Webinar:
Minimize Fire Risk in USB-C Connectors

John Hsieh
Advanced Engineering Manager, DSM Engineering Materials

April 14, 2021

NUTRITION · HEALTH · SUSTAINABLE LIVING

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

Introduction

John Hsieh
Advanced Engineering Manager
DSM Engineering Materials

- Taiwanese, lived in Shanghai for 15 years
- Master degree in Mechanical Engineering
- 20 years' of experience in a broad range of electronics applications across the value chain (electronics devices PM, connector PM, industry marketing and then engineering material technical marketing)
- Joined DSM in 2013 at Shanghai, and then relocated to California in 2016, moved back to Shanghai again in 2018.

Quick facts and figures

DSM Engineering Materials and DSM overall

DSM Engineering Materials

Workforce

~1,900

Net sales

~€ 1.4 bn

Figures for 2019

R&T Investment

~4.5%

of revenue reinvested in R&T

Production

8

production facilities

Technology

~90%

of all new cars and electronics devises use DSM technology

DSM overall

Workforce

21,000

excluding affiliates

Net sales

€ 9.01 bn

Figures for 2019

Safety

0.28

frequency index of recordable injuries for 2019

Planet

#1

globally in sustainability by Sustainalytics

AAA

rating in the MSCI index

Quick facts and figures

Global footprint to support our customers

DSM Engineering Materials

- Production locations
- R&D locations
- Offices

USB-C: The most popular data & powerful interface in the consumer electronics industry

One connector for many devices


Tablet


Earphone


HDD


Power


TV


Laptop


Smartphone


Desktop


Smart speaker


AR / VR

The mobile phone evolution

Thinnovation & Integration

iPhone Evolution 2007 - 2017

SAMSUNG Evolution 1988 - 2020

Advanced Features

Higher Power Consumption

Higher Battery Capacities

Fast Charging

Fast Charging standards

Charging Technology	USB 2.0 port	USB 3.0 port	USB 3.1 (USB-C + USB PD)	Samsung Adaptive Fast Charger	Oppo Super VOOC	OnePlus WarpCharge 30	Huawei SuperCharge 2.0	MediaTek PumpExpress 4.0 (USB-PD)	Qualcomm Quick Charge 5* (USB-PD)	Motorola TurboPower 30 (USB-PD)
Max Power	2.5W	4.5W	100W	45W	65W	30W	40W	25/ 30W	100W+	28.5W
Voltage	5V	5V	5V- 20V	5/ 9/ 20V	5/ 10V	5V	5/ 9/ 10V	3V- 6V (10-20mV per step)	5V/ 9V(USB PD) 3.6V~20V	5/ 9/ 12V
Current	0.5A	0.5/ 0.9A	0.5A/ 0.9A/ 1.5A/ 3A/ 5A	2/ 1.67/ 2.25 A	10/ 6.5A	2/ 6A	2/ 2/ 4A	5A+	5A+	5.7/ 2.85/ 2.15 A

- Qualcomm announced the Quick Charge 5 solution on July 27th, 2020. XiaoMi, ASUS, Lenovo and Samsung have announced to use this technology in their new flagship models.
- The USB PD and various fast charging standards increase the burning risk dramatically, and this brings a new challenge to smartphone and connector designers.

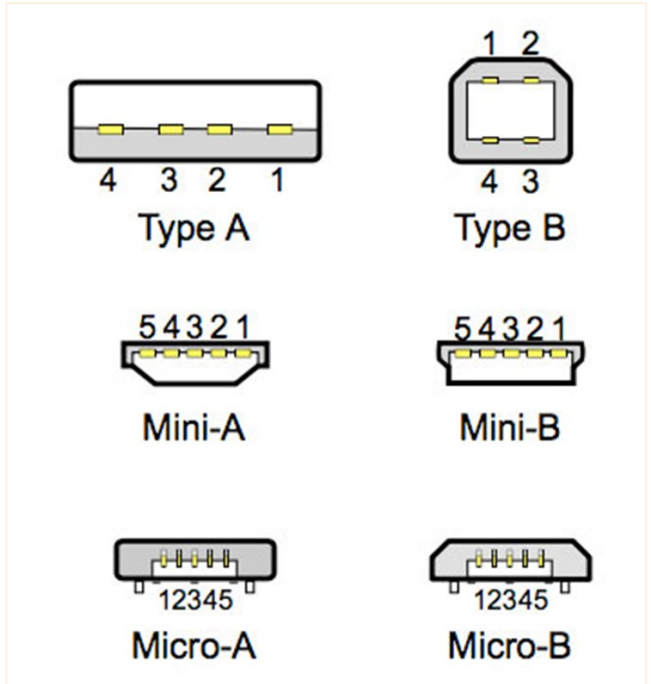
Qualcomm quick charge 5

The different generations of USB connector

Available receptacles for each connector

Generations	USB 1.0 1996	USB 2.0 2001	USB 2.0 Revised	USB 3.0 2011	USB 3.1 2014	USB 3.2 2017	USB4 2019
Data rate	1.5 Mbit/s (Low Speed) 12 Mbit/s (Full Speed)	1.5 Mbit/s (Low Speed) 12 Mbit/s (Full Speed) 480 Mbit/s (High Speed)		5 Gbit/s (SuperSpeed)	10 Gbit/s (SuperSpeed+)	20 Gbit/s (SuperSpeed+)	40 Gbit/s (SuperSpeed+ and Thunderbolt 3)
Standard	Type A			Type A			Deprecated
	Type B			Type B		Deprecated	
	N/A				Type C (enlarged)		
Mini	N/A	Mini A		Deprecated			
		Mini B					
	N/A		Mini AB				
Micro	N/A			N/A			
			Micro B	Micro B		Deprecated	
			Micro AB	Deprecated			
Connectors	USB 1.0 1996	USB 2.0 2001	USB 2.0 Revised	USB 3.0 2011	USB 3.1 2014	USB 3.2 2017	USB4 2019

