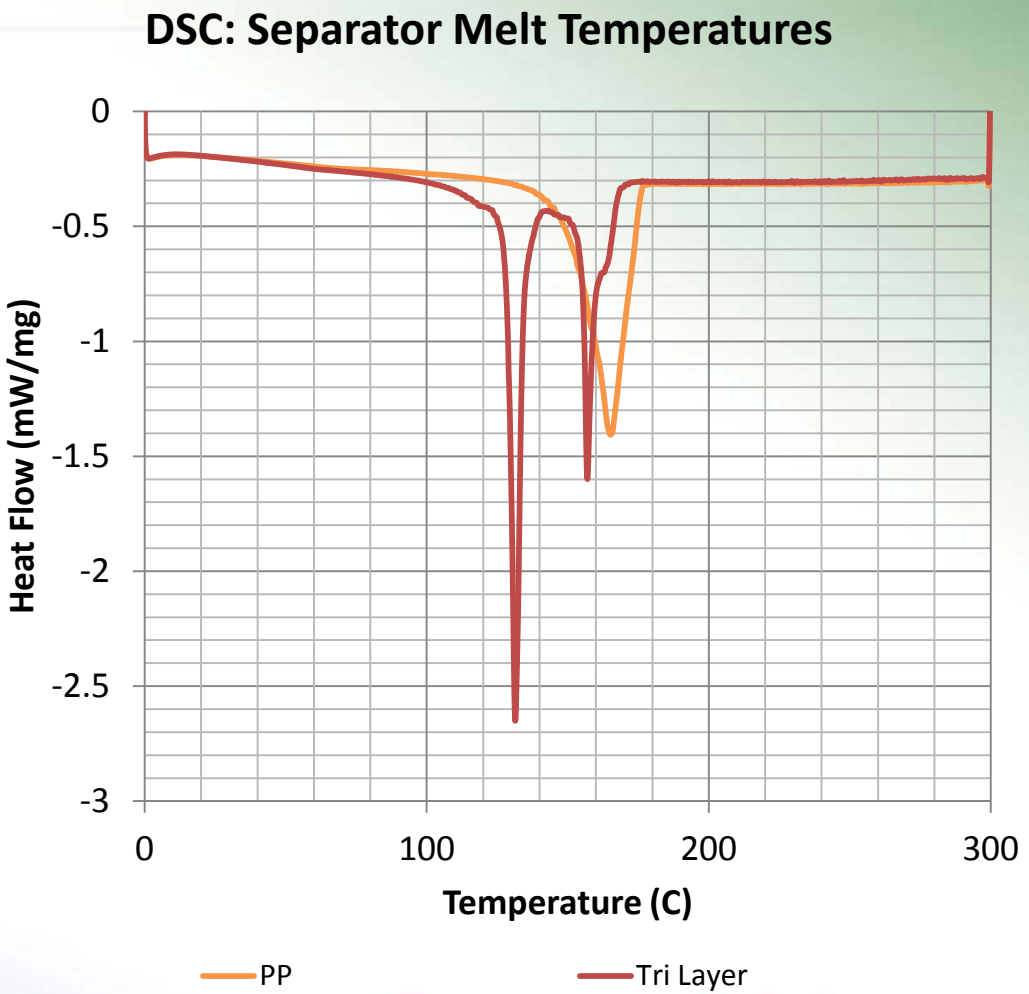
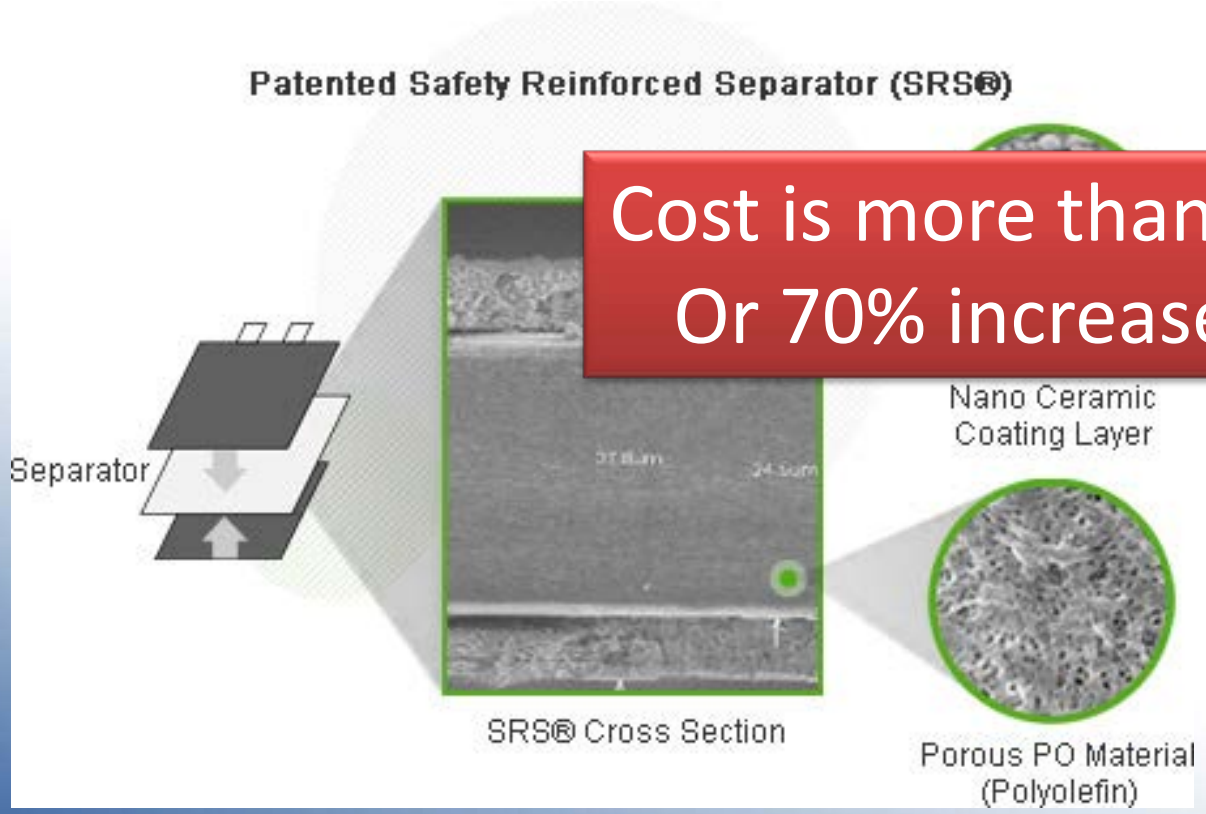
Separator Problem: Shrink at 120 and Melt at 140-160 C!



