Printed Dry Electrode Medical Sensors (EXG)

Product:
Printed Dry Electrode Medical Sensors

Development Stage:
Proof of Concept and Early Prototype

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Electrodiagnostics (or "EDX") is an important subset of contemporary medical monitoring and diagnostics. EDX employs various types of electromagnetic sensors that produce observable signals from bodily functions, collectively termed "EXG." For instance, EDX methods include electrocardiography which utilizes electrocardiograms (ECG) for heart monitoring, electromyography (electromyograms/EMG) for observing muscle tissue function, electroencephalography (electroencephalogram/EEG) for brain activity, and electrooculography (electrooculogram/EOG) for eye monitoring.

By way of example, electrocardiogram (ECG) measurement is frequently used for monitoring the heart's electrical signals for investigating and diagnosing symptoms related to heart problems. It is one of the most widely used medical diagnostic techniques. In recent years, researchers have focused on the development of different electrode designs for the measurement of ECG signals to provide greater sensitivity and reliability of the measurements.

One of the most common ECG electrodes employed in hospitals and clinics is the wet silver/silver chloride (Ag/AgCl) electrode which has good signal stability. However, it also has some drawbacks such as requiring excessive skin preparation and the attendant skin irritation or allergies caused by the conductive gels that give it the name "wet" electrode. In addition, during stress/exercise measurement, the conductive gel often fails to provide adequate contact of the ECG electrode with the patient's skin over the period of the test, resulting in motion artifacts and other inefficiencies.

Given these issues, substantial industry research has been undertaken to develop "dry" electrodes that work as well or even better than the wet electrodes. Some advanced options in dry electrodes include: nanofiber web textile dry electrodes, silver nanowire dry electrodes, conductive fabric textile dry electrodes and circular ring electrodes for ECG measurements and monitoring. These options are fabricated on substrates that are too inflexible for reliable use without an adhesive or micro-tips that can damage the skin. Moreover, their manufacture typically requires clean room fabrication, which makes them expensive.

Current EMG, EEG, EOG, and other EDX/EXG sensors face similar shortcomings to the ones just described for ECG. Accordingly, it would be advantageous to address such issues with accurate, reliable, and *(continued on next page)* user-friendly designs that can be mass produced at low cost.

Technology Description

A new flexible, printed EXG sensor has been developed by researchers at WMU which uses conductive polymers for EXG measurements. One such example of an ECG electrode is illustrated in the Figures below. The conductive polymer uses a mixture of polydimethylsiloxane (PDMS) and carbon nanotubes and is coated on a silver ink conductive layer that is screen-printed on a flexible polyethylene terephthalate (PET) substrate. The ECG sensor requires no skin preparation and performs well during exercise activity,

In a proof of concept study, several WMU dry ECG electrodes were fabricated using printed electronics techniques. ECG electrodes with different radii were affixed to either a forearm or leg without shaving the hair and without any skin preparation. ECG signals were then measured in real time while the person was moving. The ECG signal quality was independent of electrode radius and was more stable and had less noise when compared to either a wet Ag/AgCl electrode or inflexible dry ECG electrodes.

This flexible, printed, dry electrode sensor technology for ECG and EXG monitoring can be manufactured at low cost, is lightweight and patient friendly. It significantly simplifies and improves the reliability of EDX electrodes, even under significant patient motion (such as exercise, emergency transport, long-period testing). The electrode characteristics also promote a longer shelf life.

Potential Benefits

- Extremely cost efficient and reliable
- Dry and stable, promotes long shelf life
- Flexible construction provides comfort and reduces motion artifacts, during long-period testing
- Monitors EXG signals in real time
- Skin preparation and conductive gels are not required, avoiding irritations and allergic reaction

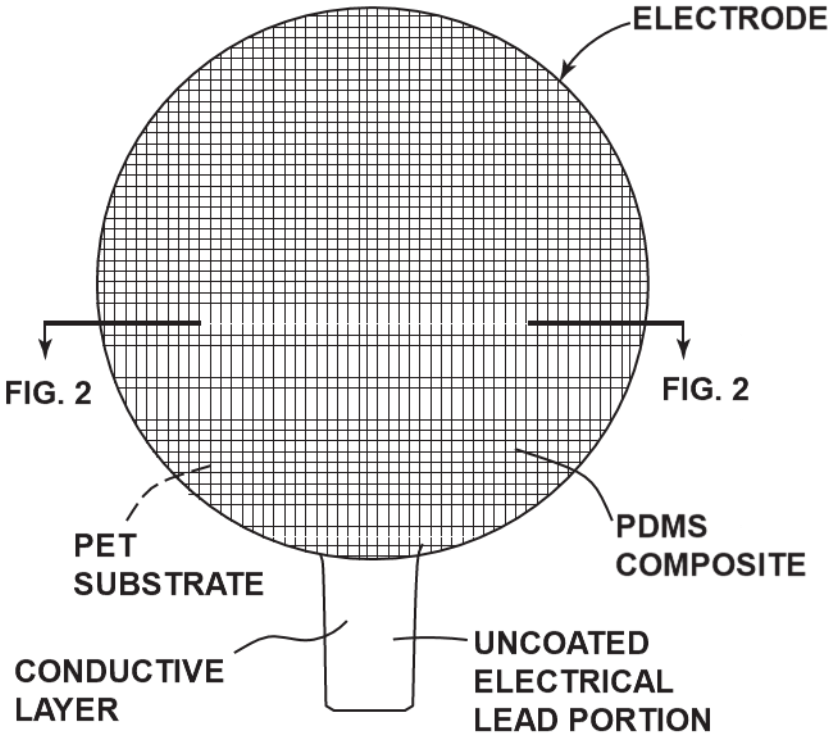

Figure 1. Example EXG Electrode

(continued on next page)

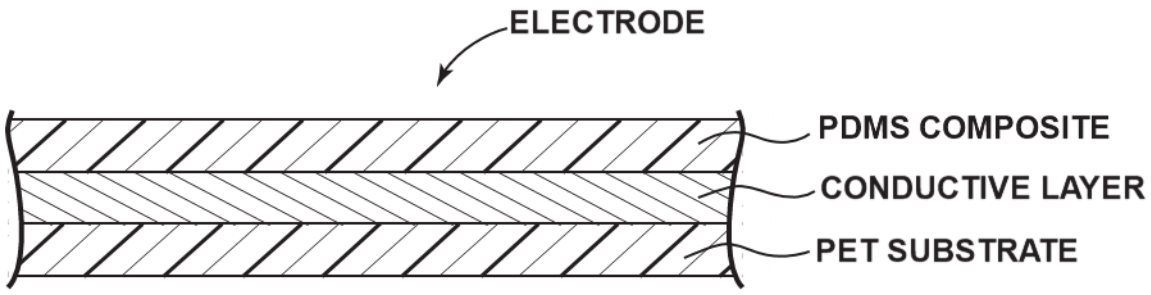

Figure 2. Cross-Sectional Cutaway of Figure 1