Connector type Zoom in

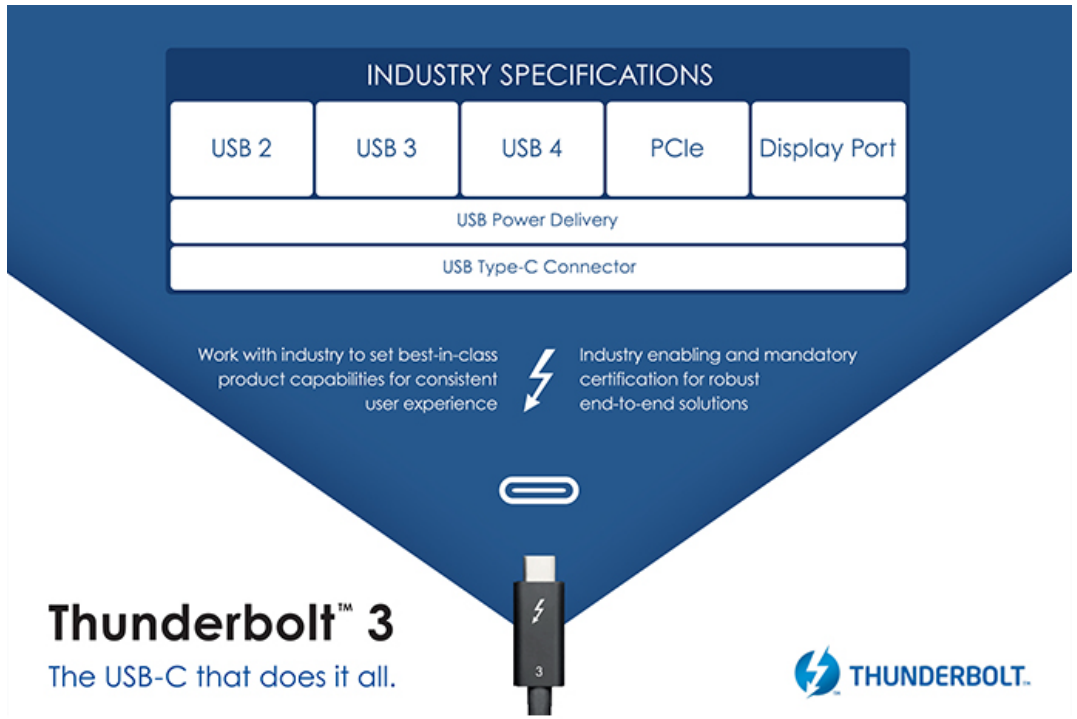


Type C receptacles

Type C plugs

USB type C connector is the only one interface to support USB 4 and onward version's USB devices.

Thunderbolt 3, 4 & USB 4



How Thunderbolt 4 is different than other solutions

Based on minimum solution requirements so people know what they are getting

		Thunderbolt™ 4	Thunderbolt™ 3	USB4	USB3/DP
Unrivaled Simplicity	One universal computer port	•	•		
	Universal 40Gb/s cables up to 2 meters in length	•			
	Accessories with four Thunderbolt ports	•			
Maximum Performance	Minimum PC speed requirements	40Gb/s	40Gb/s	20Gb/s	10Gb/s
	Minimum PC video requirements	Two 4K displays	One 4K display	One display (No Minimum)	One display (No Minimum)
	Minimum PC data requirements	PCIe 32 Gb/s USB 3.2 - 10Gb/s	PCIe 16 Gb/s USB 3.2 - 10Gb/s	USB 3.2 - 10Gb/s	USB 3.2 - 5Gb/s
	Required PC charging on at least one computer port[1]	•			
	Required PC wake from sleep when computer is connected to a Thunderbolt dock	•			
	Minimum PC port power for accessories	15W	15W	7.5W	4.5W
	Thunderbolt Networking	•	•		
Reliable Connectivity	Mandatory certification for all shipping computers, accessories and cables	•	•		
	Cable testing and cable quality audits for Thunderbolt cable manufacturers	•	•		
	Required Intel VT-d based DMA protection	•			
	USB4 Specification	Compliant	Compatible	Compliant	Compatible

[1]For thin and light notebooks that require less than 100W to charge

THUNDERBOLT.

Thunderbolt is used in high end laptop/ ultrabook.

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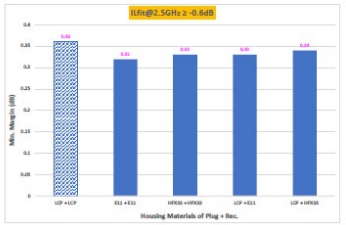
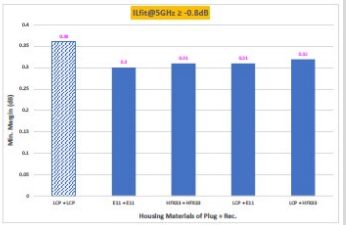
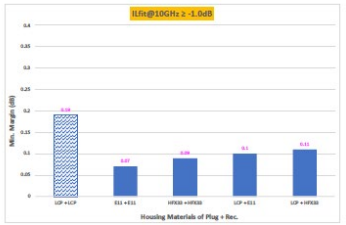
USB4 SI analysis

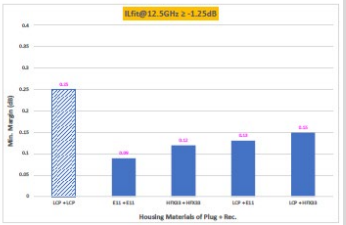
Both ForTii Eco E11 and Stanyl HFX33S meet USB 4 standard

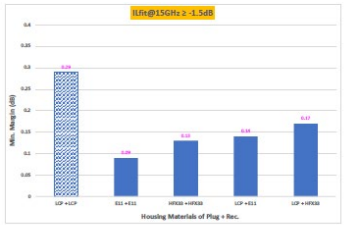
Item	Plug (Dk, Df)	Rec (Dk, Df)
1	LCP (3.4, 0.004)	LCP (3.4, 0.004)
2	E11 (3.6, 0.01)	E11 (3.6, 0.01)
3	HFX33 (3.48, 0.01)	HFX33 (3.48, 0.01)
4	LCP (3.4, 0.004)	E11 (3.6, 0.01)
5	LCP (3.4, 0.004)	HFX33 (3.48, 0.01)

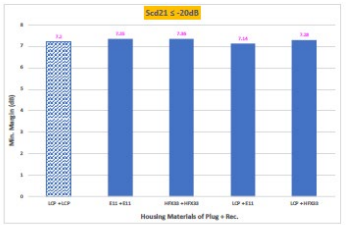


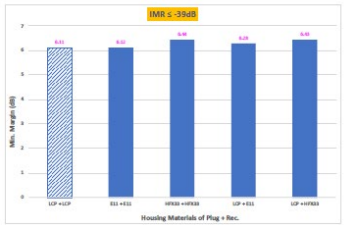


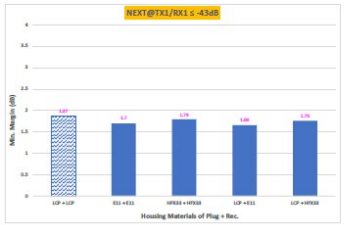


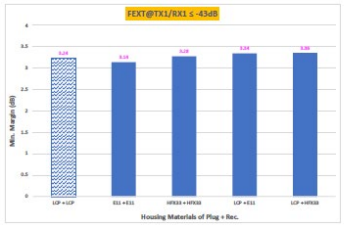


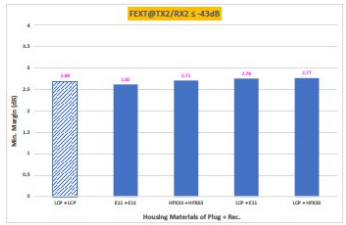












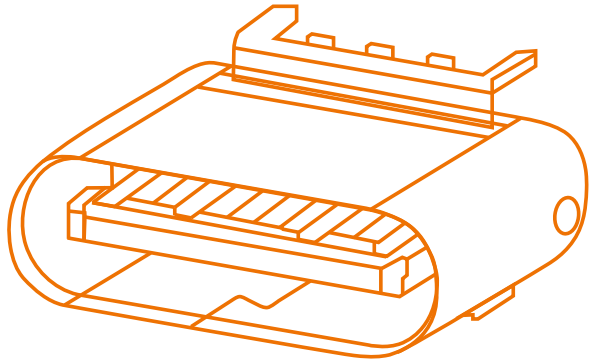
* Performed by Dr. James Lin (Lotes Co., Ltd.)

