中汇瑞德
CHUROD ELECTRONICS

Company Introduction

May 9, 2023

Churod Electronics Profile

- **Founded in 2009**, a leading **Relay, Contactor, and Sensor solution** provider for global customers.
- Our mission is to provide global customers a full range of **high-quality products and value-add services**.
- Own **5 production sites** in China, **branch offices** in the U.S. and Germany, and **research institutes** in Tokyo.
- Continuously **invest on innovation** and spend **>8%** of annual turnover on R&D.
- Equipped with **world-class internal lab** test capabilities, products are certified by CQC, CE, TUV, VDE, and cUL, etc.
- **IPD (Integrated Project Development) process** ensured development quality and quick response to customer.
- Deliver **300+million products** each year, Keep leading position in 5G, Automotive and new energy industry globally.

1200+
Global Employees

10
Institutes

5
Plants

Business Unit

Relay

- 30% sale revenue increase in 2021
- Top 3 relay brand in China in New Energy space

Sensor

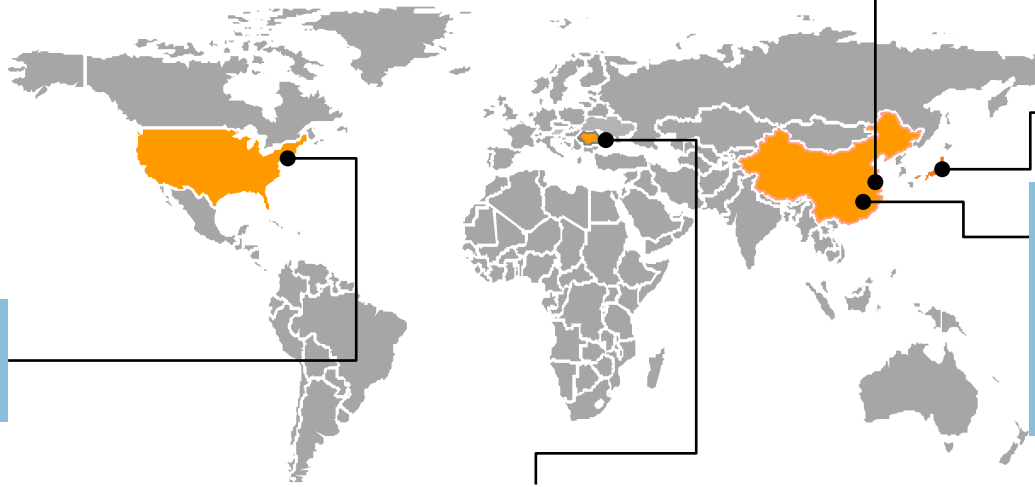
- Churod Sensing starts in 2019，Founded in 2021
- SOP in 2022

Contactor

- Joint Venture with Sensata founded in July 2021
- Supply Automotive OEM in 2021

Global Footprint

Reaching local markets around the world



Other service agencies and offices

Research Institute in Tokyo

China, Dongguan HQ; Wuhu production site; Shanghai Office; Suzhou R&D Center and Production site.

Philadelphia Office, U.S.A.

Sibiu, Romania Office

Honor & Capabilities

Honor & Qualification

- CHUROD Lab has UL & TUV Witness Test Certification
  Part of our Patent Certificate，CNAS Certification

Test Capability

- Reliability Test for new developed products
- Regular Tests for massive production products
- Special tests requested by customers

- Able to replicate most customer load tests involving resistive, inductive, capacitive, motor, and lighting loads etc.
- Our environmental testing includes heat, humidity, thermal shock, salt spray, shock, vibration etc.
- IEC testing for glow wire, ball pressure, explosion-proof seal etc.

部分专利证书



Churod实验室已获得UL及TUV试验室资格证书

体系证书ISO9001

体系证书ISO14001

体系证书IATF16949

Automation Strategy

CHUROD is a leader in overall level of automation

1. **Fully automatic injection molding**
2. **Fully automatic steel stamping**
3. **Fully automatic coil winding**
4. **Fully automatic semi-finished products assembly**
5. **Fully automatic WIP products quality check**
6. **Fully automatic workshop**

Major Industry Application

Photovoltaic

Communication Power

Energy Storage

Safety

Electricity Meter

Home Appliance

Smart Home

Industrial Vehicles

Charging Piles

Automotive

Business Partners

Auto

BYD · 吉利汽车 GEELY AUTO · 长城汽车 专注 专业 专家 · 长安汽车 CHANGAN AUTO · HYUNDAI · KIA Movement that inspires

国轩高科 GOTION HIGH-TECH · SVOLT 蜂巢能源 · ARASIS 孚能科技 · CHERY · DAIMLER

5G Indu.

HUAWEI · EMERSON · DELTA · ARTESYN Embedded Power | An Advanced Energy Company · Inovance

Home App.

