

Exhaust Aftertreatment of Gasoline Engines with Coated Particulate Filters 9<sup>th</sup> VERT Forum – Dübendorf

Frank Adam, Susanne Kunert Umicore AG & Co. KG Koorosh Sadr-Salek Umicore Autocat Luxembourg



## Agenda

- Umicore Who we are
- Global Automotive World
- Market and System Trends
- Umicore c-GPF Portfolio Technical Requirements
- Performance Data
- Durability Run Data
- Summary



### Who we are

#### A global materials technology and recycling group



One of three global leaders in emission control catalysts for light-duty and heavy-duty vehicles and for all fuel types



A leading supplier of key materials for rechargeable batteries used in portable electronics and hybrid & electric cars



The world's leading recycler of complex waste streams containing precious and other valuable metals



## From substrate to end consumer







# **Global Automotive World**

#### LDV Production by Region



#### Air Pollution



#### Upcoming legislation...



		2015 2016 2011 130 g/km 100% feet			7 2018 2019 2020			2021 2022 95 g/km 107/4 Ger		
Euro 5		Euro 6	ь		Euro 60					
,	texti	used 19			WLTC-based testing					
Development a	ind me	asurem	ent pha	50	NTE-Lim CF stage 1	it - Cor	dormit;	ed y flactor (GF) F 1929;2		
Euro Sb		Euro 6-	1		Euro 6-2	3				
	iuro 5 Pevelopment a turo 5b proval PC	turo 5 NEDC-5 tests Revelopment and me turo 5b proval PC	NEDC-based resting Arrefopment and measurem turo 5b Euro 6- proval PC	uro 5 Euro 6b NEDC-based Issaing Pereforment and measurement pha turo 5b Euro 6-1 proval PC	Iuro 5 Euro 6b NEDC-based Seating Nevelopment and measurement phase turo 5b Euro 6-1 poxal PC	iuro 5 Euro 60 Euro 60 NEDC-based sesting eventopment and measurement phase (CF ange- turo 50 Euro 6-1 Euro 63 poral PC	taro 5         Euro 6b         Euro 6c           NEDC-based Seating         MILL         N           Verdopment and measurement phase         Crange 1         N           Verdopment and measurement phase         Crange 1         Crange 1           Verdopment and measurement phase         Euro 6-0         Euro 6-0	Iaro 5         Euro 6b         Euro 6c           MDD-based Vesting         MITL-Lines Marking         MITL-Line Marking           Vestingment and measurement phase         MITL-Line - Conformity (Farage 1)         Cr           Vestingment and measurement phase         MITL-Line - Conformity (Farage 1)         Cr           Vestingment and measurement phase         Euro 6-1         Euro 6-2           popul PC         conformity         conformity	taro 5 Euro 62 Euro 62 MECC-based WITC-	





11

#### Sustainable Solutions



9<sup>th</sup> VERT Forum – Umicore Property

ĸ



# Upcoming legislation...



Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
CO <sub>2</sub> target				130 g 100% fi	130 g/km 100% fleet				95 g/km 100% fleet			
Emission standards	Euro 5			Euro 6b			Euro 60	:				
NEDC/ WLTC	NEDC-based testing						WLTC-based testing					
Real Driving	Development and an and a local					NTE-Limit – Conformity Factor (CF)						
Emissions	Development and mea		asurement phase		ise	CF stage	ige 1 CF		F stage 2			
On Board Diagnostics	Euro 5	ib		Euro 6-	1		Euro 6-2					
All dates: New type approval PC							not confirmed by final regulation.					



1800 sec; 23.3 km; Max Accel.: 1.60 m/s<sup>2</sup>



# umicore

## Sustainable solutions



ICE Internal Combustion Engine-powered vehicle HEV Hybrid Electric Vehicle PHEV Plug-in Hybrid Electric Vehicle EV Electric Vehicle BEV Battery-powered Electric Vehicle FCEV Fuel Cell-powered Electric Vehicle



# Strengthening EURO 6 PN limits require GPF

EURO 6 legislations addresses the number of particulates, with a transition period of 3 years for gasoline engines Gasoline Direct Injection (DI) engines have higher Particulate Number (PN) emissions compared to diesel engines with Diesel Particulate Filter

With RDE introduction most of the gasoline vehicles will need a GPF







**Market Trend** 

GPF Introduction for almost all DI

umicore



# **Catalyzed Gasoline Particulate Filter**

The catalyzed Gasoline Particulate Filter c-GPF

Addressing:

Hydrocarbons HC Carbon Monoxide CO Nitrous Oxides NOx Particulate Mass PM Particulate Number PN





# Advantages of Different GPF Positions



- Diagnosis unchanged over CC1 TWC
- Good filtration efficiency
- Additional conversion of traditional emissions, especially regarding RDE
- Diagnosis unchanged over CC1 TWC
  - Good conversion of traditional emissions
  - Good soot regeneration



cGPF

TWC

- Packaging and system costs benefit
- Good soot regeneration

# Umicore c-GPF Portfolio Technical Requirements



e.g.: high performance cars, application with very low raw emissions



high PN emissions

Different technical requirements call for dedicated technologies

- Special technologies for lowest pressure drop
- Portfolio of high three-way active GPF designs
- Designs for increased fresh filtration efficiency



### **GPF-Development** High-TWC Performance c-GPF



- Significant Improvements of TWC activity
- Stress Field: Activity vs. Back Pressure continues



# **Pressure Drop and Maximum Power**

#### **@** Rated Engine Speed





#### Real World Fuel Consumption Central European Driving, German Motorway included





#### Real World Fuel Consumption Central European Driving, German Motorway included



9<sup>th</sup> VERT Forum – Umicore Property

#### Real World Road Durability Validation TWC + Add On c-GPF downstream, PN over Durability Distance



umico



#### Summary

Strengthening EURO 6 PN limits require GPF for Gasoline (DI) Engines

Variable coatings in the c-GPF family are available:

- Pressure drop optimized technologies
- Portfolio of high three-way active GPF designs
- Designs for increased fresh filtration efficiency

Attention has to be turned to the conversion of gaseous emissions due to:

- High aging requirements in a CC1 position
- Lower washcoat amounts on a filter compared to a flow through substrate → assure sufficient conversion of harmful emissions over lifetime

Filtration efficiency is increasing over lifetime due to ash accumulation



# Thank you for your attention

**Questions**?