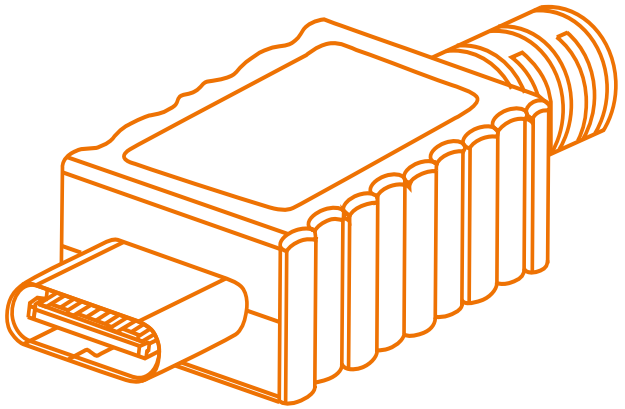
USB type C connector challenges and solutions

Challenges with traditional materials

Thinner walls require high -strength and more durable materials

- Liquid crystal polymers (LCP) are widely used for micro -USB connectors
- USB-C connectors require thinner walls than previous generations
- Fast charging increases the risk of connector defect
- Alternative materials are needed to produce reliable thin - walled connectors





Addressing safety concerns

New thinner devices pose fire risks

- Connectors with higher voltage rates and smaller pitch are more likely to result in electrical breakdown
- The tracking resistance of the insulator plastic is essential to reducing fire hazards

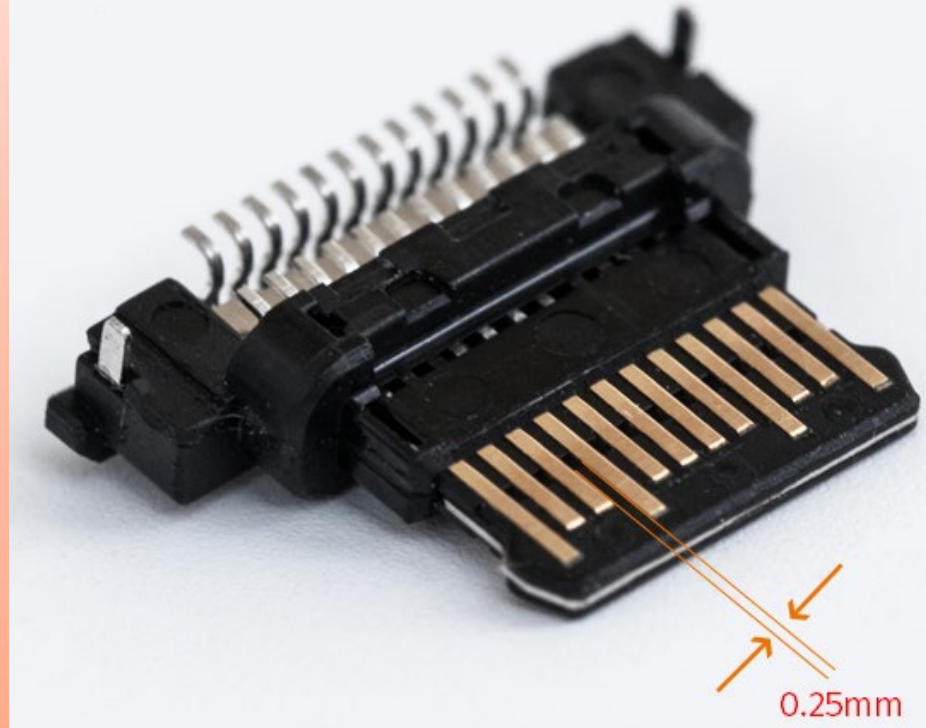
Source capabilities organized as profiles

Hand-held devices, today's peripherals	Profile 1	5V @ 2A	10W Default start-up profile
Tablets, VR/AR devices, most peripherals	Profile 2	5V @ 2A 12V @ 1.5A	18W
Thinner notebooks, larger peripherals	Profile 3	5V @ 2A 12V @ 3A	36W
Larger notebooks, hubs, docks	Profile 4	5V @ 2A 12V @ 3A 20V @ 3A	60W Limit for micro A/B
Workstations, hubs, docks	Profile 5	5V @ 2A 12V @ 5A 20V @ 5A	100W Limit for standard A/B

Requires new detectable cables for >1.5A or >5V

Qualcomm quick charge 5

Recently Qualcomm released the latest Quick Charge 5 solution, and several smartphone companies are using the technology in new devices.



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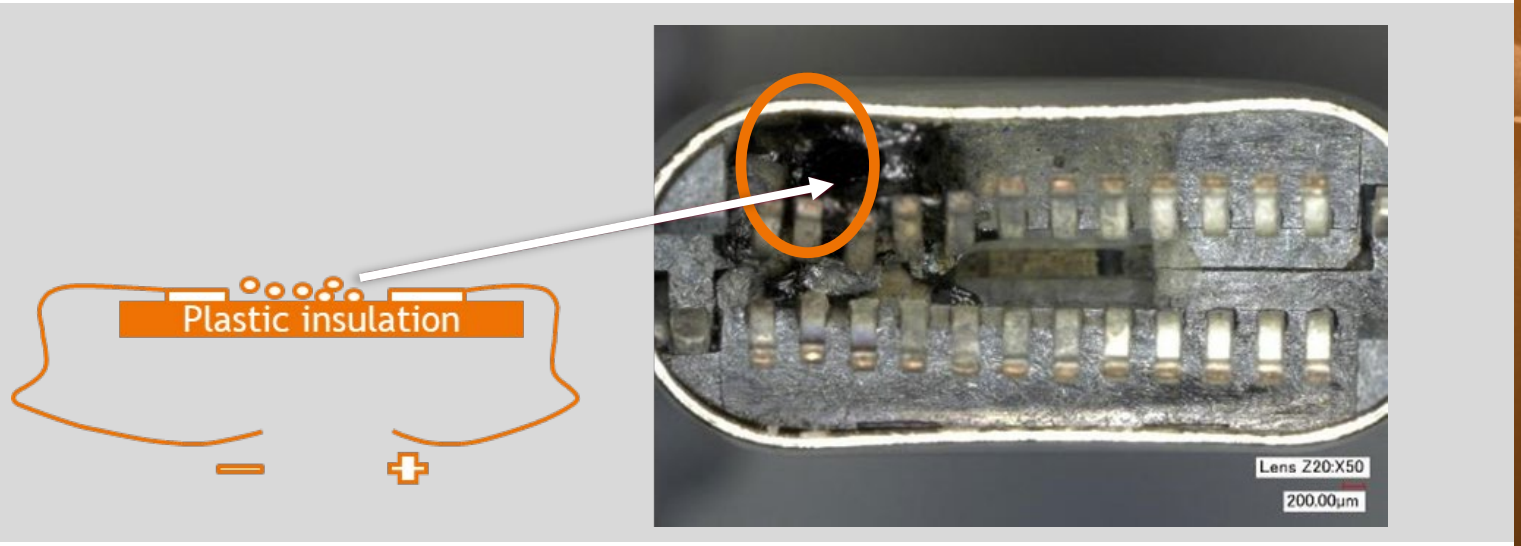
Understanding tracking

