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Overview of types of BVT Electrochemical Amperometric Sensors AC1.W * .R *

Sensor is formed on a corundum ceramic base by screen printing. First layer consists of contacting fields made of Ag. Working (WE), auxiliary (AUX/CE) and reference (RE) electrodes from variety of material are applied on to this surface, In final step, conductive lines connecting contats with active part of sensor are covered by a polymer or ceramic dielectric protection layer.

SENSOR TYPE		MATERIAL					
		contacting fields	WE	AUX/CE	RE	dielectric protection layer	
AC1.WS	RS	Ag	Au+Pt alloy	Au+Pt alloy	Ag	ceramic	
	R1				65% Ag + 35% AgCl (in polymeric binder)	polymer	
	R2				Ag covered by AgCl electrolytically	ceramic	
AC1.W1.	RS	Ag	Au	Au	Ag	ceramic	
	R1				65% Ag + 35% AgCl (in polymeric binder)	polymer	
	R2				Ag covered by AgCl electrolytically	ceramic	
AC1.W2.	RS	Ag	Pt	Pt	Ag	ceramic	
	R1				65% Ag + 35% AgCl (in polymeric binder)	polymer	
	R2				Ag covered by AgCl electrolytically	ceramic	
AC1.W3.	RS	Ag	Ag	Ag	Ag	ceramic	
	R1				65% Ag + 35% AgCl (in polymeric binder)	polymer	
	R2				Ag covered by AgCl electrolytically	ceramic	
AC1.W4.	RS	Ag	Carbon(Graphite) (in polymeric binder)	Carbon(Graphite) (in polymeric binder)	Ag	polymer	NONSTANDARD TYPE +20% price, min. order 100 peaces
	R1				65% Ag + 35% AgCl (in polymeric binder)	polymer	
	R2				Ag covered by AgCl electrolytically	polymer	NONSTANDARD TYPE +20% price, min. order 100 peaces
AC1.W5. with Manually Microdispensed Carbon (Graphite)	RS	Ag	Manually Microdispensed Carbon (Graphite) (in polymeric binder)	Au+Pt alloy	Ag	ceramic	
	R1				65% Ag + 35% AgCl (in polymeric binder)	polymer	
	R2				Ag covered by AgCl electrolytically	ceramic	

Please note, that polymeric binder has limited resistance to organic solvents and sonification. Polymeric dielectric protection layer has limited resistance to organic solvents. Ceramic protection layer has limited resistance to strong acids.

BVT offers two types of Carbon (Graphite) sensors (see table above):

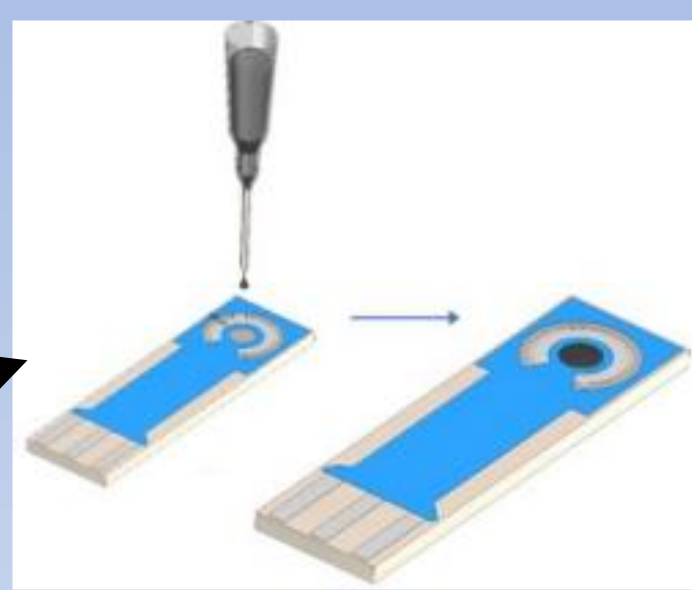
AC1.W4. with screen printed Carbon (Graphite) WE and AUX/CE

Auxiliary and **working electrode are made by screen printing** - printed Carbon (Graphite) working electrode has **better properties in terms of surface reproducibility** but has greater resistance between the electrode and the measuring device. The last production step is a polymeric dielectric protection layer, which is weak to organic solvents (this needs to be taken into account when ordering and carrying out tests).

AC1.W5. with Manually Microdispensed Carbon (Graphite) WE on printed Au+Pt alloy (Au+Pt alloy AUX/CE)

In the first phase of production, the auxiliary electrode is made of a chosen material (Pt+Au alloy) by screen printing. Then **Carbon (Graphite) as a working electrode is applied by microdispensing manually (a precise amount of Carbon (Graphite) is applied as drop, by a specialised syringe)** - manually applied working Carbon (Graphite) electrode has **better properties in terms of conductivity** between the active surface and the input of the device, but it is not possible to ensure reproducibility of the surface in same level as in screen printing.

