

### Ceramic Patterned Electrodes

Pine's ceramic patterned electrodes offer a complete three-electrode cell on a single surface. Available in either gold or platinum, the working electrode is a 2.0 mm OD disk surrounded by a large counter electrode. Connection to these two electrodes and the reference electrode (see below) is made using a standard edge-card type connector. The traces which connect the electrodes to the edge card connector are insulated with a chemically resistant layer of (clear) ceramic.

The surface of a screen printed electrode is not nearly as pristine as more traditional electrodes fashioned from pure metal rods or sheets. Screen printed surfaces are rough (making an exact determination of electrode area difficult), the proprietary binder compounds found in the ink may introduce stray (but small) features in voltammograms. While none of these problems are of great concern when using these electrodes for routine purposes, the electrochemical purist may find fault when comparing screen printed electrodes to more expensive traditional electrodes.

### Reference Electrode Options

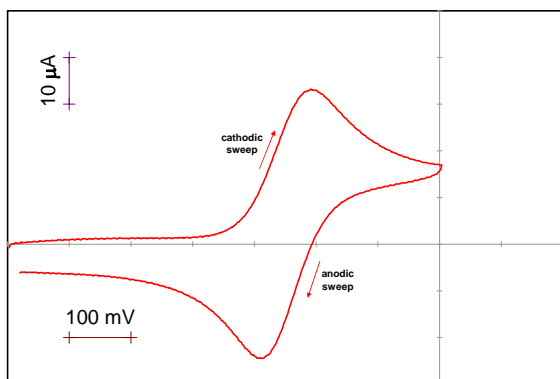
The reference electrode on a Pine ceramic patterned electrode is a small disk located between the working electrode and the counter electrode. While the working and counter electrodes are fabricated from a noble metal (such as gold or platinum), the reference electrode is silver (Ag) or silver/silver chloride (Ag/AgCl).

For work in aqueous solutions, the best option for the reference electrode is the silver/silver chloride redox pair. This type of reference is quite stable when used in an aqueous solution containing chloride ions. When using Ag or Ag/AgCl reference electrodes, it is important to allow the reference electrode to equilibrate with the solution for about 60 seconds before use.

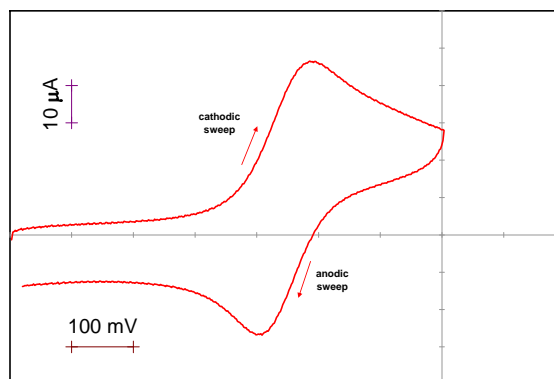
For work in non-aqueous solutions (or in cases where chloride ion may interfere with the electrochemical experiment), Pine offers a silver "pseudo-reference" electrode. This electrode must be standardized against a known redox couple. Typically, ferrocene (or one of its derivative compounds) is added to the test solution as an internal standard, and potential measurements against the silver pseudo-reference are corrected with respect to the known position of the ferrocene redox couple.

### Example Voltammograms

Ceramic patterned electrodes have been used to perform cyclic voltammetry in a solution containing a popular electroactive ion, ferricyanide. This ion exhibits a fairly well-behaved redox couple at about +0.220 volts versus the Ag/AgCl reference electrode on the ceramic substrate (see voltammograms below, sweep rate = 100 mV/sec).



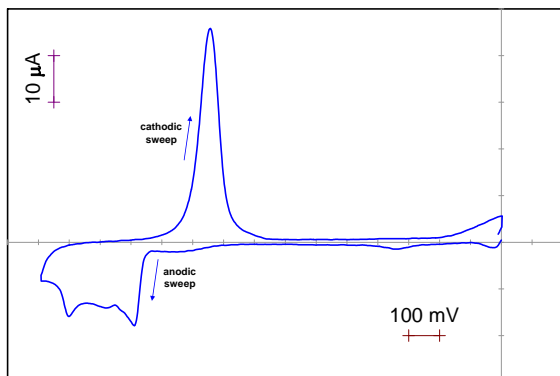
Voltammogram of 5mM  $K_3Fe(CN)_6$  in 0.1M KCl using a gold electrode (RRPE2001AU)



