



Microfabricated Patch Clamp Electrodes for Ion Channel Measurements


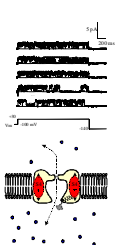
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1 Conventional Patch Clamp Technique

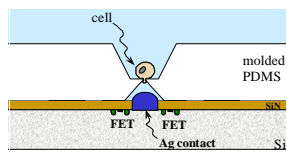



Ion channels
voltage dependent, transmembrane proteins underlie many cell functions neurotransmitter & hormone release muscle contraction cell signaling cascades

Studied via PATCH CLAMP technique glass micropipette electrode in contact with cell membrane
10-100 GΩ seal, ~1μm tip ionic current through channel measured

Disadvantages
Serial Process --> Low Throughput
Requires Skilled Operator
Noise Limited Measurement

2 Planar Microfabricated Patch Clamp Electrodes

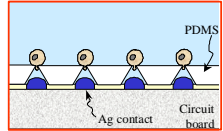


Silicone elastomer: Polydimethyl Siloxane (PDMS)
Low noise dielectric
Inexpensive = Disposable

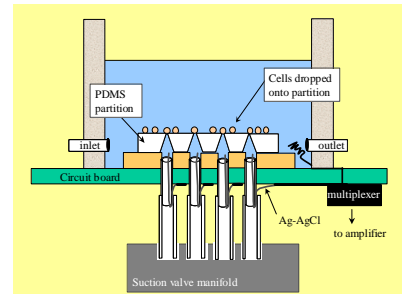
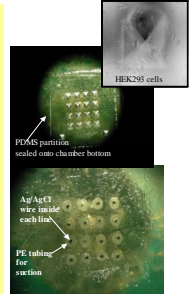
Cast from microlithographically fabricated mold
MEMS fabrication techniques allow feature sizes << conventional technique

Surface treatment with plasma permits seal to cell membrane

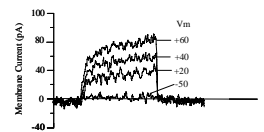
Planar geometry allows electrode arrays



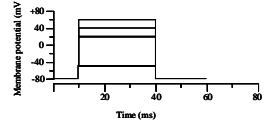
5 Patch Clamp Electrode Array Recording


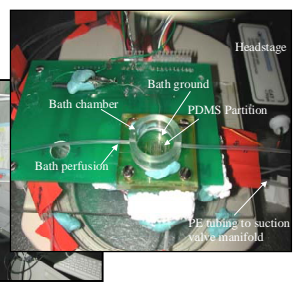
Macropatch recording of Shaker K⁺ channel



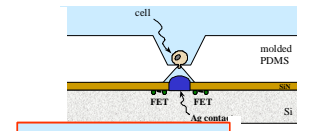
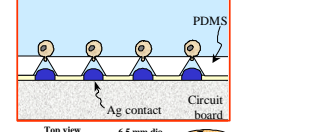
Oocyte dropped onto a single electrode of planar array, after surface treatment



Seal yield:
Single electrode - 13 %
Array (extrapolated) ~89%

3 Advantages of Microfabricated Patch Clamp Electrodes

Microfabrication
smaller solution volume:
lower noise

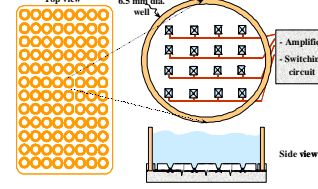
PDMS
low dielectric noise
disposable

Planar geometry
PDMS seals onto electronic chip
Pipette solution exchange possible

Arrays of electrodes
Increases yield

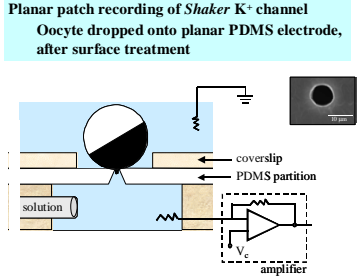
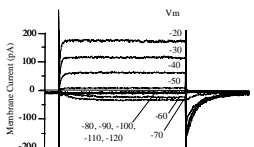
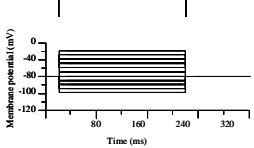
Cells dropped "blindly" - no need for operator!

Scalable to industry standard 96-well plate



4 Planar Patch Clamp Recording

Planar patch recording of Shaker K⁺ channel
Oocyte dropped onto planar PDMS electrode, after surface treatment

Experimental Details: Current traces recorded from a cell-attached patch on *Xenopus* oocyte expressing inactivation-removed *Shaker* potassium channels. No leakage subtraction was employed. The aperture was 8 μm in diameter; initial electrode resistance was 3.2 MΩ. Filtered at 2 kHz.

In press: K. Klemic et al., *Biosensors and Bioelectronics*, 17, 2002

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