Technical Ceramics in Pressure Sensors: Why, When, and Where Are They Used?

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CoorsTek®

Agenda

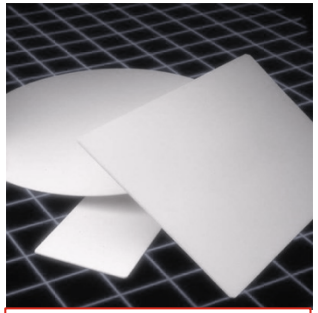
- Brief CoorsTek overview
- Pressure sensors explained
- Why, when, and where are Technical Ceramics used
- Choose the right Technical Ceramics partner

Brief CoorsTek Overview

Heritage of Innovation

GOLDEN POTTERY

ISOSTATIC PRESSED GRINDING MEDIA



THIN-FILM SUBSTRATES

GLOBAL EXPANSION

COORS CERAMICS BECOMES COORSTEK

CENTER FOR ADVANCED MATERIALS

1870s

COORS BREWERY IN GOLDEN/COLORADO

1900s

1920s

WORLD LEADER IN LABWARE

1940s

CERAMIC-TO-METAL BONDING

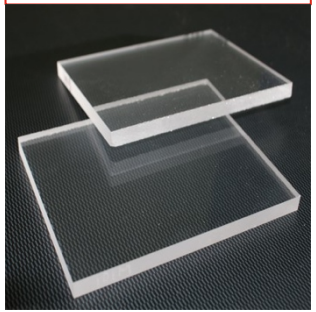
DRY PRESS FORMING

RECYCLABLE ALUMINUM CAN

1960s

1980s

ADVANCED TECHNICAL CERAMICS



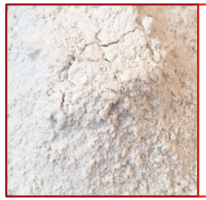
2000s

PURESIC® CVD SILICON CARBIDE

DURA-Z™ ZIRCONIA

PLASMAPURE-UC™ ALUMINA

Technical Ceramics Leader



61/118
Utilizing over ½ of Earth's known elements

GLOBAL CAPACITY
500,000 m^2 ceramic manufacturing space

EXPERTISE
6,000 employees worldwide

½+

CoorsTek

6000

Materials Expertise

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Over ½ of Earth's known elements

