

Electrochemical Biosensor Materials



GWENT GROUP
ADVANCED MATERIAL SYSTEMS

The Gwent Group

The development of biosensors has been rapid during recent years. Recent key developments have been the integration of sensor systems, miniaturisation of smaller systems, cheaper components, and mass production.

Why the Gwent Group?

Gwent Electronic Materials Ltd (GEM) and Applied Enzyme Technology (AET) are leaders in ink manufacturing and sensor/biosensor development. As well as our standard product range, we can manufacture products directly for individual customers and these products are tailored to suit specific processes.

Our sister company AET has core expertise in protein stabilisation. Our patented technology has resulted in the successful stabilisation of many enzymes, spanning a wide variety of applications.

The synergy between the two companies brings together the expertise of AET in enzyme stabilisation and the skills of GEM in the design and production of specialist electronic sensor materials. This gives us the unique position to offer a '1 stop shop' for the development and production of Biosensors.

Our company has designed materials for many applications including Diagnostic Sensors, Environmental Sensors and Electrochemical Sensors.

GEM and AET prides themselves on high standards and quality we have obtained ISO 9001:2000 and ISO 13485: 2003 for the development, design and manufacture of medical devices.



Electrochemical Sensors and Biosensors

Introduction

Bio-Sensors can be used in many different applications; at GEM we have split our range of base transducers into three distinct areas which are; diagnostic sensors, environmental sensors and agri-food sensors.

The main application method for non-biological base transducers is screen-printing; however, materials can be supplied that are suitable for flexographic or gravure printing. There are three distinct types of sensor materials that we manufacture and sell at GEM: high temperature materials, thermoplastic polymeric materials and thermosetting polymeric materials which are suitable for electrochemical sensors and biosensors.

We can offer a full **screen-printing** prototype service for base electrode manufacture in a class 100 clean room for any of the above systems; many customers use this route before purchasing their own screen-printing equipment.

Although the main application method uses screen printing we are able to tailor materials to ensure suitability for **flexographic** or **gravure printing**. Please contact our sales department if you require information on materials for these printing techniques.

GEM will supply individual sensor inks for niche large-scale applications. All of our materials and ink systems can be supplied to ISO 9001:2000 or ISO 13485:2003 quality specifications; this allows full traceability throughout our manufacturing and production processes.

Materials for Screen Printed Electrochemical Sensors and Biosensors

The two main areas where our materials are used are single shot disposable sensors as used in the detection of blood glucose, and reusable systems as used for blood gas analysis.

The major measurement technique used for electrochemical sensors is chrono-amperometry our materials can also be used for both potentiometric and coulometric measurements.

High Temperature Materials

High temperature materials are commonly used in flow through reusable sensors as used for blood gas analysis but they have a wide range of uses in all three-market sectors. They are often used when a low voltage or current needs to be measured, as they tend to have lower electronic noise than polymeric systems. We offer a wide range of precious metal based printing systems which can be used for working, counter and/or reference electrodes.

Polymeric Materials

Our polymeric materials are split into two ranges. If membrane systems containing polar solvents are used in conjunction with our materials then we would recommend our thermosetting systems as these will withstand re-solvation by strong solvents. If membranes are not included then our normal thermoplastic systems are recommended.

Polymeric materials have to be formulated for individual polymer support structures; the most commonly used polymer substrate materials are PVC and polyester.

We supply a wide range of carbon-graphite **working electrodes ink** materials for all forms of electrochemical analysis. These include chrono-amperometry and potentiometric methods. The formulations are customized to meet the analytical requirements of the analytical test and the specific electrode design constraints. A number of key electrochemical and surface properties can be customized to meet customer requirements

Reference electrode materials are normally silver/silver chloride but other metal and carbon systems are available. Popular ratios of Ag/AgCl are 50: 50, 60:40, 70:30, 80:20 and 90:10. Other ratios can be formulated to meet individual customer requirements.

A range of polymer **dielectrics and cover coats** are available based on a wide variety of different polymer chemistries, which include polyester, acrylic, and butyl rubber systems. They are formulated so that they do not contaminate the working electrode area; their physical properties can be adjusted to concentrate the sample within the working area of the electrode.

Complete sensor systems of both working and reference materials can be offered and tailored to meet individual customer requirements, these materials can be tested, electrochemically in-house to ensure that they conform to agreed specifications.