Insulating plastics may create fire risks

Potential real -life failure mode

- The build-up of dust, sweat or moisture creates a conductive track on plastic materials – increasing the risk of fire

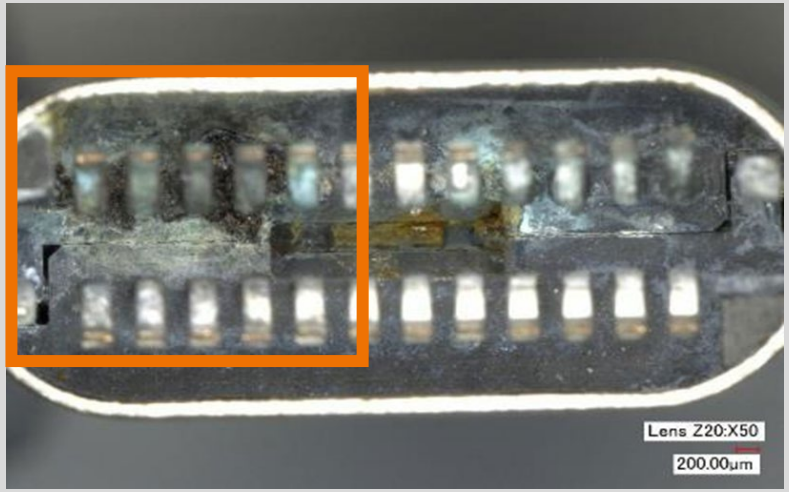


LCP after testing with 12 droplets — significant burn marks and electrical breakdown

Tracking resistance testing

High CTI material decreases safety risks for connectors and devices

- Materials need a high comparative tracking index (CTI) to ensure products are safe
- Higher CTIplastic remains structurally intact even after testing of 60 droplets!



Insights

Charging electronics have been linked to device fires

- Some fires may result in property damage or injury
- If liable, manufacturers risk recalls, damage to their reputation and legal action
- Tracking posed fire risks with the previous generations of USB connectors. With USB-C, the smaller pitch and increased power density may further increase the risk of fire.
- “Home fires due to electrical failure or malfunction primarily involve some form of arcing. Arc faults can be produced by damaged connectors…”

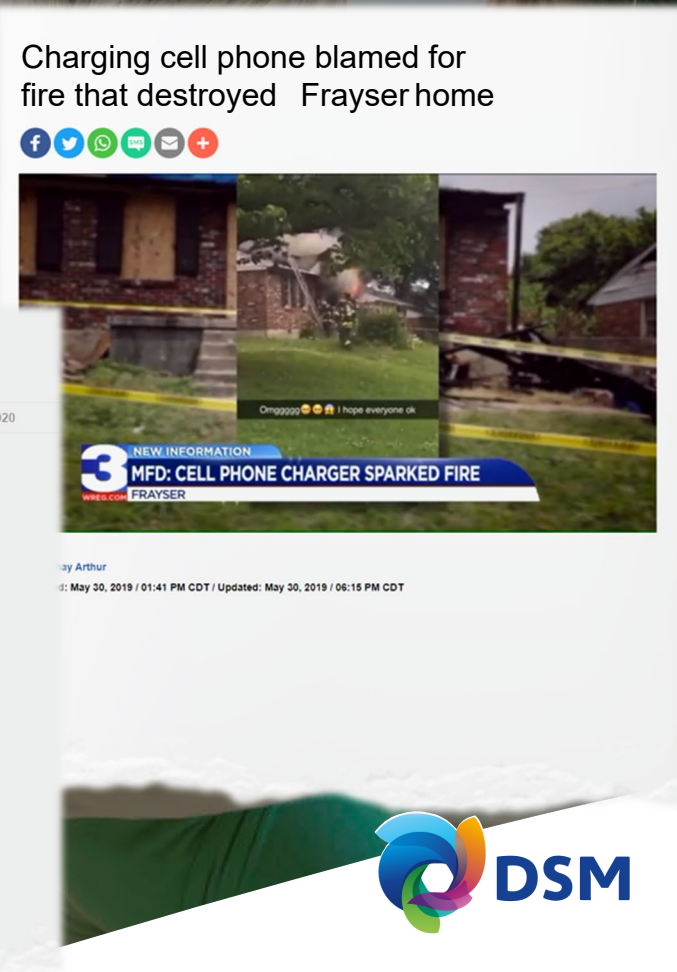
Source: “Home Electrical Fires” report by NFPA


Cell phone charger not ruled out as cause of Tuesday house fire in Redding

Damon Arthur, Redding Record Searchlight Published 8:38 a.m. PT Feb. 11, 2020 | Updated 4:00 p.m. PT Feb. 11, 2020

CONNECT TWEET LINKEDIN COMMENT EMAIL MORE

Redding firefighters knocked down a house fire Tuesday, Feb. 11, 2020 on Lacey Lane. *(Photo: Damon Arthur/Record Searchlight)*