Microdispensing is when a precise amount of Carbon (Graphite) is applied (manually) as a drop by a specialised syringe, see the image.



Please note that each material of RE has different mechanical and chemical properties

RS - Ag

97-98% Ag reference electrode with additives (2-3%) for better adhesion. Reference layer is partially covered by ceramic dielectric layer which is fired in temperatures more than 850°C. They have **excellent resistance against temperature and organic solvents**. They have lover resistance against acids and bases. The electrodes AC1.W*.RS **can be heated up to 600°C** (except of W4.RS and W5.RS).

R1 - 65% Ag + 35% AgCl (powder mixture in polymeric binder)

Ag/AgCl (65%:35%) reference electrode. Polymeric binder with limited resistance to organic solvents and sonification. Reference layer is covered by polymer dielectric layer which is cured at low temperatures. They **have limited resistance to temperature and organic solvents**. They are **resistant against bases and acids**.

The electrodes AC1.W*.R1 **can be heated to 150°C to about 2 hours** until significant change of parametres. The longer curing will cause reference electrode degradation. **If your measurement is sensitive to silver contamination, prefere R2 or RS reference electrode.**

R2 - Ag covered by AgCl electrolytically

Ag reference electrode (RS), then covered by AgCl electrolytically. The color of this layer can be from light to dark brown. This layer **degrades under the influence of light and in ammonia**. The electrodes AC1.W*.R2 **can be heated up to 300°C** (except of W4.R2 and W5.R2).

Active layers properties

Working electrode made of pure metals can have low adhesion. **The active surface of sensors lies in range ± 10%**. Bigger active surface has beter geometrical acuracy. The lifetime of sensors with fired layer is some years. The sensors quality is controled statistically. It is possible to deliver sensors with lower parameters variability. It is not possible to assure 100 % reproducibility of sensors from one batch. Active surface is sensitive to mechanical demages, contamination by fingers and light. The measurement is influenced by used chemicals quality and sensor connector quality.

WS – Au+Pt alloy: The active layer is from Au+Pt alloy. Main advantage – good adhesion and chemical resistance.

W1 – Au: The active layer is from pure Au.

W2 – Pt: The active layer is from pure Pt. This layer can be destroyed by sonification, current over 10 mA and mechanical cleaning.

W3 – Ag: The active layer is from pure Ag.

W4 and W5 – Carbon (Graphite)

This layer can be created by **printing (W4)** or **microdispensing (W5)**. The resulting printed layer (W4) has a working and auxiliary electrode made of Carbon (Graphite), the dielectric layer is made of polymer.

The coated layer (W5) is made by microdispersing. It has only a working electrode made of Carbon (Graphite), the auxiliary electrode is made of another material (Au+Pt alloy), the dielectric is usually ceramic.