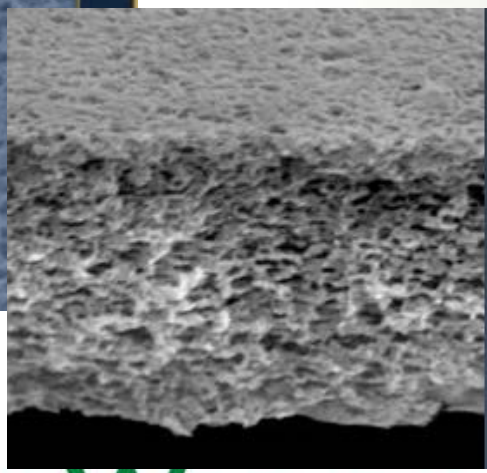


What are Separator Manufacturers Proposing?

Ceramic coating



Ceramic in the sidewalls



Cost is more than $1/m^2 of separator
Or 70% increase in separator cost

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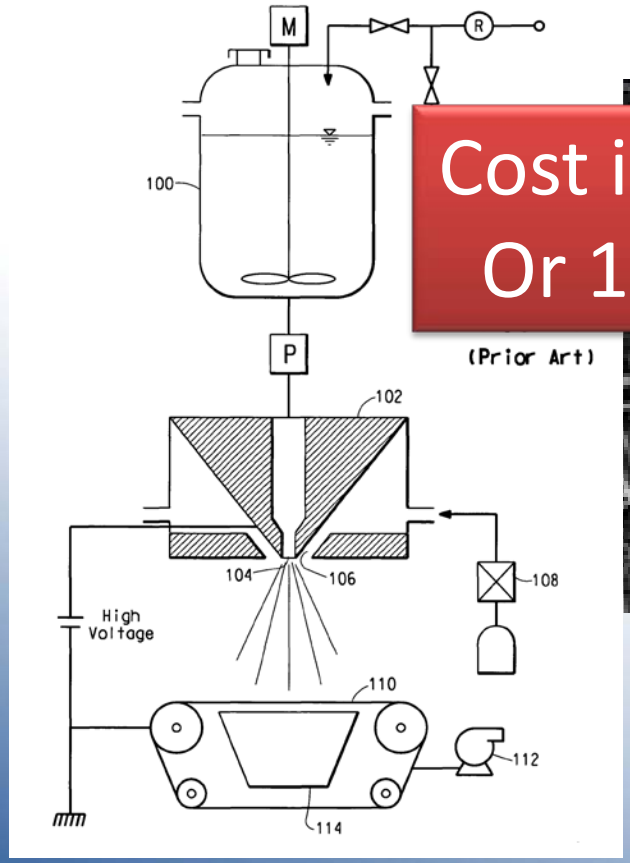
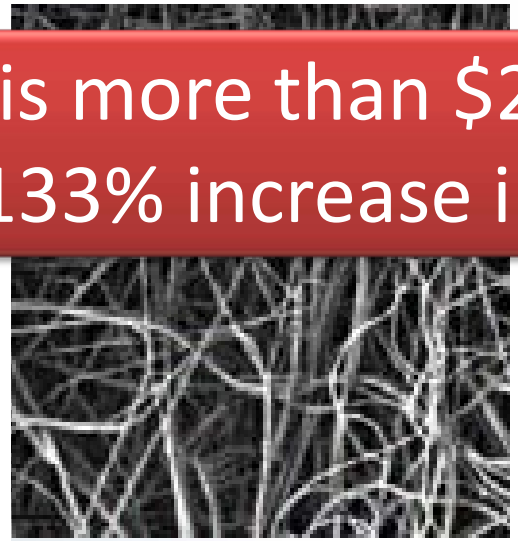
What Else?