Charging cell phone blamed for fire that destroyed Frayser home

NEW INFORMATION

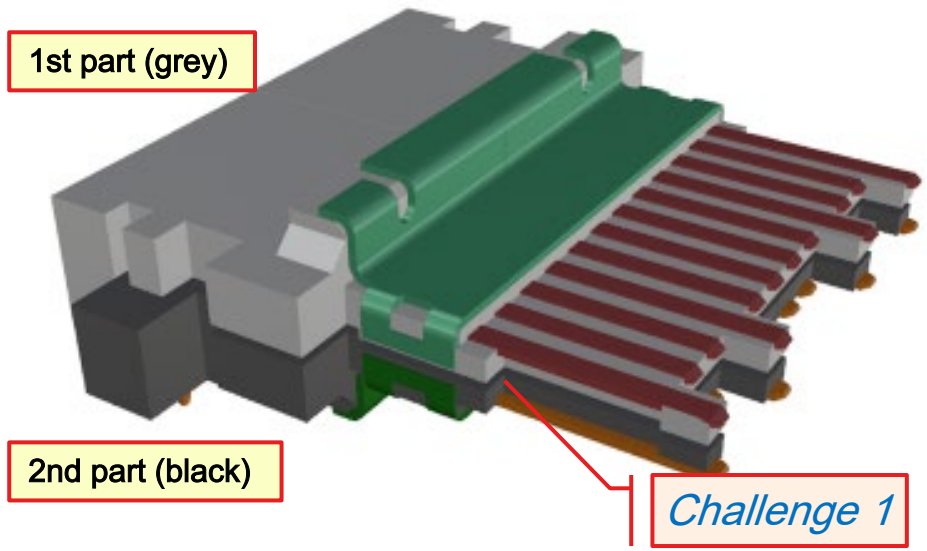
MFD: CELL PHONE CHARGER SPARKED FIRE

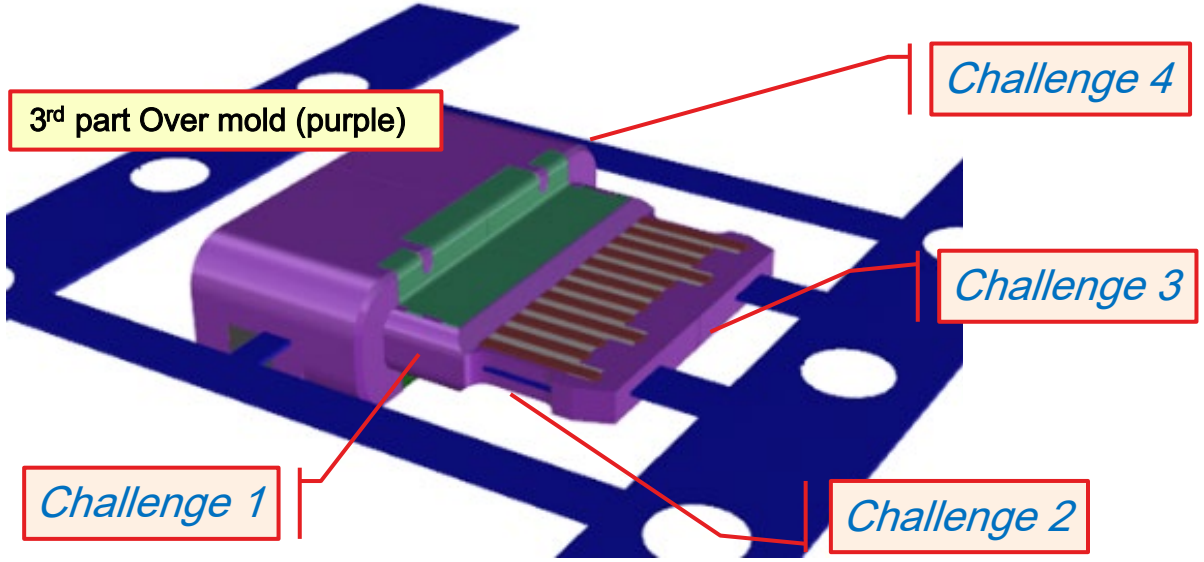
FRAYSER

ay Arthur

d: May 30, 2019 / 01:41 PM CDT / Updated: May 30, 2019 / 06:15 PM CDT

USB type C Receptacle structure and challenges





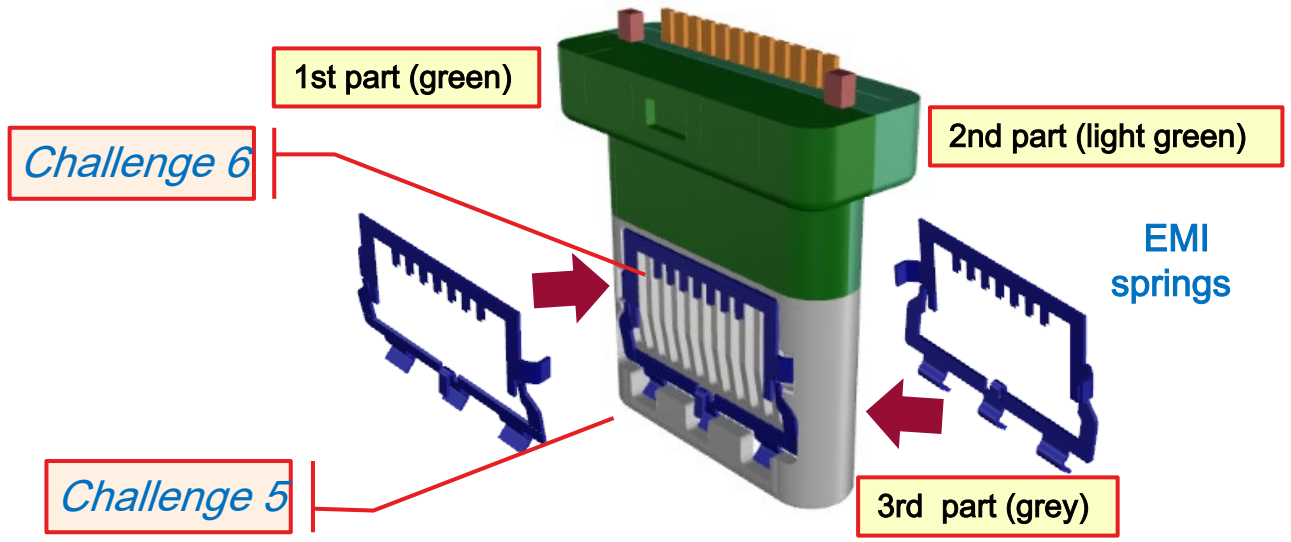
Challenge 1: the over mold parts need to be bounded with 1 st and 2nd parts well

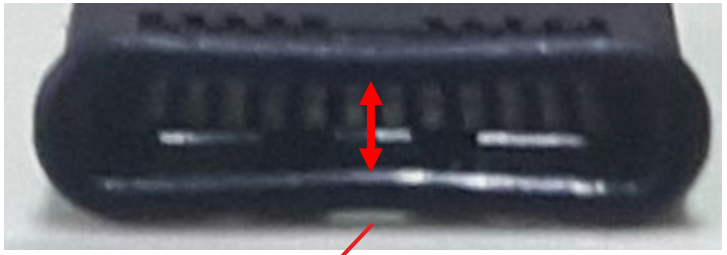
Challenge 2: Very thin wall in the both sides (0.1~0.2mm only), need very high flow material

Challenge 3: front end plastics to protect metal contact, need high wear resistance material to ensure the reliability and durability during mating/ un-mating cycles.