GREE 格力 掌握核心科技 · Midea · GE · Whirlpool · PHILIPS

photovoltaic

阳光电源 SUNGROW · SMA · 固德威 GOODWE · KSTAR 科士达 · Growatt

……

SHARP · hp · invt · lenovo 联想 · TP-LINK The Reliable Choice

TGOOD 特锐德 · 科陆 · Sinexcel 盛弘电气 · Enpower 英博尔 · 三星电气 SANXING ELECTRIC

Churod Sensing History

- **2006-2009**
  OEM Manufacturer

- **Jan. 2010**
  CHUROD'S First Plant started production

- **Jun. 2016**
  CHUROD's Third Plant started production

- **2021**
  CHUROD SENSING TECHNOLOGIES is founded

2006 — 2010 — 2016 — 2021

2009 — 2014 — 2020 — 2021

- **Oct. 2009**
  CHUROD launched the brand

- **Jun. 2014**
  CHUROD's Second Plant started production

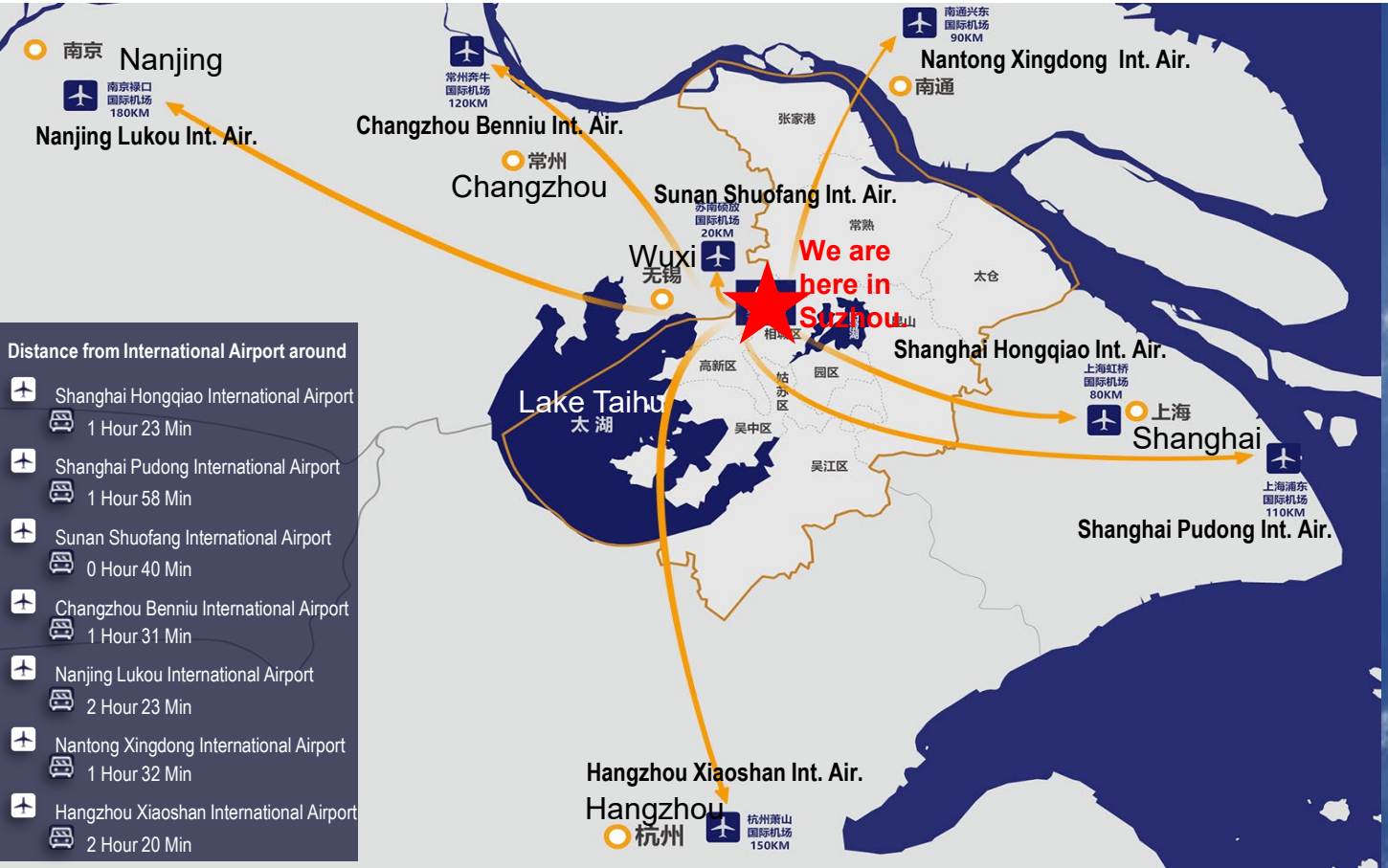
- **Oct. 2021**
  CHUROD's Fourth Plant started construction

- **2021**
  CHUROD SENSING acquired Sensata BPS business

R&D Center and Manufacturing Site

Churod Sensing Technologies located in Suzhou city, JiangSu Province.

Where Are We Located?



Distance from International Airport around

- Shanghai Hongqiao International Airport
  1 Hour 23 Min
- Shanghai Pudong International Airport
  1 Hour 58 Min
- Sunan Shuofang International Airport
  0 Hour 40 Min
- Changzhou Benniu International Airport
  1 Hour 31 Min
- Nanjing Lukou International Airport
  2 Hour 23 Min
- Nantong Xingdong International Airport
  1 Hour 32 Min
- Hangzhou Xiaoshan International Airport
  2 Hour 20 Min

Our Vision

A world leading sensing solution provider to make the world smarter!