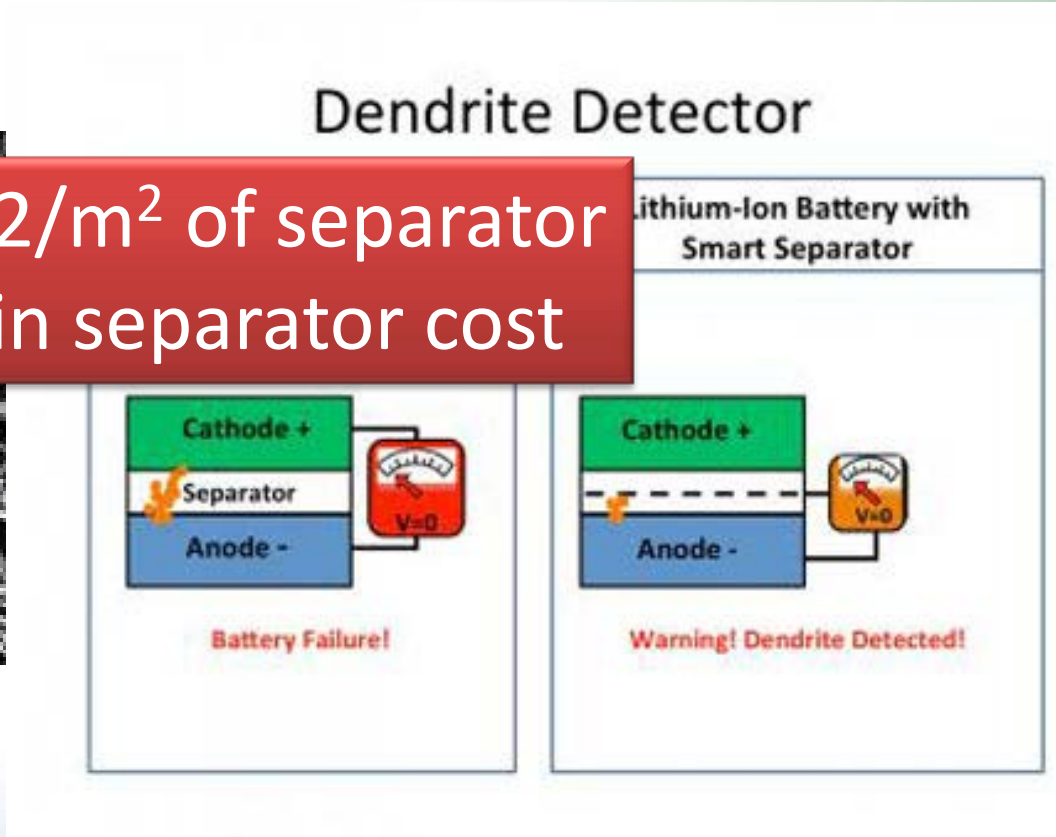
Polyimide Electroblown Nanofibers





Cost is more than $2/m^2 of separator
Or 133% increase in separator cost

Dendrite detectors



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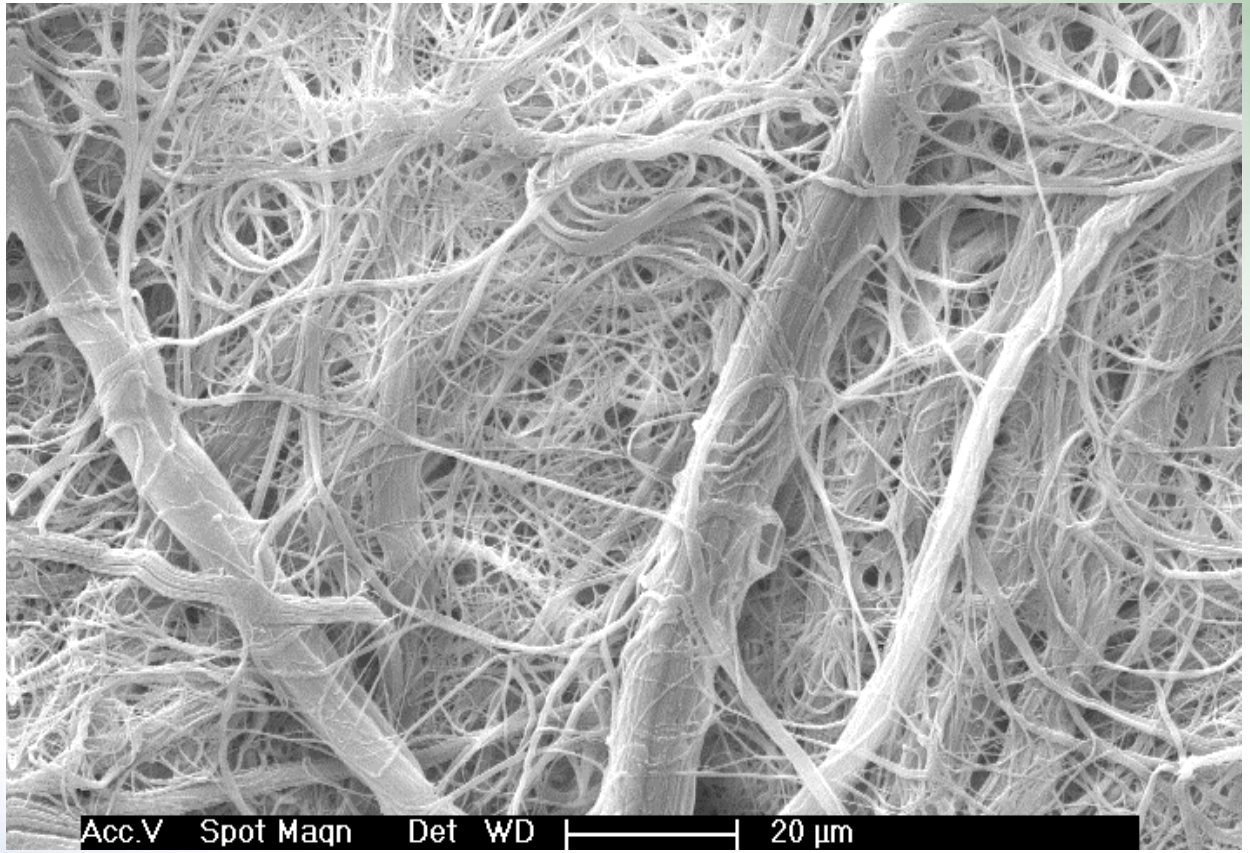
Dreamweaver Technology