Challenge 4: inappropriate tooling design may cause other issues such as void inside the housing or delamination

USB type C Plug structure and challenges





Challenge 5: There is welding line in the front end and very easy to be broken. The broken parts may cause connector malfunction. Need high welding line strength material

Challenge 6: The ribs are very thin (~0.15mm) and very easy to break during EMI spring assembly. Need high stiffness material

Challenge 7: Deformation in the front end of plug housing, need higher strength material

Overcoming plug housing challenges

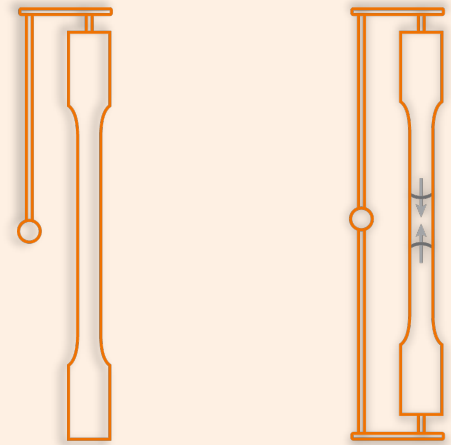
Meeting all durability, flow and toughness needs

- Molding thin ribs requires high flow, highly durable materials
- Final components must retain a balance between toughness and stiffness
- High-strength weldlines are very durable

Stanyl shows the highest weldline strength among competitors

Base polymer	[-]	PA46		PA9T	PA6T/ 66	LCP
GF content	[%]	20	35	45	35	35
Mechanical property weldline strength	[MPa]	60	50	22	40	17

Weldline strength measurement is based on UL tensile bar

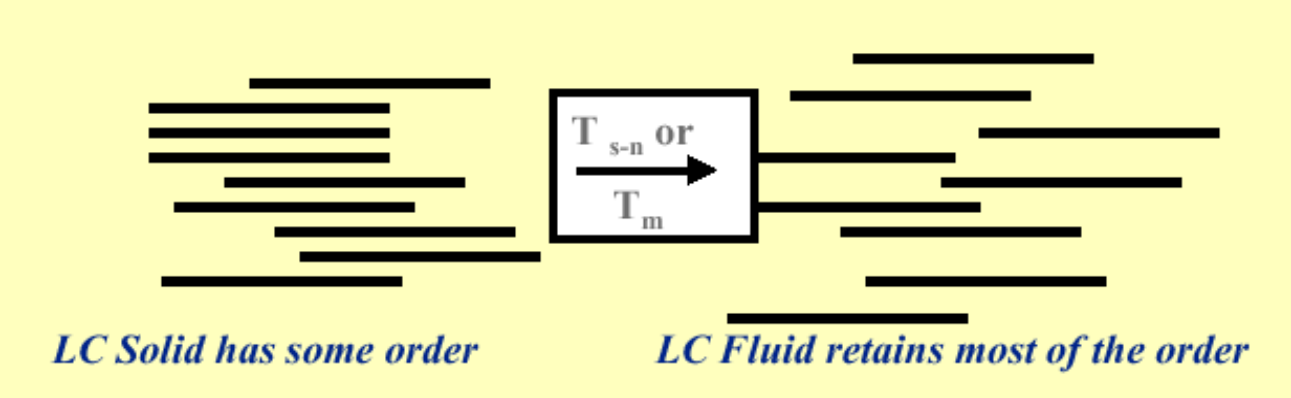


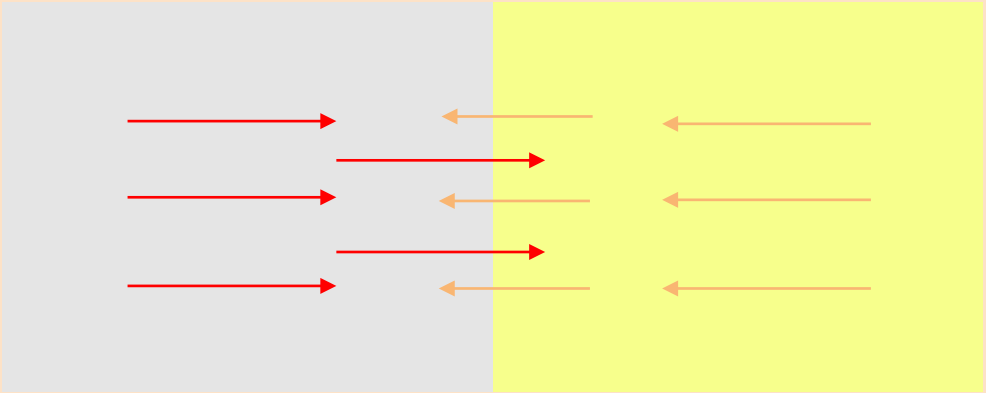
Normal tensile bar

Weldline tensile bar

Low weldline strength material shows cracking in plug designs

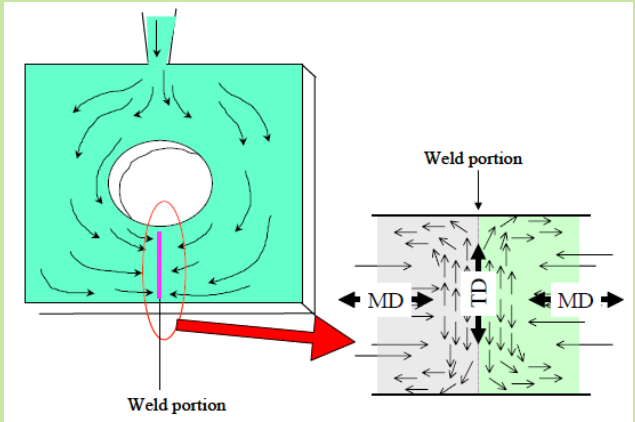
Different polymer structure leads to different material characteristics





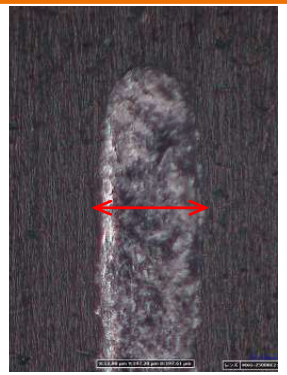
LCP has very rigid molecular structure in both solid and melt state, therefore the very few entanglements and chemical interactions cause the very low weldline strength

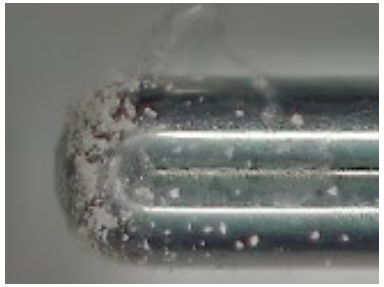
Stanyl/PA46 has flexural molecular chain, easier for entanglement, and Fast crystallization to solidify the entanglement area



Wear resistance comparison of Halogen Free V0 grades

Stanyl shows the highest wear resistance

	Stanyl HFX33S GF20%	ForTii F11 GF30%	PA9T GF45%	PA6T GF35%	LCP GF+MD35%
Wear & Friction					
Depth	8µm	22µm	47µm	36µm	23µm

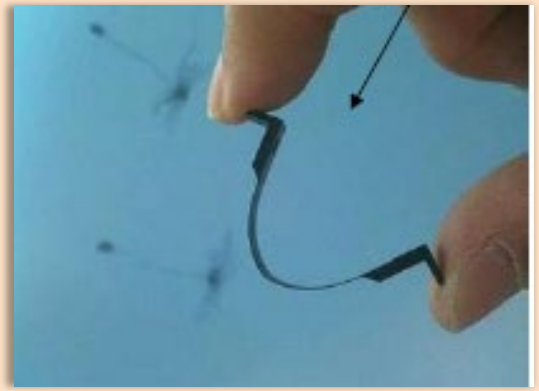


* Test Condition: 20g, Stroke 40mm, Speed 70cycle/min, 100Kcycles. Probe Pin Front end R 0.4mm