传感科技的引领者，让世界更智能！

Our Values

Respect	尊重
Responsibility	负责任
Innovation	创新
Excellence	卓越

Technical Platform and Application

Engine

Transmission

Battery Pack Thermal Runaway Detection

HVAC

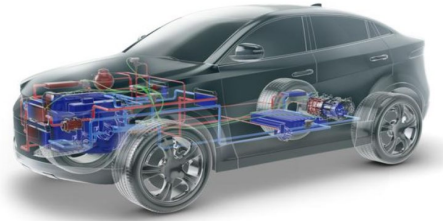
MEMS
Micro-Electromechanical Systems

CCP
Ceramic Capacitive Pressure

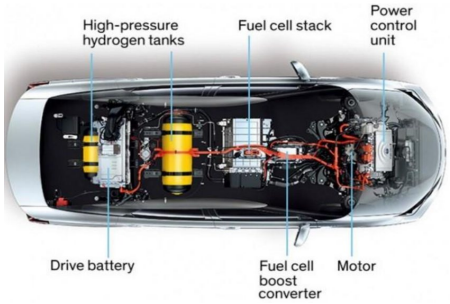
GSG
Glass-Bonded Strain Gauge

EMS
Electro-Magnetic Sensor

Thermal Management



Fuel Cell



Product Development Experience – on Passenger Cars

Cabin Comfort
- ✓ AC pressure + temperature
- ● CO_2 concentration

Engine System
- ✓ GDI rail pressure sensor
- ✓ Common rail pressure sensor
- ✓ Fuel pressure sensor
- ✓ Crankcase pressure sensor
- ✓ Oil pressure + Temperature
- ✓ Air intake manifold pressure + Temperature
- ✓ Fuel evaporation pressure sensor

Exhaust Treatment System
- ✓ DPF differential pressure sensor
- ✓ GPF differential pressure sensor
- ✓ Exhaust back pressure sensor

For EV
- ✓ Battery thermal runaway detection
- ✓ Current sensor
- ✓ Contactor

Transmission System
- ✓ DCT pressure sensor
- ✓ AT pressure sensor
- ✓ CVT pressure sensor
- ✓ Transmission Speed and position sensor
- ✓ Accelerator pedal

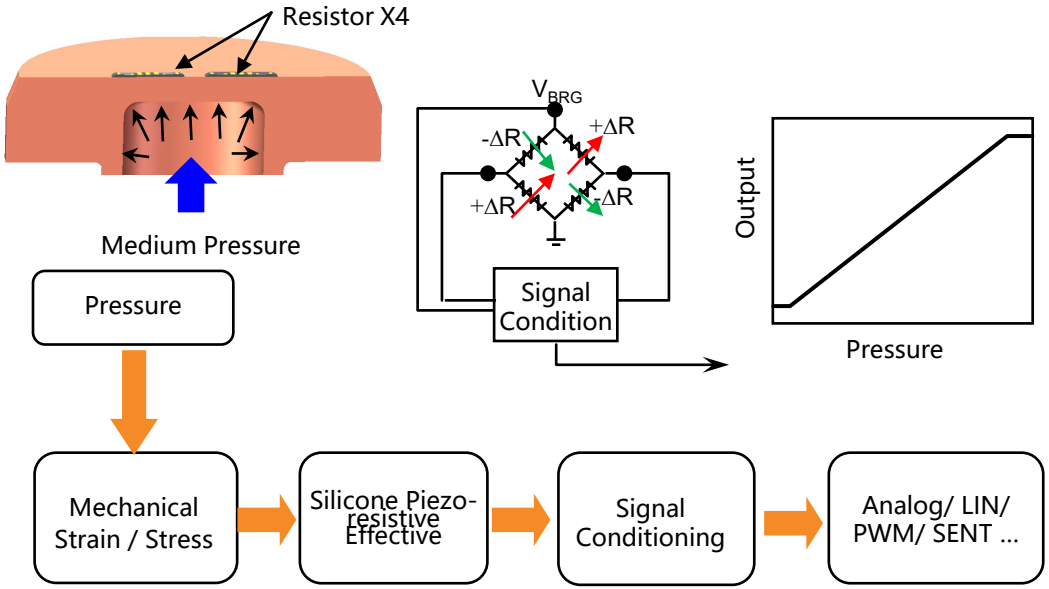
Chasis System
- ✓ Air suspension pressure sensor

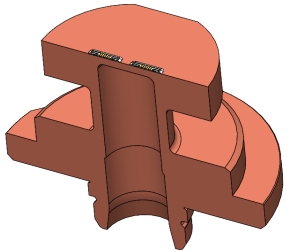
Active Safety / ADAS
- ✓ ESC pressure sensor
- ✓ Vacuum booster pressure sensor

- ✓ R&D experience
- ● To be developed

Churod GSG Pressure Sensor

GSG (Glass-Bonded Strain Gage)： Based on piezoresistive effect. Strain gages are bonded onto the metal membrane through micro-fused glass. The pressure changes in the port will result in resistive changes which can be conditioned to gage the pressure.