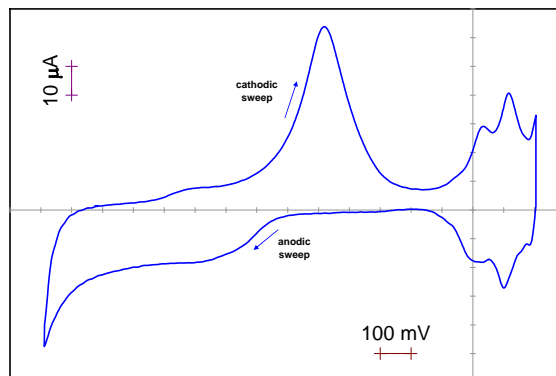
Voltammogram of 5mM  $K_3Fe(CN)_6$  in 0.1M KCl using a platinum electrode (RRPE2001PT)

## Activation of the Electrode Surface

In the event that the electrode surface becomes fouled, or in advance of a particularly sensitive electrochemical experiment, it may be desirable to clean and/or activate the electrode surface. One way to do this is via repeated cycling of the working electrode potential in a dilute sulfuric acid solution (see below). Repeated cycling at 100 mV/sec for about 5 minutes will often remove surface contamination and improve subsequent cyclic voltammetry results.



Background Scan in 0.5M H<sub>2</sub>SO<sub>4</sub>  
using a gold electrode (RRPE2001AU)

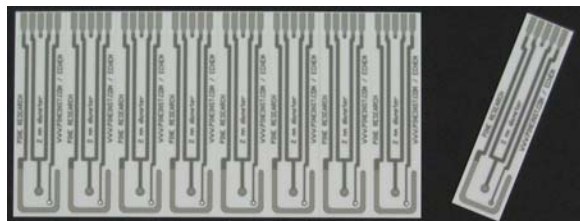


Background Scan in 0.5M H<sub>2</sub>SO<sub>4</sub>  
using a platinum electrode (RRPE2001PT)

## Available Electrode Patterns

The following ceramic electrode patterns are available from Pine Research Instrumentation. All patterns share the same basic electrode geometry, with working and counter electrodes being fabricated from gold or platinum, and reference electrodes being fabricated from silver and/or silver chloride inks.

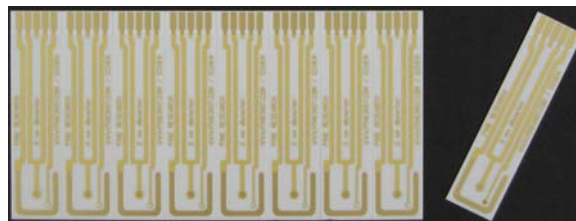
Individual units have these dimensions: 15 x 61 x 0.67 mm.



**RRPE2001PT** 2.0 mm OD platinum disk with Ag/AgCl reference electrode recessed in a clear & inert insulating layer

**RRPE2011PT** 2.0 mm OD platinum disk with Ag reference electrode recessed in a clear & inert insulating layer

**RRPE2021PT** 2.0 mm OD platinum disk



**RRPE2001AU** 2.0 mm OD gold disk with Ag/AgCl reference electrode recessed in a clear & inert insulating layer

**RRPE2011AU** 2.0 mm OD gold disk with Ag reference electrode recessed in a clear & inert insulating layer

**RRPE2021AU** 2.0 mm OD gold disk

## Mounting Ceramic Patterned Electrodes

Ceramic patterned electrodes are designed to be mounted in Pine's Student Voltammetry Cell. This cell features a custom cap with a built-in edge card connector into which the ceramic electrode card may be inserted. A mini-USB connector on the top of the custom cap permits electrical connection to be made to the electrode card. To connect to the card, always use the mini-USB port which is on the left when viewing the top of the card (see red arrow in photo). Contact Pine for more details regarding the Student Voltammetry Cell.



## References

- (1) VV Pavlishchuk, AW Addison, *Conversion constants for redox potentials measured versus different reference electrodes in acetonitrile solutions at 25°C*, Inorganica Chimica Acta 298 (2000) 97-102.