Full product portfolio for different design

Supplier		DSM			Competitor A	Competitor B	Competitor C	Standard
Grade	[-]	HFX33S	HFX61S	HFX82S	GP2450NH-2	FR52G35NHF	E471i	
base polymer	[-]	PA46			PA9T	PA6T/ 66	LCP	
GF content	[%]	20	35	45	45	35	35	
Mechanical property								
TM	[MPa]	7400	11500	15000	15100	12800	13800	ISO 527-1/ -2
TS	[MPa]	110	145	180	146	135	130	ISO 527-1/ -2
EAB	[%]	2.7	2.1	2.2	1.5	1.4	2.5	ISO 527-1/ -2

- Stanyl HFX33S has highest elongation at break ration and ductility among competitions
- DSM provides the product portfolio solution to meet different connector design needs



Blistering free solution

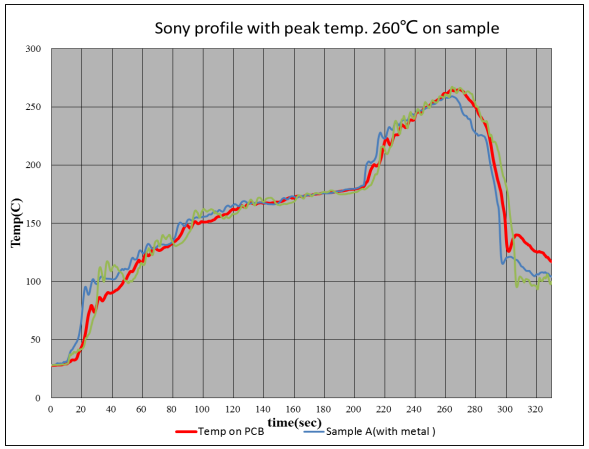
JEDEC MSL-1 test

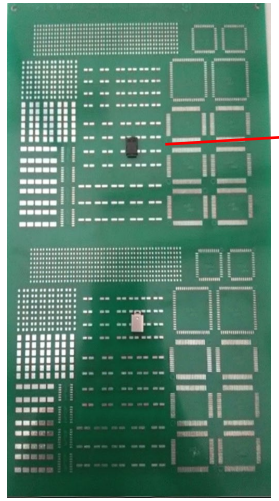
Sample: Connectors
Material: Stanyl HFX 31S/33S/61S BK
pre-dried: 105℃*16hrs
Preconditioning: MSL-1(85℃×85%RH×168hrs) MSL-2(85℃×60%RH×168hrs)
Reflow profile:Sony profile with peak temp. 260℃
Reflow time: one time pass

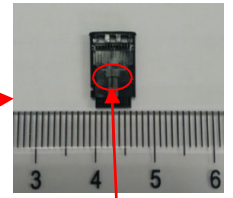
Material	Sample type	Pre-conditioning	Water absorption(%)	Blistering
HFX 61S with metal shell	connectors	85℃*85%RH*168hrs	0.4	0/9
HFX 61S without metal shell			1.7	0/9
HFX 61S with metal shell		85℃*60%RH*168hrs	0.2	0/9
HFX 61S without metal shell			0.8	0/9

Note: The moisture absorption was measured by weight gain, which is only for reference due to metal pin included.

Material	Sample type	Pre-conditioning	Water absorption(%)	Blistering
HFX 31S/33S with metal	Connector	85℃*85%RH*168hrs	1.95	0/4
HFX 31S/33S without metal		85℃*60%RH*168hrs	3.89	0/4







Thermocouple position

* No blistering at the both receptacle and plug connectors test

Choosing the best material

Robust plastics reduce fire risk

- Multiple considerations go into picking materials for USB-C components:
  - Receptacle tongues
  - Plug housings
- Choosing a halogen-free polyamide material reduces the risk of fire

COMPONENT	*MATERIALS*
Cable	Conductor: copper with tin or silver plating
	SDP Shield: AL foil or AL/ mylar foil
	Coaxial shield: copper strand
	Braid: Tin-plated copper or aluminum
	Jacket: PVC or halogen-free substitute material
Cable Overmold	Thermoset or thermoplastic
Connector Shells	Stainless steel or phosphor bronze
Plug Side Latches	Stainless steel
Receptacle Mid-Plate	Stainless steel
Plug internal EMC Spring	Stainless steel or phosphor bronze
Receptable EMC Pad	Stainless steel or phosphor bronze
Receptable Shell	Stainless steel or phosphor bronze
Receptable Tongue	Glass-filled nylon
Housing	Thermoplastics capable of withstanding lead-free soldering temperature
Note: Halogen-free materials should be considered for all plastics	

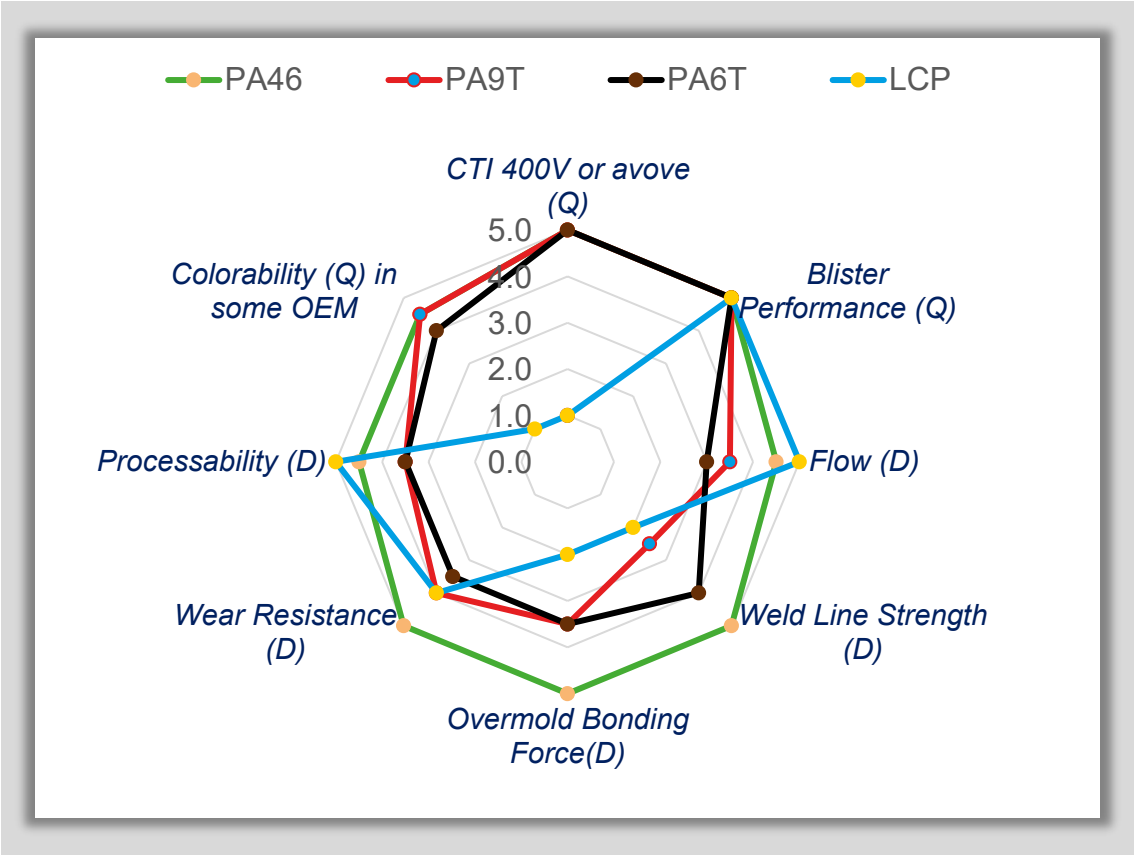
*Source: USB Type C specification release 1.0