Pastes for Screen Printing Electrochemical Sensors and Biosensors

Working Electrodes Materials

- **Unmediated Carbons** – This range of products gives superior electrochemical performance and a low coefficient of variation. We offer a wide range of metallised and non-metallised carbon graphite pastes for different electrochemical applications.
- **Metallic Inks** - This range of metallic and metal-coated carbon inks include low and high temperature materials.
- **Mediated carbons** - Mediators are materials that lower the overall potential within an electrochemical reaction. Mediators can be used with different types of enzyme for instance Cobalt Phthalocyanine and Prussian Blue, lower the oxidation potential when oxidase enzymes producing H_2O_2 are used. While Meldolas Blue lowers the oxidation potential of NADH and is effective in conjunction with NADH dependent dehydrogenases.

Reference Electrodes Materials

- All of our reference electrode materials are based on Silver/Silver Chloride. These are supplied in various ratios to meet specific customer's needs for response and conductivity.
- Pseudo carbon reference electrode materials are also available.
- We also have a high temperature Silver/ Silver Chloride system.

Counter Electrode Materials

- The range includes Carbon, Silver/Silver Chloride, Silver polymer and high temperature Silver/Silver Chloride. These are all highly conductive materials, which have been designed to have low resistance.

Insulator/ Polymer Dielectric Materials

- These can be used to define the working electrode area or to isolate a sensitive part of the circuit and minimise the pin-holing effect.

Adhesives for Diagnostic Sensors

- Our adhesives are screen printable and are used in sensor construction.

Products for Flow Injection analysis and Membrane Disposition

- This range offers a superior cross-linking effect that enhances the resistance to polar solvents.

Research and Development

- We can design and tailor make materials to fit your requirements.

Electrode Type	Paste Type	Product Code	Compatible Substrates	Primary Applications	Additional notes	Product Benefits
Working/Counter	Carbon/Graphite	C2000802P2	Alumina, Polyester, PVC, Valox FR1	Used for determination/measurement of electrochemical active components. Can be used in the development of electrodes, sensors and biosensors.	Resistivity: 40 Ohms/square at 25 microns	Low viscosity
Working/Counter	Carbon/Graphite	C2030519P4	Alumina, Polyester, PVC, Valox FR1	Used for determination/measurement of electrochemical active components. Can be used in the development of electrodes, sensors and biosensors.	Resistivity: 24 Ohms/square at 25 microns	Medium viscosity
Working/Counter	Carbon/Graphite	C2050517D1	Alumina, Polyester, PVC, Valox FR1	Used for determination/measurement of electrochemical active components. Can be used in the development of electrodes, sensors and biosensors.	Resistivity: 103 Ohms/square at 25 microns	High Viscosity
Working	Meldola's Blue mediated Carbon	C2030519P5	Alumina, Polyester, PVC, Valox FR1	Used in the determination of NADH. Can be used in the development of biosensors in conjunction with dehydrogenases		Used in the determination of NADH.
Working	Cobalt Phthalocyanine mediated Carbon	C2030408P3	Alumina, Polyester, PVC, Valox FR1	Used in the determination of hydrogen peroxide. Can be used in the development of biosensors in conjunction with oxidases		Used in the determination of hydrogen peroxide at a high potential.
Working	Prussian Blue mediated Carbon	C2070424D2	Alumina, Polyester, PVC, Valox FR1	Used in the determination of hydrogen peroxide. Can be used in the development of biosensors in conjunction with oxidases		Used in the determination of hydrogen peroxide at a low potential. Suitable for use in flow injection systems.
Working	Polymeric Gold	C2041206D2	Alumina, Polyester, PVC, Valox FR1	Used for electrochemical sensors and biosensors. Can be used for self-assembled monolayers in enzymatic biosensors, as well as DNA and immuno sensors		Used for immunosensors
Working	High Temperature Gold	C2070117D2	Alumina	Used for electrochemical sensors and biosensors. Can be used for self-assembled monolayers in enzymatic biosensors, as well as DNA and immuno sensors		Higher conductivity than polymeric gold. Lower signal to noise ratio. Suitable with polar solvents on high temperature substrates.
Working	Cross link Polymeric Platinum	C2040323D1	Alumina, Polyester, PVC, Valox FR1	Used for electrochemical sensors and biosensors. Can be used to detect Hydrogen peroxide and to develop biosensors based on oxidase type enzymes as well as DNA/Immuno sensors.		Used with polar solvents where low temperature cure is required.
Working	Polymeric Platinum	C2050804D9	Alumina, Polyester, PVC, Valox FR1	Used for electrochemical sensors and biosensors. Can be used to detect Hydrogen peroxide and to develop biosensors based on oxidase type enzymes as well as DNA/Immuno sensors.		Used for electrocatalytic sensors without a need for a mediator.
Working	High Temperature Platinum	C51002D6	Alumina	Used for electrochemical sensors and biosensors. Can be used to detect Hydrogen peroxide and to develop biosensors based on oxidase type enzymes as well as DNA/Immuno sensors.		Used with polar solvents on high temperature substrates.
Working	Platinised Carbon	C2000511D1	Alumina, Polyester, PVC, Valox FR1	Used for electrochemical sensors and biosensors. Can be used to detect Hydrogen peroxide and to develop biosensors based on oxidase type enzymes as well as DNA/Immuno sensors.		Used for electrocatalytic sensors without a need for a mediator. Has a high surface area.
Connectors	Polymeric Silver	C2080415D2	Alumina, Polyester, PVC, Valox FR1	Used for improving the conductivity and making better contacts. Can be used as a highly conductive layer under the carbon layer.	A 45% Silver paste. Suitable for use with design BE2050621D1	Used as a highly conductive layer under the carbon layer.
Connectors	Polymeric Silver	C2081126D2	Alumina, Polyester, PVC, Valox FR1	Used for improving the conductivity and making better contacts. Can be used as a highly conductive layer under the carbon layer.	A 65% Silver paste. Suitable for use with design BE2050621D1	Used as a highly conductive layer under the carbon layer.
Reference	Silver/Silver Chloride (60:40)	C61003P7	Alumina, Polyester, PVC, Valox FR1	Can be used as a reference electrode.	Other ratios of silver /silver chloride available e.g. 70:30, 80:20, 90:10	Most common screen printed reference electrode.
Insulator	Grey Dielectric	D2070423D5	Alumina, Polyester, PVC, Valox FR1	Insulative layer to determine electrochemical cell surface and avoid shorting.	Grey	Most popular dielectric. Flexible.
Insulator	Green Dielectric	D2070412D3	Alumina, Polyester, PVC, Valox FR1	Insulative layer to determine electrochemical cell surface and avoid shorting.	Green	Flexible.
Insulator	Green Dielectric	D2081009D6	Alumina, Polyester, PVC, Valox FR1	Insulative layer to determine electrochemical cell surface and avoid shorting.	Green, transparent	Transparent.
Insulator	Blue Dielectric	D50706D3	Alumina, Polyester, PVC, Valox FR1	Insulative layer to determine electrochemical cell surface and avoid shorting. Alcohol resistant.	Blue	Solvent resistant
Insulator	Blue Dielectric	D2071120D1	Alumina, Polyester, PVC, Valox FR1	Insulative layer to determine electrochemical cell surface and avoid shorting.	Blue	Flexible.
Insulator	Cross link Dielectric	D2060131D1	Alumina, Polyester, PVC, Valox FR1	Insulative layer to determine electrochemical cell surface and avoid shorting.	White	Designed for use with polymeric substrates where low temperature cure is required. Flexible.