>300 advanced ceramic material formulations

∞ custom options, one optimized solution

300+ Technical Ceramic Compounds

OXIDES

ALUMINAS

SILICATES

RARE EARTHS

ZIRCONIAS

NON-OXIDES

CARBIDES

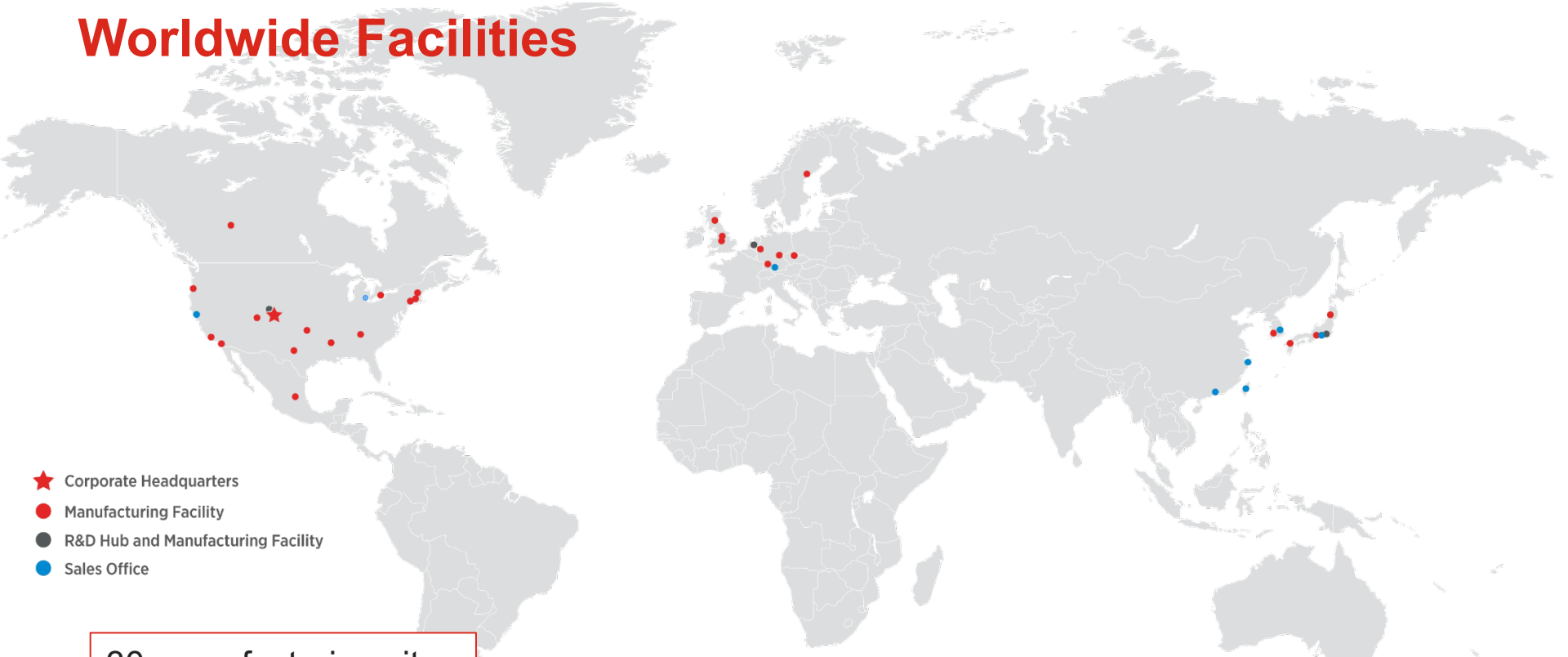
NITRIDES

SPECIALTY

COMPOSITES

CUSTOM

Worldwide Facilities



30 manufacturing sites

Technology & manufacturing customers in 70 countries

Connect & collaborate worldwide

Diverse Offerings in Key Global Markets

AUTOMOTIVE

DEFENSE & AEROSPACE

CHEMICALS & ENERGY

SEMICONDUCTOR

Diverse Offerings in Key Global Markets

CHEMICALS

CONSUMER & HOUSEHOLD

ELECTRONICS

EQUIPMENT & MANUFACTURING

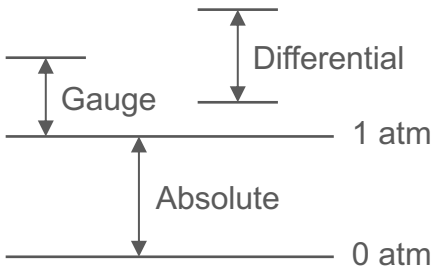
AGRICULTURE & NUTRITION

MEDICAL

Pressure Sensors Explained

Basic Physics of Pressure Sensing

$$P = \frac{F}{A} \; or \; \frac{\Delta F}{\Delta A}$$



In practice, many noise factors exist

Where:

P = Pressure

F = Force

A = Area

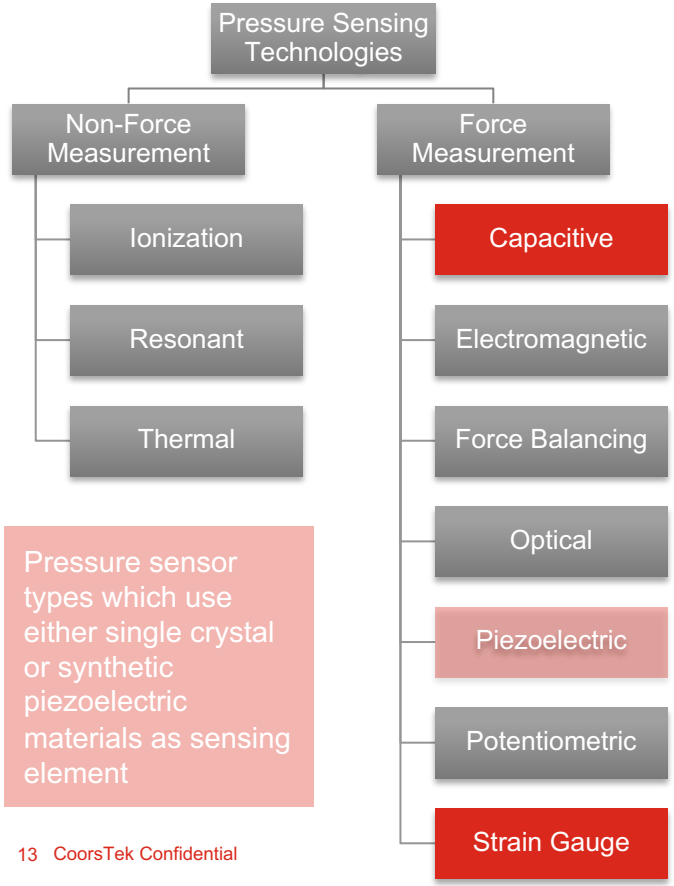
Δ = Change in

- **Absolute Pressure:** Measured relative to a perfect vacuum
- **Differential pressure:** Difference in pressure between two points of Measurement
- **Gauge Pressure:** Measured relative to ambient pressure

- **Gas Effects:** Gases are highly compressible
- **Temperature Effects:** Temperature can influence density and other mechanical properties
- **Dynamic Effects:** Most practical applications involve dynamic pressures

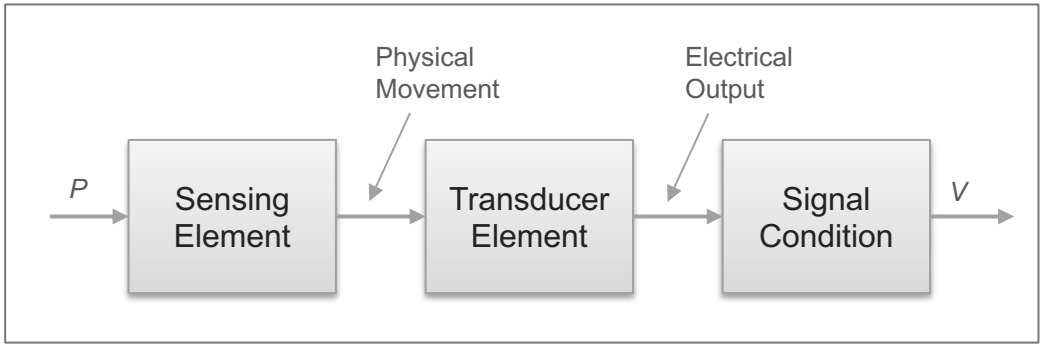
Source: Bicking, Robert E. "Fundamentals of Pressure Sensor Technology." *Sensors Magazine*, 1 Nov. 1998, www.sensorsmag.com/components/fundamentals-pressure-sensor-technology.

Pressure Sensing Technologies



Pressure sensor types which use either single crystal or synthetic piezoelectric materials as sensing element

Functional Block Diagram of Basic Pressure Sensor



Pressure sensor types that commonly use technical ceramics shown in dark red

Source: Bicking, Robert E. "Fundamentals of Pressure Sensor Technology." *Sensors Magazine*, 1 Nov. 1998, www.sensorsmag.com/components/fundamentals-pressure-sensor-technology.

Why, When, and Where Are Technical Ceramics Used

Why Technical Ceramics?

MECHANICAL

- Hardness
- Rigidity
- Toughness
- Wear

THERMAL

- Shock & Stability
- Conductivity
- Expansion
- Creep

CHEMICAL

- Corrosion
- Biocompatible
- Ultra-pure
- Inert (or active)

ELECTRICAL

- Resistivity
- Conductivity
- ESD-safe
- Dielectric Strength

Why Use Technical Ceramics for Pressure Sensors?