- Nanofiber on microfiber
  - "spider-web-on-Tinkertoy"
- Nanofibers form good barrier
- Microfibers give open structure
  - good window
- Microfibers also add strength



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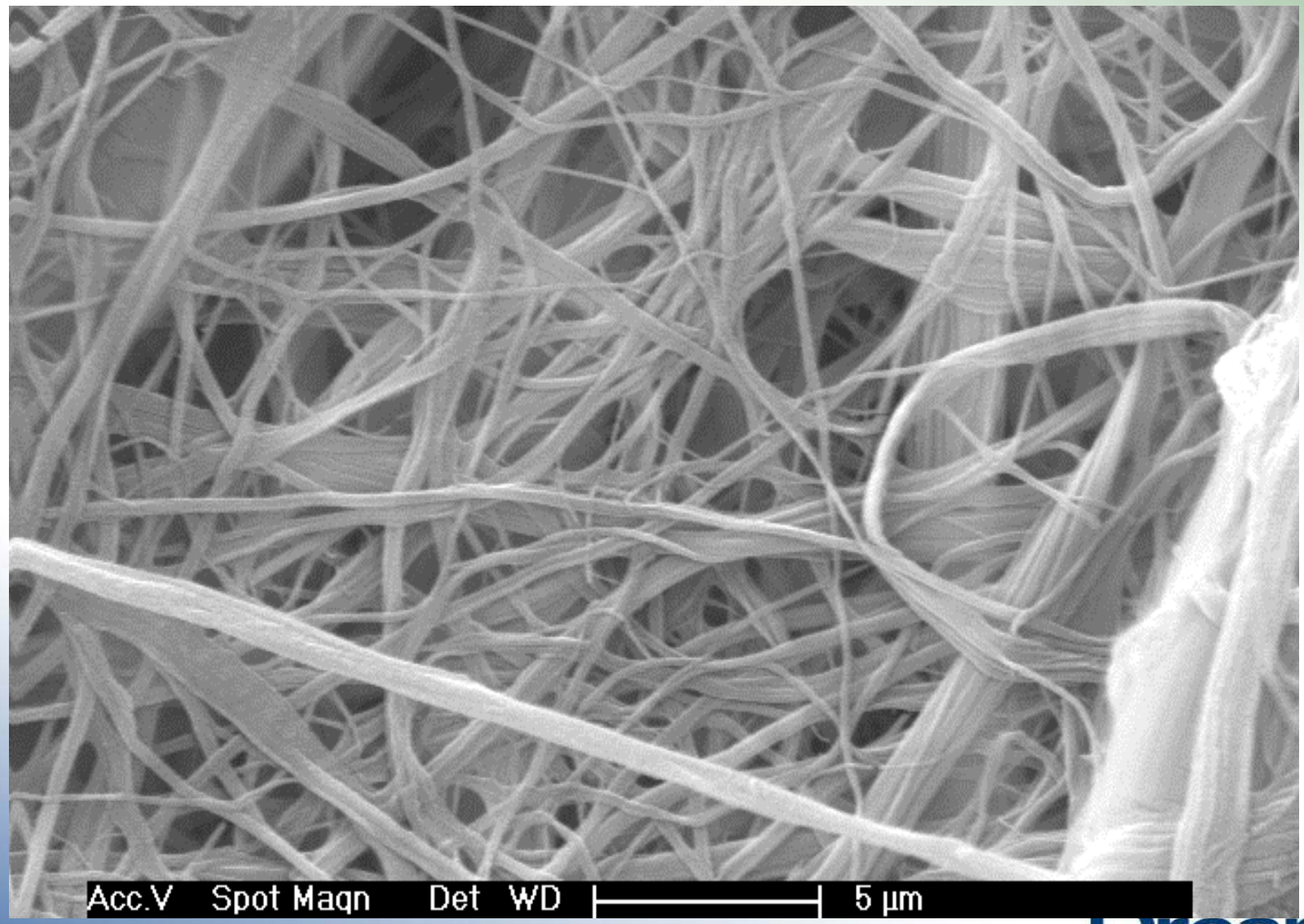
Nanofiber Structure