Electrochemical Sensor Designs

Screen Printing Services

The Gwent Group has the ability and the production equipment to print, dry and fire on a large scale. We offer the service of printing circuits, electro ceramic sensors and biosensors.

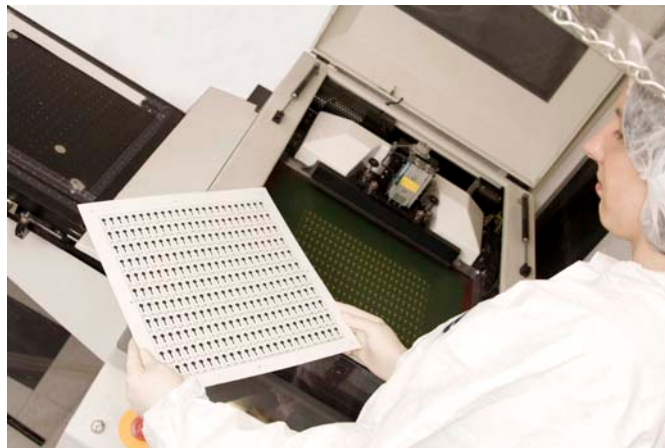
We offer a full **screen printing** prototype service for base electrode manufacture, for either polymeric or high temperature substrates in a class 100 clean room for any of the above systems; many customers use this route before choosing to purchase their own screen-printing equipment.

Quality standards are vital to our customer so we use strict protocols when quality controlling electrodes.