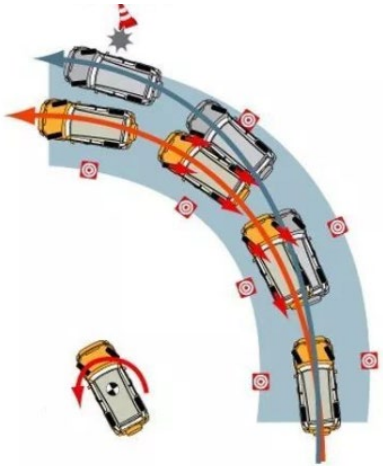


- Pressure applied onto the stainless steel port, used to measure high pressure up to 4000Bar.
- True hermetic design.
- Good Medium compatibility and good corrosion resistance.
- High accuracy by linearity + temperature compensation.
- **Typical Application: Common Rail, GDI, ESC, Braking Force etc.**

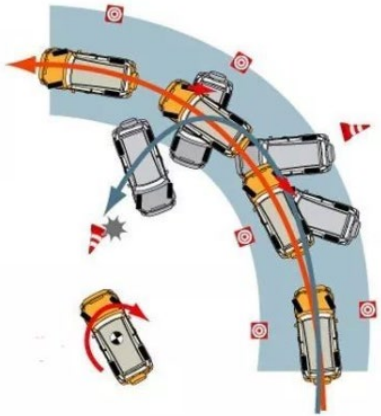
Typical Application – ESC/One box

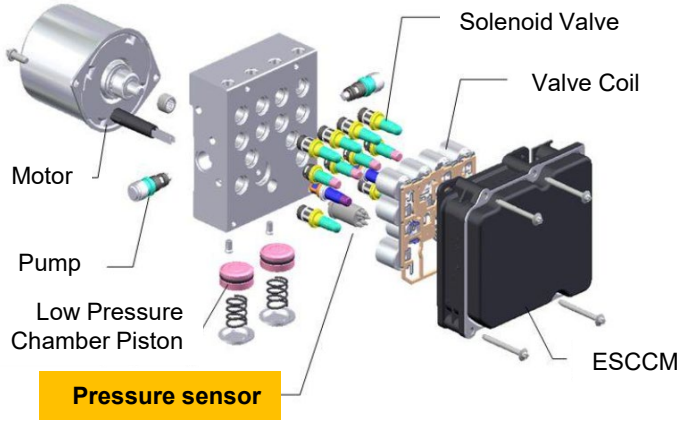
Keep vehicle stable by braking one or multiple wheels.

Under steering



Over steering

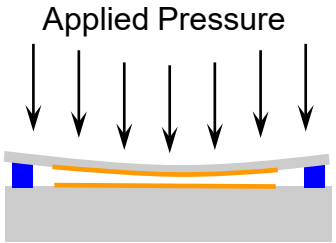




High performance requirements on ESC sensor. Because it is impact passenger safety.

- High reliability
- Meet Functional Safety (ASIL C)
- Performance stability
- Small form factor

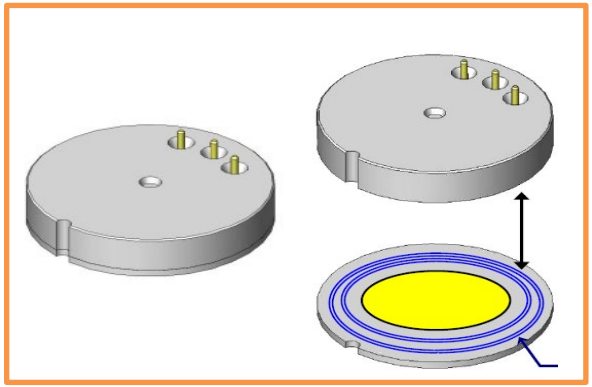
Churod CCP Pressure Sensor



$$C = \frac{\varepsilon A}{d}$$

Signal Conditioning

Analog/LIN/ PWM/ SENT …

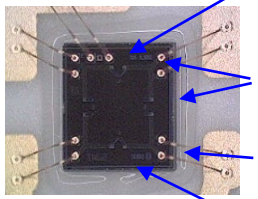


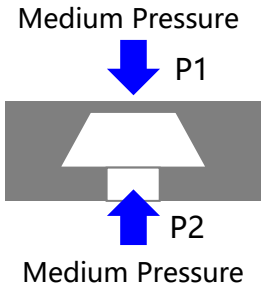
C = Capacitive
ε = Permittivity
A = Area
d = Distance

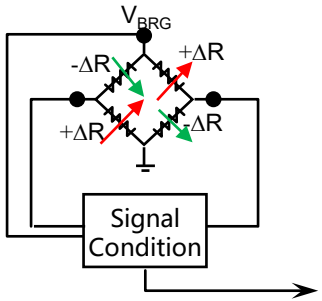
- Based on mature CCP technology, can achieve high reliability and high accuracy;
- Excellent medium compatibility;
- **Typical Application: Exhaust Back pressure, AC, FCV, Oil pressure, Transmission pressure etc.**

Pressure → Ceramic Diaphragm deformation → Distance change results in capacitive change → Signal Conditioning → Analog/LIN/ PWM/ SENT …

Churod MEMS Pressure Sensor

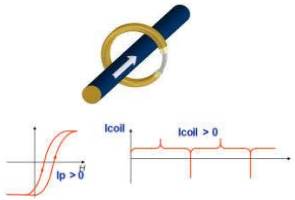
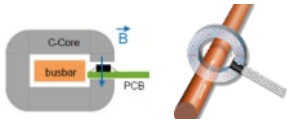






- Pressure across diaphragm results in tensile stress in center, compressive stress at edge.
- Strain-sensitive piezo resistors are implanted in silicon substrate and connected in a full bridge configuration.
- Applied pressure results in a bridge imbalance that is amplified and compensated in signal conditioning electronics.
- **Typical Application: Exhaust differential pressure sensor, TMAP, Crankcase pressure, Fuel Vapor pressure, Vacuum Booster pressure, BPS etc.**