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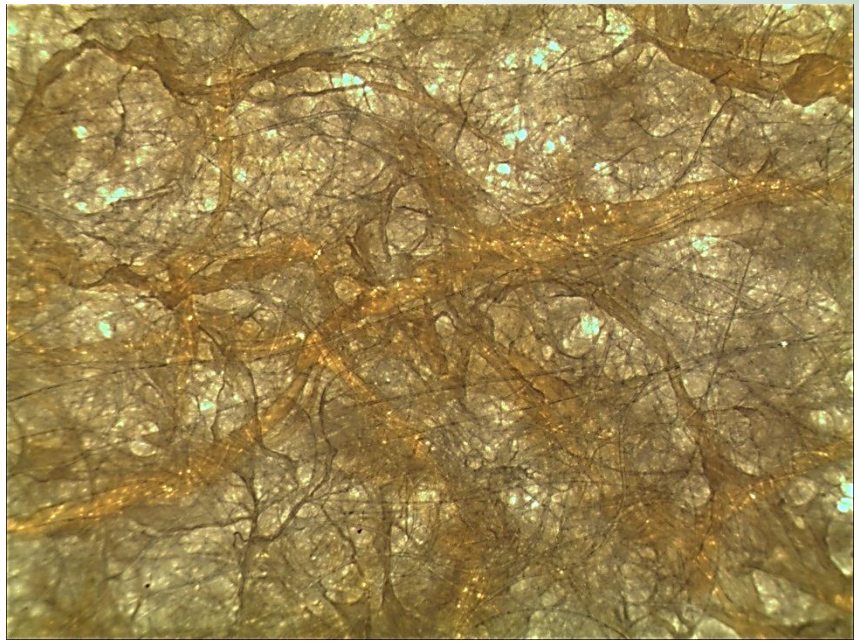
Dreamweaver Gold™

- Blend of high temperature fibers
- Featuring Teijin Twaron
- Features
  - High rate capability
  - Stable to 300 C
  - Below market price



Twaron®
The power of Aramid

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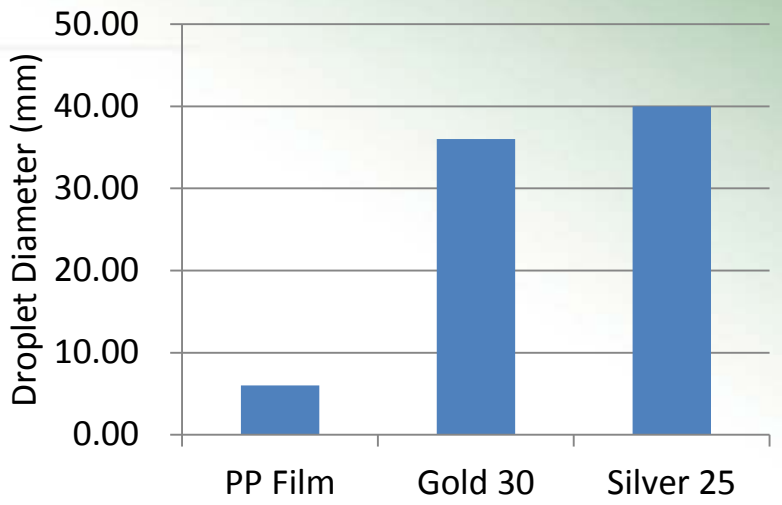
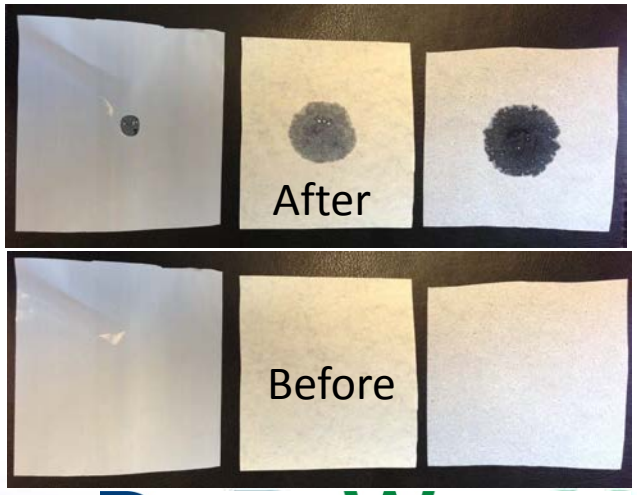
Separator Features