Sensor and Biosensor Printing

Using the materials overview presented above electrochemical sensors and biosensors can be custom designed for different applications like:

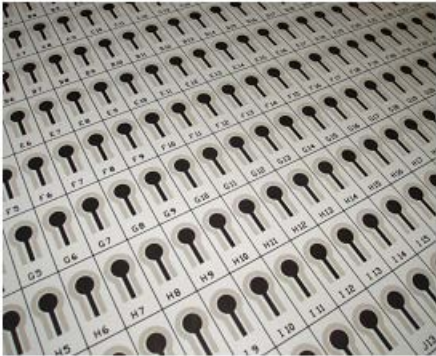
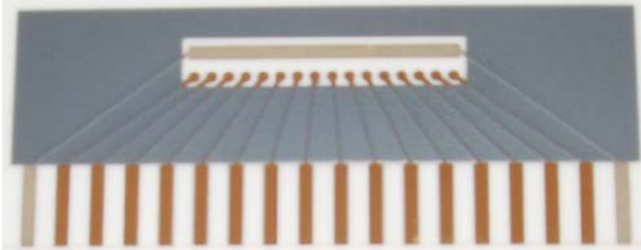
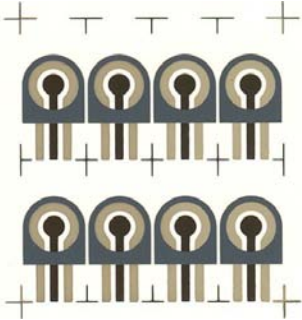
- Blood glucose test.
- Diagnostic tests.
- Antibody tests.
- Agri- food analysis.
- Flow injection systems.
- Membrane compatibility systems.
- Immunoassays.
- Environmental tests.

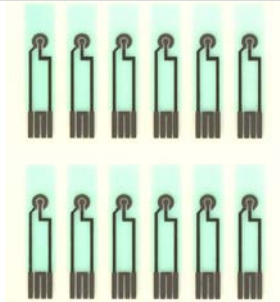


(Above: Printing electrodes)

We offer an off the shelf range of sensor designs as well as prototyping facility so that our customers and collaborators may obtain quantities of fabricated sensors for distribution, pilot scale production, validation, or mass production.

Examples of electrochemical sensor designs used for different applications are presented below together with some of our most popular electrode designs:

	<p><i>2 - Electrode System:</i> Working electrode and common counter / reference electrode printed onto polyester substrate. Card of 220 sensors. Product code: BE2070921D1</p> <p>(Please contact us for more information)</p>
	<p><i>2 - Electrode System:</i> Screen-printed electrodes on alumina substrate. Card of 12 gold working electrodes and one common reference and counter electrode. Product code: BE2050601D1</p> <p>(Please contact us for more information)</p>
	<p><i>2 - Electrode System:</i> Working electrode and common counter / reference electrode printed onto polyester substrate. Card of 8 sensors. Product code: BE2030408D7</p> <p>(Please see the product information sheet)</p>



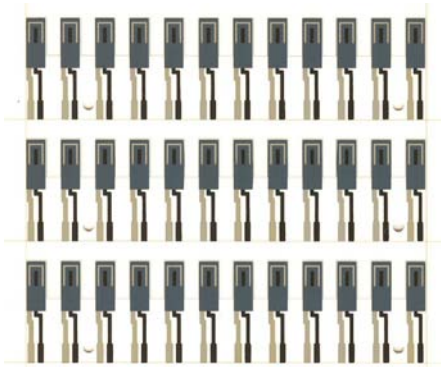
2 - Electrode System:

Working electrode and common counter / reference electrode printed onto polyester substrate.

Card of 12 sensors.

Product code: BE2050621D1

(Please see the product information sheet)



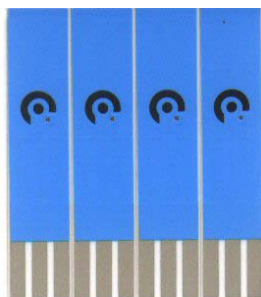
2 - Electrode System:

Working electrode and common counter / reference electrode printed onto scribed alumina or polyester substrate.

Card with 3 combs and 36 sensors suitable for tests in 96 well plate.

Product code: BE2060320D8

(Please see the product information sheet)



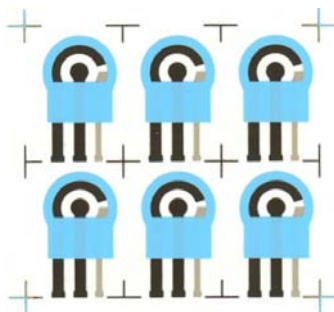
3 - Electrode System:

Working, counter and reference electrodes printed onto polyester or scribed alumina substrate.

Card of 4 sensors.

Product code: BE2050824D1

(Please see the product information sheet)



3 - Electrode System:

Working, counter and reference electrodes printed onto polyester substrate.