DSM

Stanyl: Best polyamide for increased product safety and reliability

Highest weldline strength and best wear resistance

- High CTI reduces the risk of electrical tracking by 50%
- Excellent flow properties ensure high yields to lower molding costs
- Up to 50% more wear resistance than competing high temperature polyamides
- Unmatched reliability during use ensured by extensive mating cycle testing
- Proven track record of more than 300 million USB-C connectors with zero blistering or quality complains made by Stanyl for major OEMs

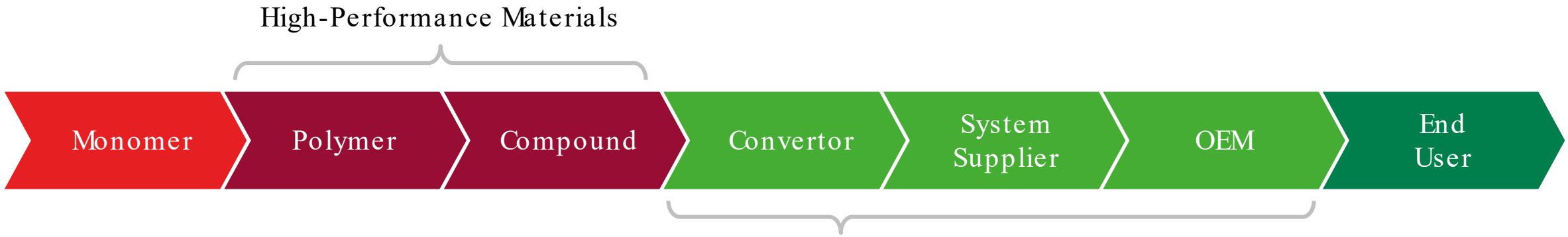


DSM Engineering Materials

Your best partner for connector development

Bright Science in advanced materials

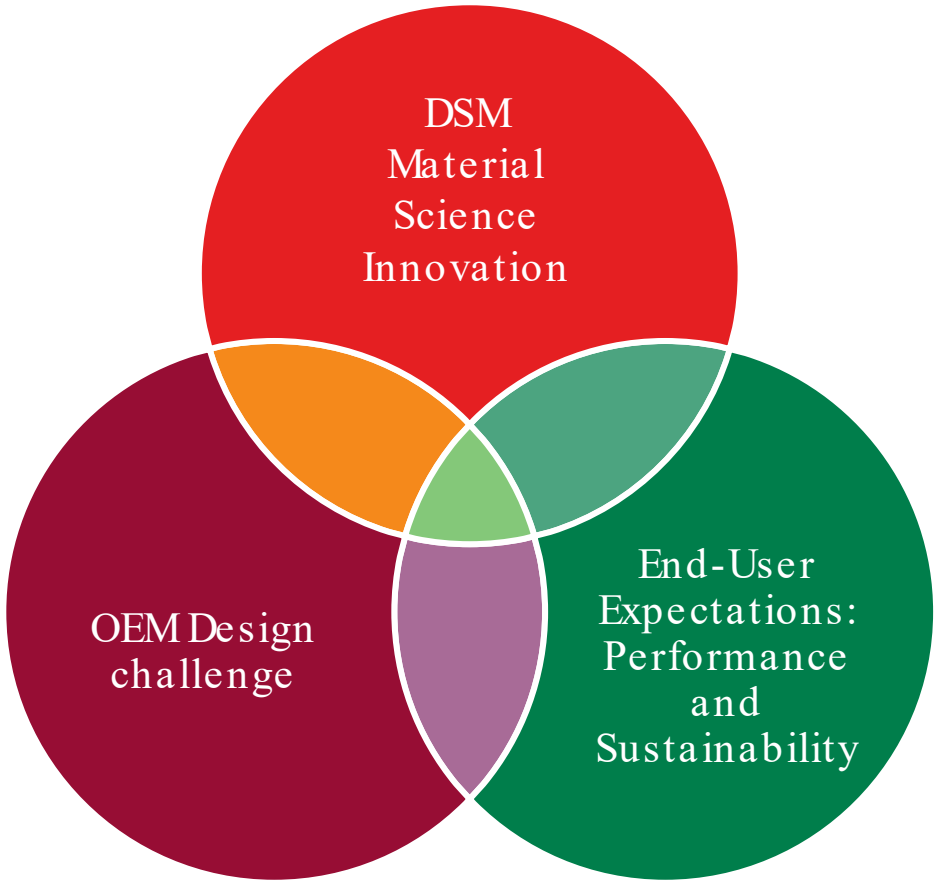
Co-developing throughout the value chain



Design	Measure Performance	Production Support	Compliance
• Review application requirements • Analyze datasets • CAE support	• Temperature • Mechanical • Chemical resistance • UL and other global safety standards	• Quality control • Identify production efficiencies	• Documentation • Data sheets • Regulatory affairs statements • Life cycle analysis

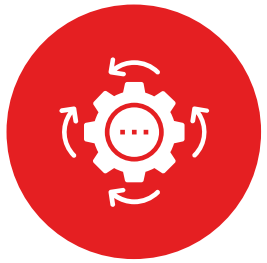
Bright Science in advanced materials

Delivering advanced material solutions for the world's leading manufacturers



Summary

Why DSM Engineering Materials?



Materials trends in sustainability and technology evolve rapidly

Engineers face challenges in staying up to date with advanced materials science, innovations and shifts in legislation - and in choosing the right solution for their design challenges

DSM Engineering Materials supports with:

- *Global footprint*
- *Broad materials portfolio*
- *Application expertise*
- *Design support*
- *Materials innovation*
- *Sustainable solutions*
- *Security of supply*

Delivering:

Security in selecting the right materials for applications with speed and agility.

A trusted partner with a strong track record

A preferred partner of leading multinationals, with a strong track record in automotive, electronics & electricals and food packaging.

DSM Engineering Materials

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Questions and Answers

John Hsieh
John.Hsieh@dsm.com
+86 13818977651

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