- Look & feel of paper
  - Fast roll-to-roll processing
- Electrolyte Wet Out
  - Very fast, uniform
- Thermal stability
  - <2% shrinkage up to 300 C
- Open structure
  - Delivers high energy at high rate





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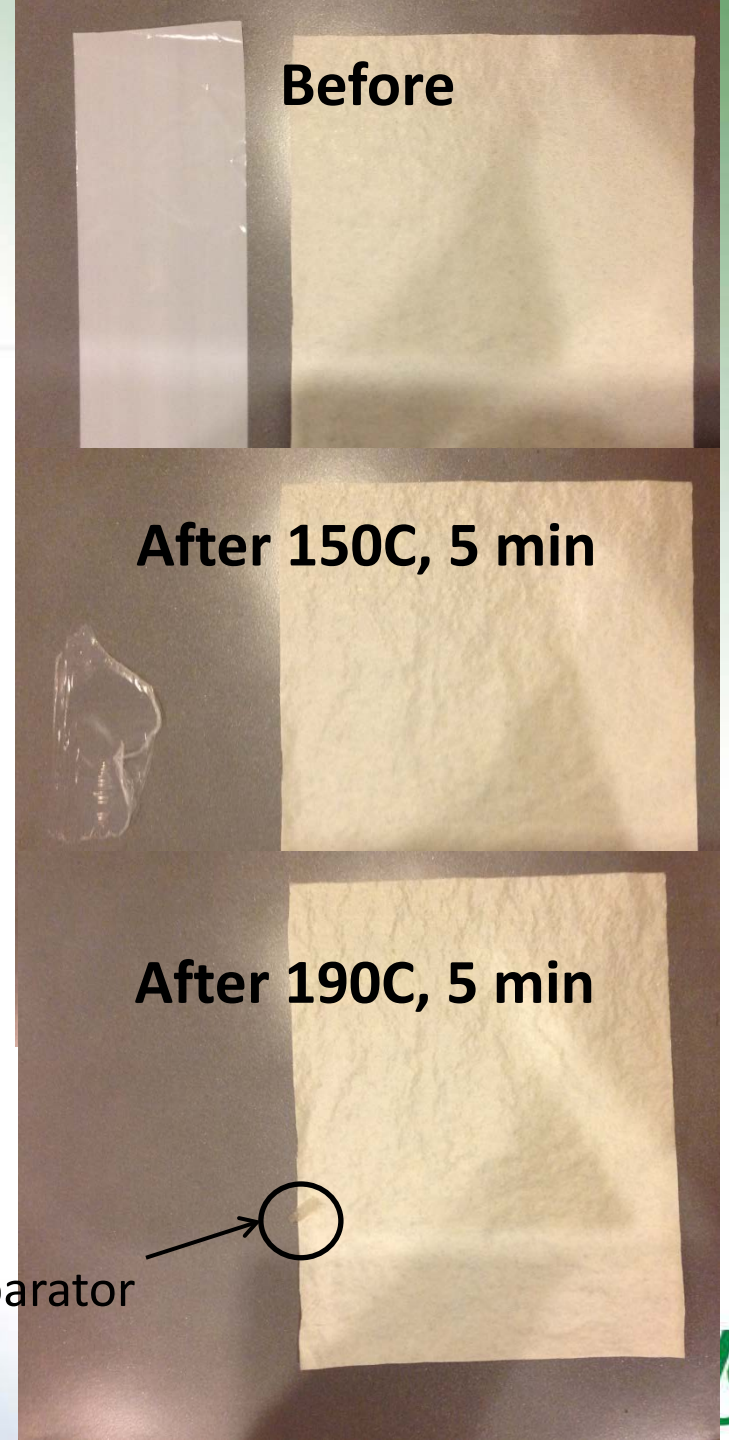
Separator Shrinkage