Card of 6 sensors.

Product code: BE2030605D1

(Please contact us for more information)

Applied Enzyme Technology

Introduction

AET is fast becoming the leading company world-wide in the field of Protein stabilisation, our research is currently assisting:

- Pharmaceutical companies
- Diagnostic companies
- Biosensor manufacturers
- Enzyme producers
- Agricultural / food companies
- Biotechnology companies
- Instrument manufacturers

Solutions

AET are providing solutions to:

- Improve protein stability
- Increase product shelf life
- Remove the need for refrigeration
- Improved operational stability
- Increase activity of enzyme preparations.
- Reduce manufacturing costs

Protein Stabilisation Technology

Protein stabilisation is the core technology of AET Ltd. Enzymes, Antibodies and Pharmaceutical proteins have been stabilised to thermal, chemical and proteolytic degradation after processing.

AET's enzyme preparations retain high activity when dehydrated by lyophilisation or air drying. We are able to stabilise enzymes and antibody conjugates in solutions. AET provides these services for a number of different enzyme systems; we have the capacity to apply this technology to a multitude of enzyme targets.

Synergy GEM – AET in biosensor design and manufacture

The synergy between the two companies brings together the expertise of AET in enzyme stabilisation and the skills of GEM in the design and production of specialist sensor materials. This gives us the unique position to offer a '1 stop shop' for the development and production of Biosensors.

The cooperation between the two sister companies resulted in the full development and manufacture of disposable biosensors for ammonia detection in water and pyruvate detection in onions; including development of the hand held instrument HandiLab. The two biosensors are available for sales; please contact our sales department for more information.



(Above: Handilab Instrument.)

The complementary expertise between GEM and AET resulted in the development of different other types of enzymatic, DNA and Immuno-biosensors as indicated below.

Food:

Alcohol, Pyruvate, Glucose, Sucrose, Lactate, Algal toxins, Mycotoxins, Organophosphates, Progesterone.

Healthcare:

Glucose, Cholesterol, Lactate, DNA sensor, Acetyl choline, Ammonia, Glutamate.

Environmental:

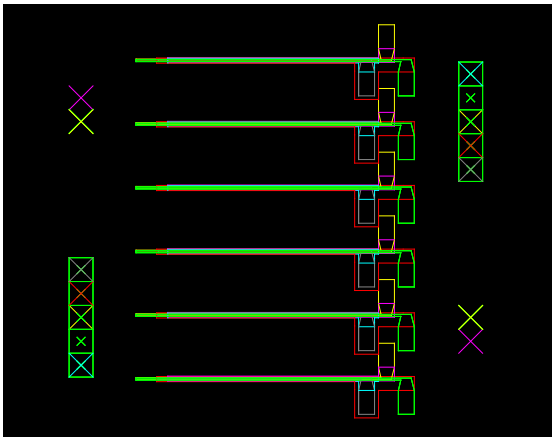
Ammonia, Organophosphate.

What other services do the Gwent Group provide?

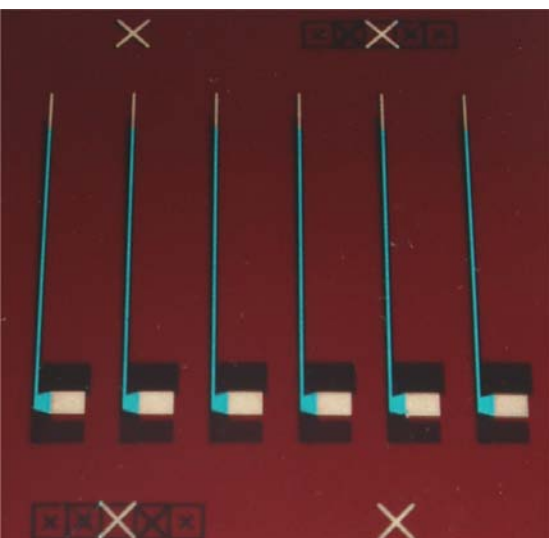
Research and Development

Through research and development work, we can supply our customers with unique products by specifically tailoring materials to our customer's requirements. Our company work in confidence with individual customers to produce novel materials; this can be through contract research or through confidential disclosure of formulae.

Biosensor Research and Development.



(Above: Schematic of needle sensor)



(Above: In vivo needle sensor printed on a Kapton substrate)

The Gwent Group offer research and development into:

- Inks and pastes.
- Sensor design.
- Alterations to existing sensor designs.
- Stabilisation of enzymes.
- Biosensor fabrication.
- Protein stability problems.



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ADVANCED MATERIAL SYSTEMS

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