- **Durability** – Ceramics are inherently resistant to chemical corrosion and mechanical abrasion
- **Reliability** – Ceramic diaphragms operate at their calibrated values longer than other conventional materials
- **Precision** – Ceramics can be manufactured into complex and precise form factors for optimal packaging
- **Temperature** – Ceramics maintain superior thermal stability during extreme temperature exposure

When and Where Are Technical Ceramics Used?

Pressure Sensors

Range	Classification
<10 bar	Low
10-100 bar	Medium
100-250 bar	High
>250 bar	Extreme

Ceramic sensors commonly used in medium range applications

Ceramic pressure sensors are ideally suited for high duty cycle applications and can handle a wide range of working media. This combination of requirements commonly exist in the following industries:

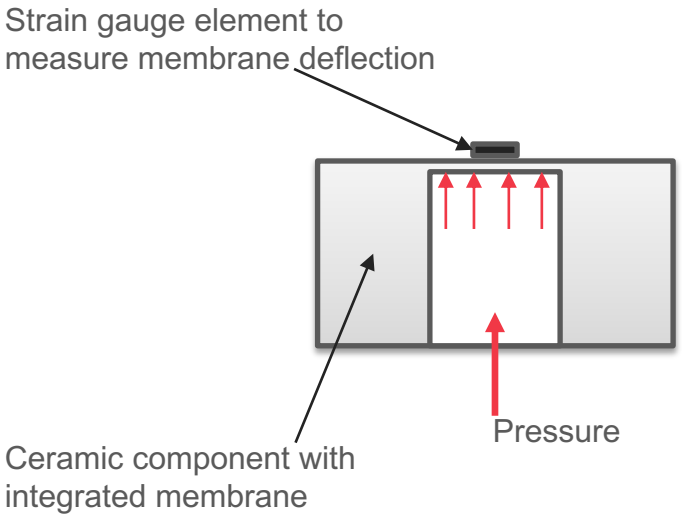
- Agricultural & Off-Road Vehicles
- Automotive & Transportation
- Energy & Chemical
- Equipment & Machinery
- Food & Beverage
- Heating, Ventilation, and Air Conditioning (HVAC)
- Medical
- Military



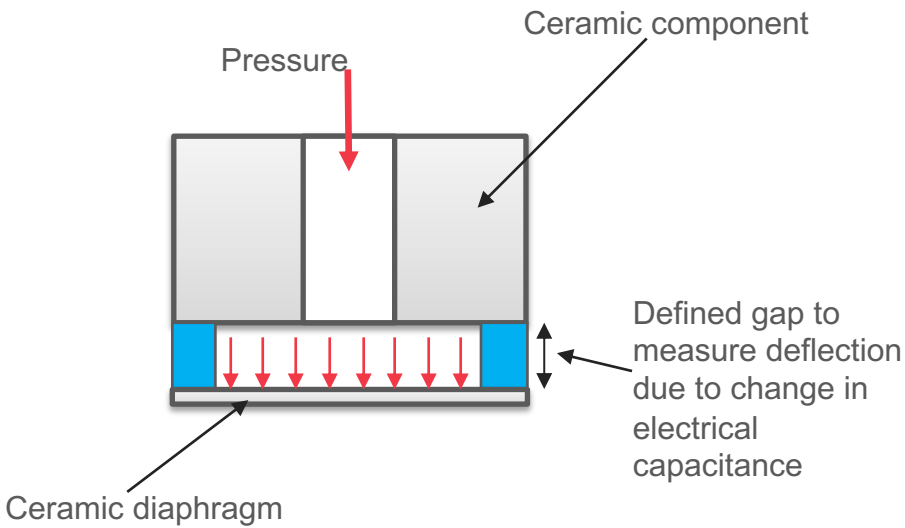


Pressure Sensing Technologies using Technical Ceramics:

Strain Gauge



Capacitive



Choose The Right Technical Ceramics Partner

Choose The Right Technical Ceramics Partner

Ease of Doing Business **Global presence**	Design Expertise **Material and manufacturing**	Material Portfolio **Customized material options**
Manufacturing Capabilities **Vertically integrated**	Advanced Secondary Processing **Single source service**	Quality Systems **State of the Art**

Thank You

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CoorsTek Stand 1-101

CoorsTek