Churod EMS Sensor

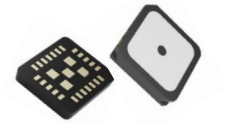
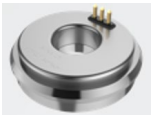
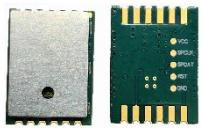
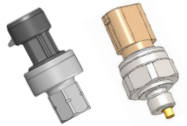
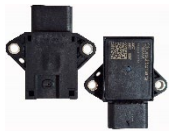
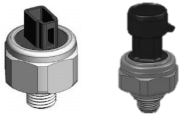
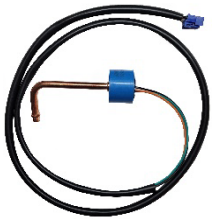
Current Sensor Technologies		Sensor Product	Current Range	Accuracy
Fluxgate			±500A ±1500A	<0.3%@RT <0.5%@All T
Open-loop Hall			±600A ±900A ±1000A ±1200A	<1.25%@RT <2.75%@All T

- Based on mature technology, can achieve high reliability and high accuracy;
- Small zero offsite;
- **Typical Application: Battery pack main current, Motor control etc.**

Market Timing

Many Others + Custom Design

Market Timing

MEMS	CCP	GSG	EMS
 Gen 3 BPS **2023.12**	 Air Brake, suspension, etc. **2024.6**	 EMB force sensor **2024.12**	 1200A Hall open-loop **2023.12**
 Gen 2 BPS **2023.10**	 Heat Pump P / P+T **2024.2**	 Braking cylinder, GDI, CR, etc. **2024.6**	 1500A Fluxgate **2024.3**
 Gen 1 BPS **In Production**	 DHT/Transmission Pressure **2023.11**	 Extra form factor on ESC **2024.3**	 500A Fluxgate **2023.10**
   VRF Pressure Sensor **In Production**			

In Production

SOP in 2023

SOP after 2023

Product Family

中汇瑞德
CHUROD ELECTRONICS

Smart BPS Introduction

May 8, 2023

What Is a Sensor or a Transducer?

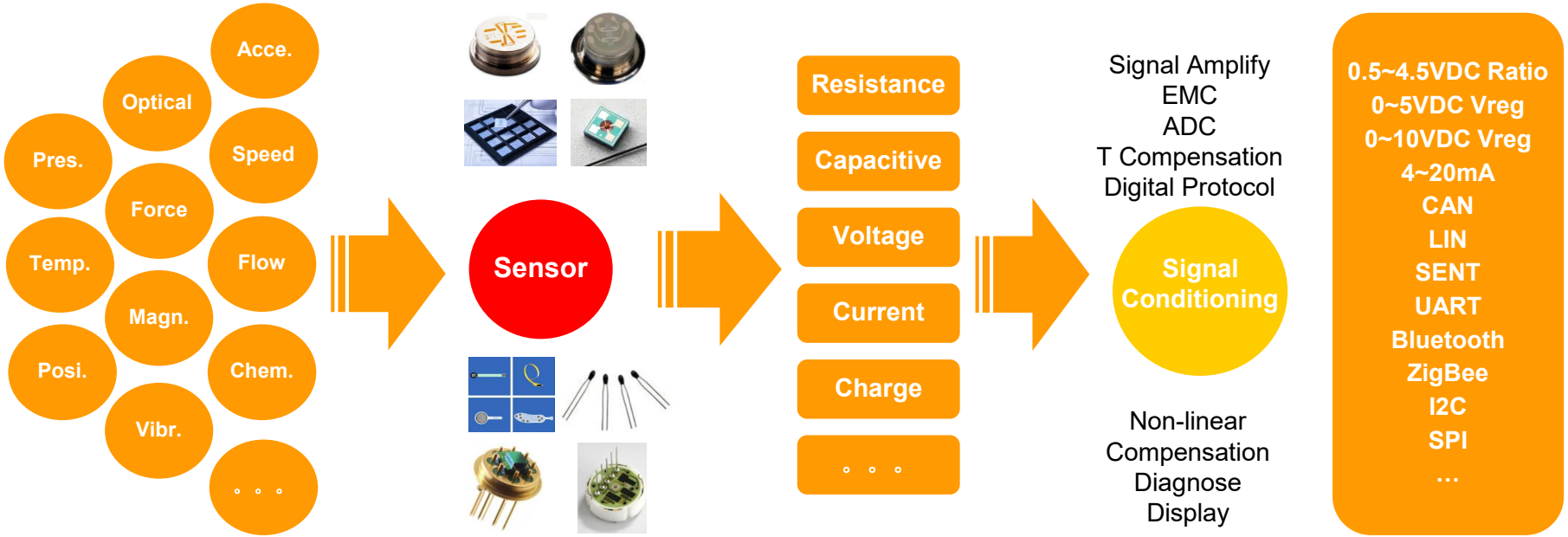
- The **sensor** is a device that measures the physical quantity (i.e. Heat, light, sound, etc.) into an easily readable signal (voltage, current etc.).