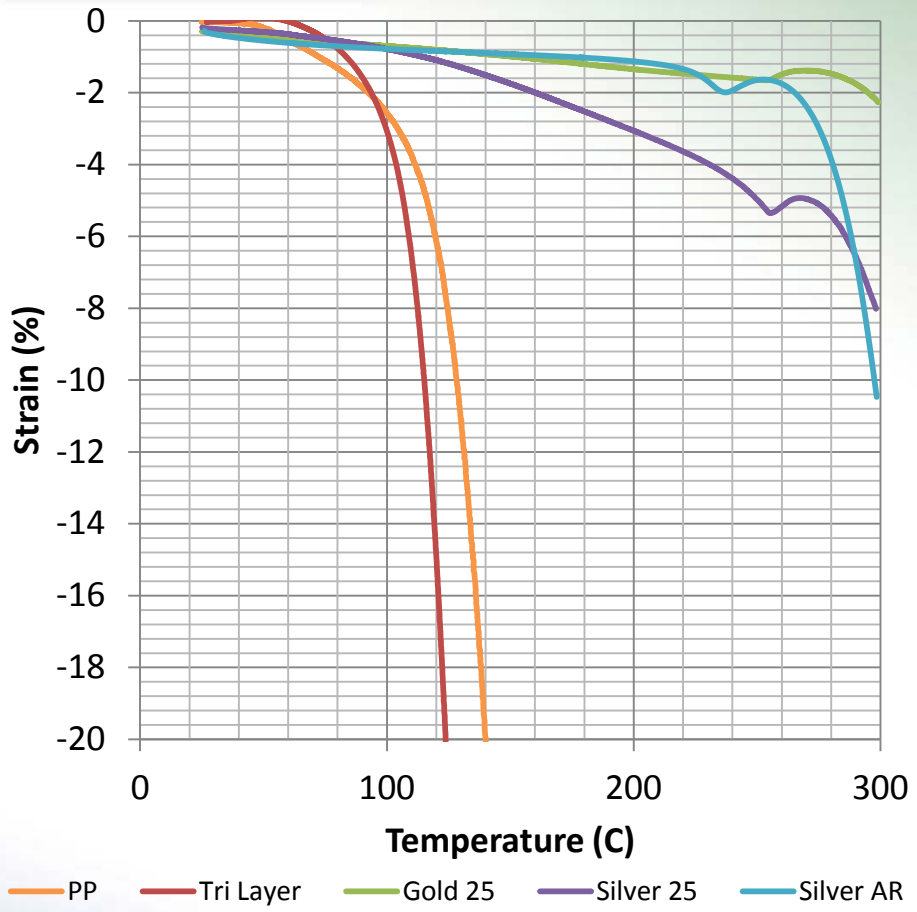
Property	Units	Film	Gold™ 30
TD Shrinkage 90 C	%	0	0
MD Shrinkage 90 C	%	5	0
TD Shrinkage 160 C	%	Melted	1
MD Shrinkage 160 C	%	Melted	1
TD Shrinkage 280 C	%	Oxidized	1
MD Shrinkage 280 C	%	Oxidized	2

If thermal stability and nail penetration are primary concern, we strongly encourage you to test Dreamweaver™ Gold



Separator Shrinkage <2% to 300 C

- DMA—measures shrinkage
- Temperature limits:
  - Trilayer: 120 C
  - PP: 140 C
  - Silver >250 C
  - Gold >300 C



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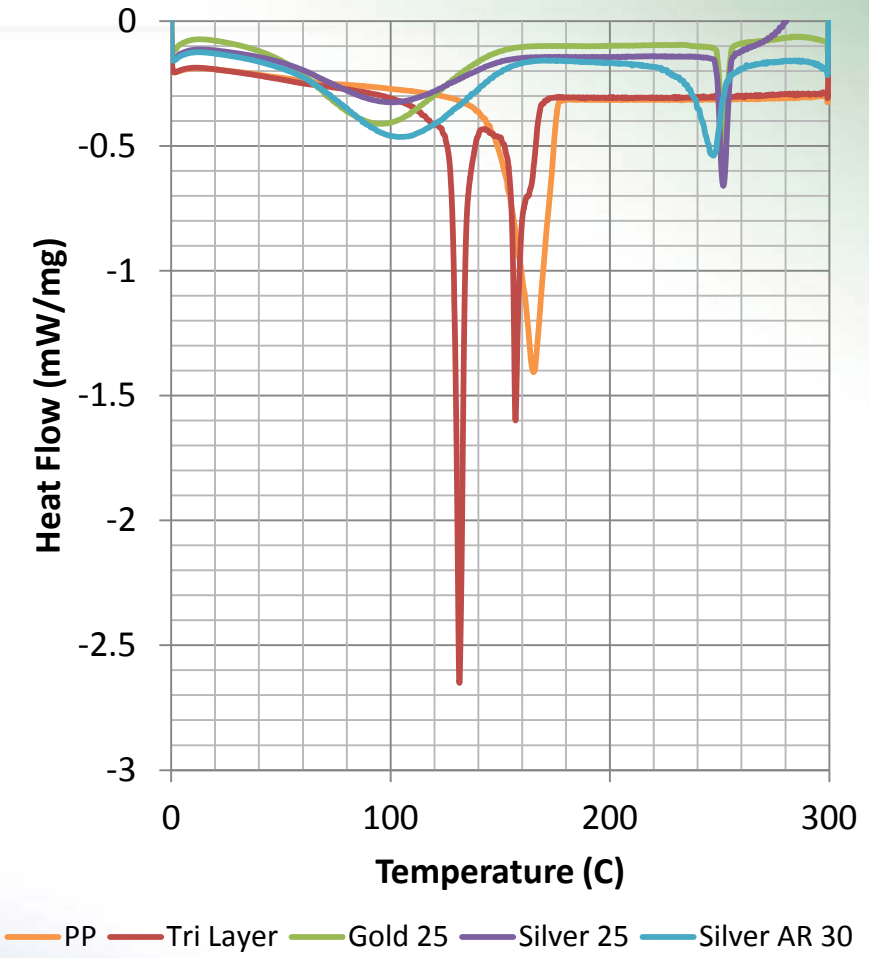
Separator Melt Stability to 300 C