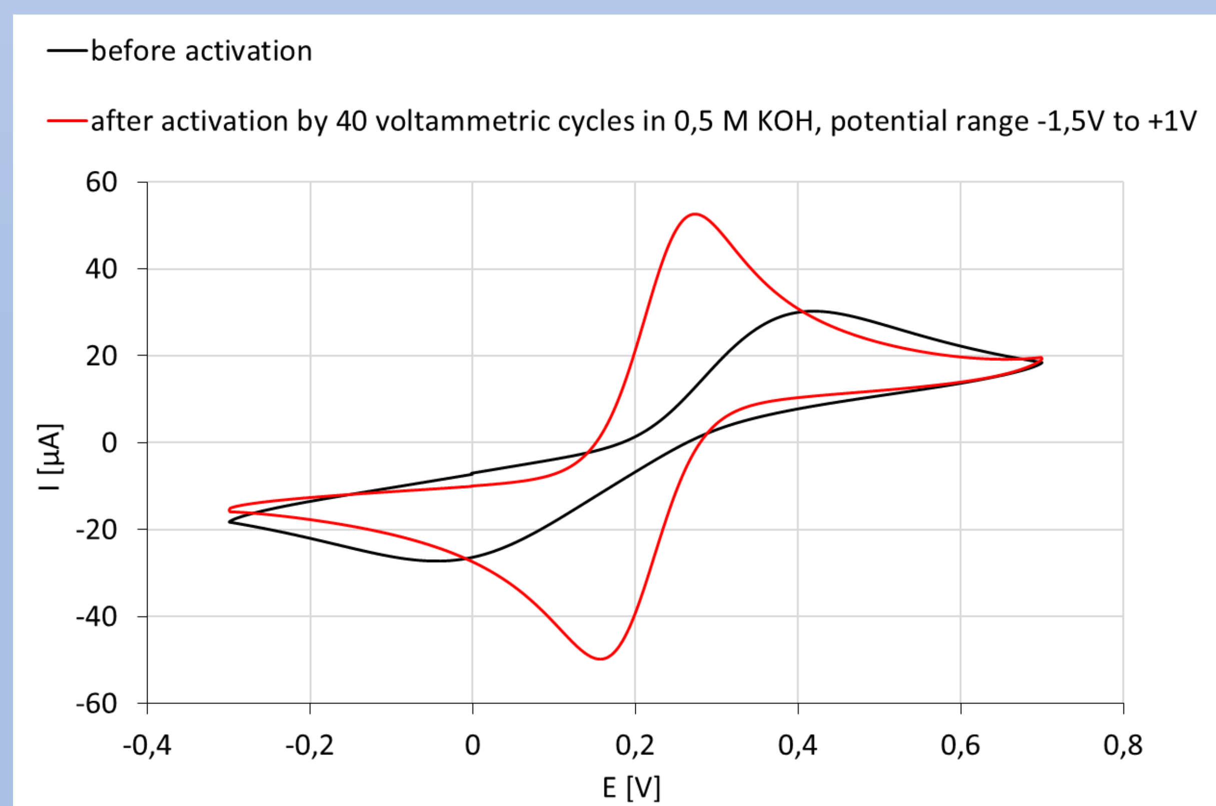
Polymeric binder of active graphite layer has limited resistance to organic solvents and sonification. Main difference - the resistance of W4 and W5 surface and output contact lies in range (0,1-10 kΩ) and (1-10 Ω) respectively.

BVT offers *unactivated versions of both graphite sensors W4 and W5 for standard tests and direct measuring. For specialised testing and more precise results **it is recommended to have the W4 and W5 activated** – see graph.
(the activation in most cases, is unique for each type of test being carried out).

***BVT also offers activated graphite sensors on customer request**
(standard with repeated CV scans in KOH, see graph on the right). →

Carbon (Graphite) SPE sensor activation example: AC1.W4.RS (2 mm WE)

CV scans of Graphite SPE sensor **before** and **after activation**, measured in a 3-electrode arrangement by cyclic voltammetry **in 0.005 M ferri-ferro potassium cyanide in 0.2 M KOH**, potential range -300 to +700 mV, scanning rate 50 mV/s.



Graphite WE of the SPE sensor **activated** by 40 voltammetric cycles in **0.5 M KOH** in a 3-electrode arrangement **using an external ! Pt AUX and an external ! Ag/AgCl REF**, potential range -1500 to +1000 mV, scan rate 100 mV.

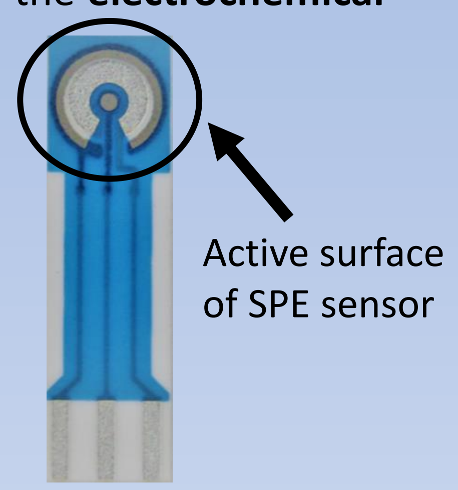
CC – conductometric sensors

CC sensors require a minimum frequency of 100 kHz to measure conductivity. For these sensors, the customer must perform his own calibration, because the response of the sensor will also depend on the chamber in which the measurement will be performed.

Measurement conditions, sensor handling and storage

The **sensors measure best in flow mode** (for this purpose we offer the **flow cell FC2, FC3, FC4** - see https://bvt.cz/kategorie-produktu/cell/flow-cells/), the active surface of the sensor with electrodes mustbe immersed in the measured solution (for this purpose we offer the **electrochemical glass cells TC4, TC5, TC6, TC7, TC9** – see https://bvt.cz/kategorie-produktu/cell/glass-cells/).

The active surface of the **sensor should not be wiped mechanically or with a cloth** with an organic solvent - there is a risk of contamination of the working electrode of the sensor with silver by its mechanical transfer from the reference electrode. The active surfaces of the **sensor should not be touched by fingers** during handling.



The active surface of the **sensor can be rinsed or immersed, sensors can be dried in an oven up to 150 °C (max. 2 hours) or left to dry freely . Sensors should be stored in a closed box with silica gel away from light**.