Transducer

Physical Inputs

Sensor + Signal Conditioning

Output Signals

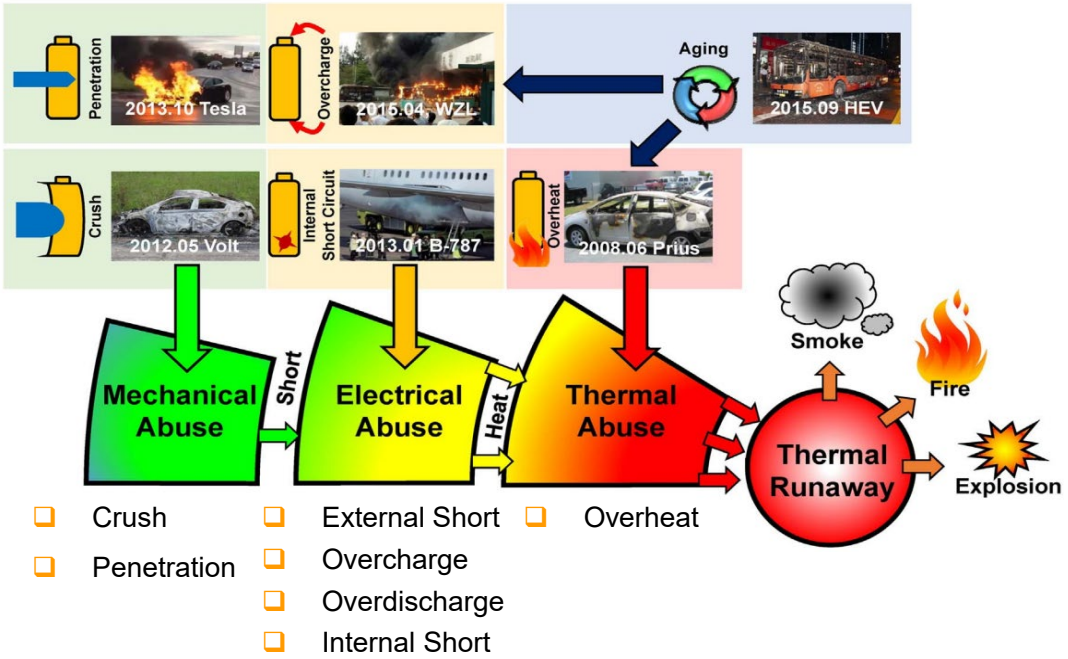


Where Are the Sensor Used?

Sensors are everywhere.

Battery Thermal Runaway Event

- Thermal runaway is an uncontrolled chain reaction caused by mechanical, electrical, thermal abuses or a combination of abuse.
- Thermal runaway leads to battery uncontrolled self-heating up to 400-1000℃ and easily propagates to other cells which could end with a destructive result like fire or explosion.

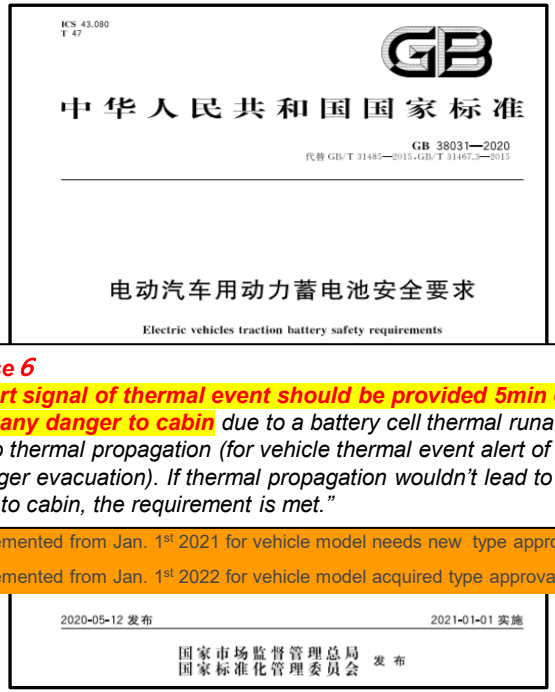


Though the battery technology is kept on optimizing,

the thermal runaway events are still unavoidable nowadays!

Safety Legislations for Thermal Runaway

CN MIIT legislation of
'Electric vehicles traction battery safety requirements'
*Effective on **Jan 1st 2021**.*


ICS 43.080
T 47

中华人民共和国国家标准

GB 38031—2020
代替 GB/T 31485—2015，GB/T 31467.3—2015

电动汽车用动力蓄电池安全要求

Electric vehicles traction battery safety requirements

2020-05-12 发布　　2021-01-01 实施

国家市场监督管理总局
国家标准化管理委员会　发布

Purpose 6
*"**An alert signal of thermal event should be provided 5min earlier before any danger to cabin** due to a battery cell thermal runaway leads to thermal propagation (for vehicle thermal event alert of passenger evacuation). If thermal propagation wouldn't lead to any danger to cabin, the requirement is met."*

- Implemented from Jan. 1st 2021 for vehicle model needs new type approval.
- Implemented from Jan. 1st 2022 for vehicle model acquired type approval.

NEV Global Safety Technical Specification / EVS-GT unanimously approved at the 174th conference of WP.29 in Mar.2018.

- EVS - GTR Phase 1
  - Scheduled for adoption March 2018
  - Amended ECE R 100 adopted end of 2020
- EVS - GTR Phase. 2 / mandatory
  - No ext. fire / explosion / smoke in cabin within 5 minutes after warning
  - Implementation 2020 and beyond
  - China earlier (2020)
  - Status:
    - Adoption end 2021
    - Amended ECE R 100 adopted 2023

What's Hidden Behind the Thermal Runaway Events?