- DSC—measures phase change
- Features:
  - Trilayer: melt peaks at 130 and 160 C
  - PP: melt peak at 165 C
  - Silver:
    - Water elution at 100 C (non-dried sample)
    - PET melt at 250 C
  - Gold:
    - Water elution at 100 C
    - PET melt at 250 C



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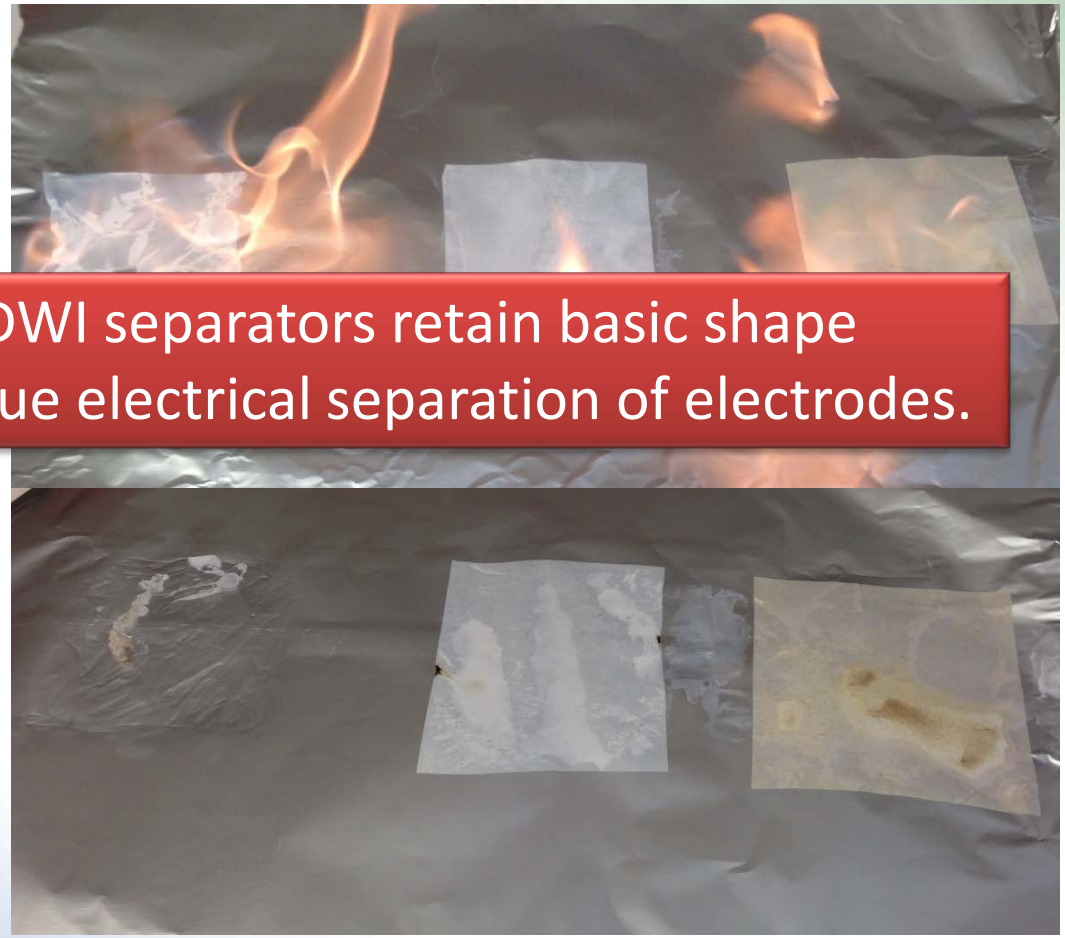
Flame Test: Saturated with Electrolyte

- The test nobody would ever do:
  - Saturate separator with electrolyte
  - Watch burn
- Results
  - PP: melt and burn
  - Silver: some charring
  - Gold: minor charring

Trilayer DWI Silver DWI Gold



After electrolyte burns out, DWI separators retain basic shape and size and ability to continue electrical separation of electrodes.

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Flame Test: Saturated with Electrolyte

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Key Benefits

Feature	Benefits
Safety	• Better safety at large cell size • Better ability to withstand excursions in local environment • More durable against manufacturing defects
Higher Energy Density	• Lighter, thinner cell phones and laptops • Power tools that last longer between charges • Lighter electric vehicles
Higher Power	• Fewer batteries in hybrid vehicles • Power tools with more gusto
Longer Lifetime	• Cell phones, laptops and power tools that require a new battery less frequently • Lower battery depreciation cost for electric and hybrid vehicles
Lower Cost	• Lower cost batteries for cell phones, laptops and power tools. • Greater acceptance of electric/hybrid vehicles.

THANK YOU!!

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