2021/12/22 driving

2022/3/22 Driving

2020/8/20 Charging

2022/4/21 Charging

2020/10/5 Parking

2022/5/15 Parking

Vehicle status of thermal runaway event

Status	2018	2019	2020	2021	2022
Driving/%	36	41	38	40	40
Charging/%	43	19	19	35	22
Parking/%	21	40	43	25	38
*Source	China EV Battery Safety Summit, August 2018	https://www.d1ev.com/news/jishu/97394	https://zhuanlan.zhihu.com/p/363323648	2022 World Power Battery Conference -- Jinhua Sun	http://www.360doc.com/content/22/1206/02/33818803_1059111103.shtml

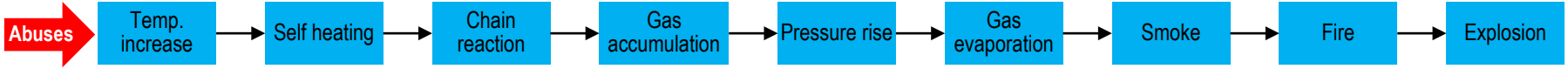
** The statistics are based on some reported thermal runaway events*
Accident caused events are classified in Driving mode

Possible causes of thermal events during parking

1. When the vehicle is parked, thermal management system stops working but hot battery's heat may not be completely dissipated yet;
2. Environmental temperature can reach over 65℃ in summer, which exceeds the operating temperature range of NCM battery;
3. High humidity/water cause short of electrical components.

Thermal runaway detection during **parking** is essential for safety & legislation compliance

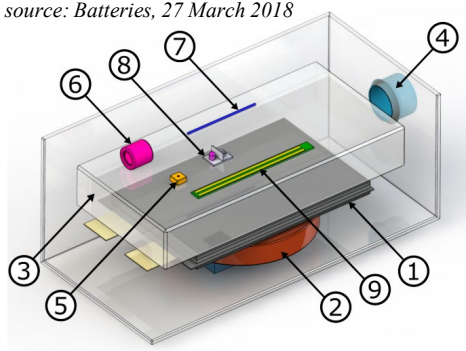
Thermal Runaway Process & Detection



Temperature, Pressure, Gas .etc Can Be Measured as Signal to Indicate Thermal Runaway
Which One is the best (Fast, Most Reliable and Low Cost)?

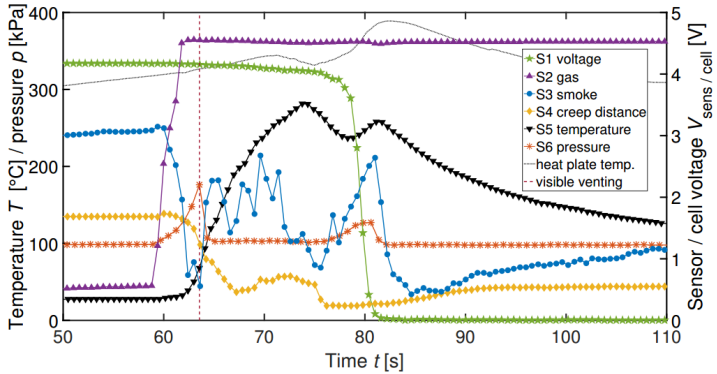
Thermal runaway Detection solutions

Data source: Batteries, 27 March 2018



1. Battery cell
2. Heat plate
4. Vent opening
5. Pressure sensor
6. Gas sensor
7. Temp. sensor
8. Smoke detector
9. Creep distance sensor

Sensor	Detection Speed	Signal Clarity	Sensor Feasibility
S1 voltage	-	+	+
S2 gas	+	+	-
S3 smoke	-	0	0
S4 creep distance	-	-	+
S5 temperature	0	0	0
S6 pressure	+	-	+
S7 force	+	-	0



Conclusions:

- Gas, Pressure, Smoke, and force have shown to react the fastest. And pressure sensing is the one with highest feasibility.
- Signal clarity can be addressed by software algorithm.
- Pressure measurement does not depend on position within battery, because pressure travels with the speed of sound.

Detection methods Comparison

- **Why current BMS (voltage, current & temperature) is not sufficient for thermal runaway detection?**
  - ✓ BMS with low confidence level to detect thermal runaway if no additional sensing
  - ✓ High probability of cell signal lost since CMU or harness be damaged in early stage due to high temperature venting
  - ✓ BMS can't achieve 24/7 operation especially in parking due to power consumption
- **Sensing technologies comparison**

Sensor type	Qualified Auto grade	Detecting speed	Reliability	Signal clarity	Power consumption	Diagnostics	Flexibility[2]	System cost
Pressure	+	+	+	0	+	+	+	+
Gas	–	+	–	+	–	0	0	0
Smoke	–	–	–	0	0	0	0	0
T (point)	+	0[1]	+	0	+	+	–	0
T (cable)	–	+	0	+	+	0	–	–

Note1: T(point) is position sensitive
Note2: Including flexibility for mounting location/position and the flexibility to adapt different cells, modules and packs

Pack pressure is the best add-on signal for thermal runaway detection (well recognized by most OEMs)
Pressure (coupled with V/T from BMS) is the most reliable, easy-to-use and cost-effective system solution

Churod Smart Solution – More than a Pressure Sensor

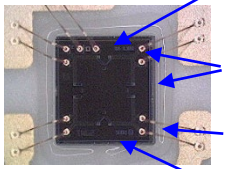
- Churod Smart BPS enables parking mode with BMS wakeup function and low power consumption.

Churod Sensing Smart Battery Pressure Sensor Solution (BPS)

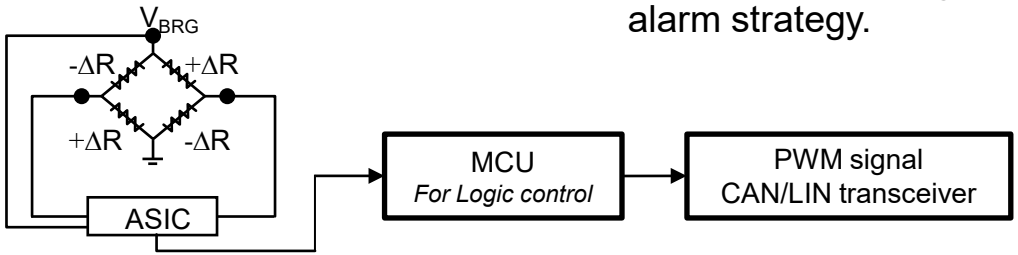
Churod Smart BPS's Value

- Proven algorithm to eliminate false warning and miss warning for thermal runaway with **high reliability**
- Extremely **low power consumption** during parking (<0.2mA)
- 24/7 operation, and offer **wakeup BMU** function during parking
- **Automotive Grade** Design
- **Easy to mount,** and independent from mounting position
- **Quick response** & warning to thermal propagation within 10s
- Help Customer to **reduce system cost**

Sensing Technology - Working Principle



- Pressure across diaphragm results in tensile stress in center, compressive stress at edge
- Strain-sensitive piezo resistors are implanted in silicon substrate and connected in a full bridge configuration
- Applied pressure results in a bridge imbalance that is amplified and compensated in signal conditioning electronics
- MCU is used for logic control for different working mode and alarm strategy.

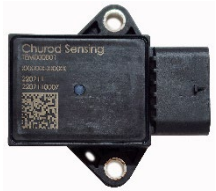


PRESSURE APPLIED → MECHANICAL DEFLECTION/ STRESS → SILICONE PIEZORESISTIVE EFFECT → CONDITIONING ELECTRONICS → PWM/CAN/LIN OUTPUT PROPORTIONAL TO MECH. INPUT

BPS Roadmap

Gen 1 BPS

- Protocol: ***CAN/PWM/LIN***
- Power supply: 6~18V, 12V typ.
- Power consumption:
  - <35mA @ high power operating
  - <0.2mA @ BMS sleep mode
- Working temperature: -40~125degC
- Pressure range:
  - 50~165KPaA
  - Providing customization
- Accuracy:
  - ±1% FS @ 0 ~ 100degC
  - ±2% FS @ -40 & 125degC
- Automotive grade electronics w/ MCU
- BMS Wakeup & Sensor status warning

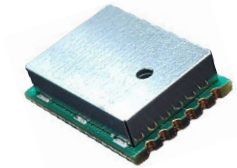


Schedule

- In Production

Gen 2 BPS

- Protocol: ***UART/IIC***
- Power supply: 3~5.5V
- Power consumption:
  - <7mA @ high power operating
  - <0.06mA @ BMS sleep mode
- Pressure range:
  - 50~165KpaA
  - Providing customization
- Accuracy:
  - ±1% FS @ 0 ~ 100degC
  - ±2% FS @ -40 & 125degC
- **State machine and software algorithm can be transferred directly from Gen 1 product**
- **Low cost**

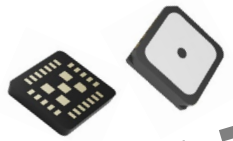


Schedule

- 2022. 10 → B Sample
- 2023. 6 → C Sample
- 2023. 10 → SOP

Gen 3 BPS

- ***Protocol: UART***
- Power supply: 3.3V
- Power consumption:
  - <7mA @ high power operating
  - <0.06mA @ BMS sleep mode
- ASIL C (TBD)
- **State machine and software algorithm can be transferred directly from Gen 1 & Gen 2 product**
- **Low cost**



Schedule

- 2023. 6 → B Sample
- 2023. 9 → C Sample
- 2023. 12 → SOP

Target Customers

Battery Pack Suppliers：

CATL 宁德时代 · LG Energy Solution · 国轩高科 GOTION HIGH-TECH · SAMSUNG SDI · SK on

ARASIS 孚能科技 · SVOLT 蜂巢能源 · 华人运通 HUMAN HORIZONS · 。。。

Key OEMs Globally：

蔚来 NIO · 长城汽车 专注 专业 专家 · 长安汽车 CHANGAN AUTO · 理想 · 小鹏汽车 XPENG MOTORS · 吉利汽车 GEELY AUTO · 上汽大通 MAXUS

HYUNDAI · KIA Movement that inspires · GM · Ford · DAIMLER · Das Auto. · STELLANTIS · 。。。

Power Storage Companies：

SUNGROW 阳光电源 · HUAWEI · EVE 亿纬锂能 · BYD · 。。。

Thanks！