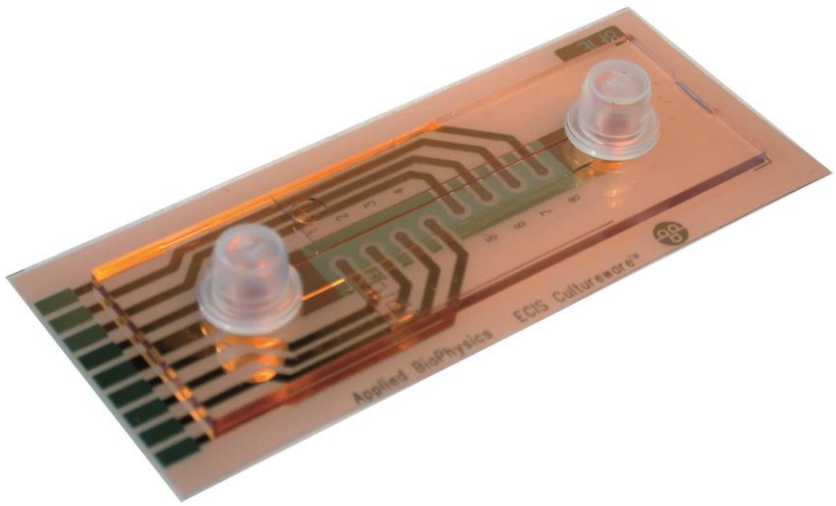
Shear Stress and Shear Rate Calculations in ECIS® Flow Arrays (1E | 10E)

Electric Cell-substrate Impedance Sensing (ECIS®) is an impedance-based method to study the physiological characteristics of cells grown *in vitro*. These include morphological and structural changes, cell locomotion, and other physiological parameters. Applied BioPhysics, Inc. provides several geometries to cultivate cells directly on impedance measurement electrodes, under which also channel slides (Flow Arrays).

The geometry of the ECIS® Flow Arrays is the same as for ibidi's µ-Slide I Luer. Nevertheless, the shear stress calculation in the ECIS® Flow Arrays differs from the standard channel slides due to the gluing process, which increases the height of the channels by 260 µm. This Application Note gives instructions how to calculate the correct shear stress in the ECIS® Flow Arrays.

Related topics:
AN 11 "Shear Stress and Shear Rates"
AN 13 "Endothelial Cell Culture under Perfusion"

Keywords:
Endothelial cells, shear stress, flow, perfusion, shear rate, ECIS®, impedance measurement, TEER, blood brain barrier



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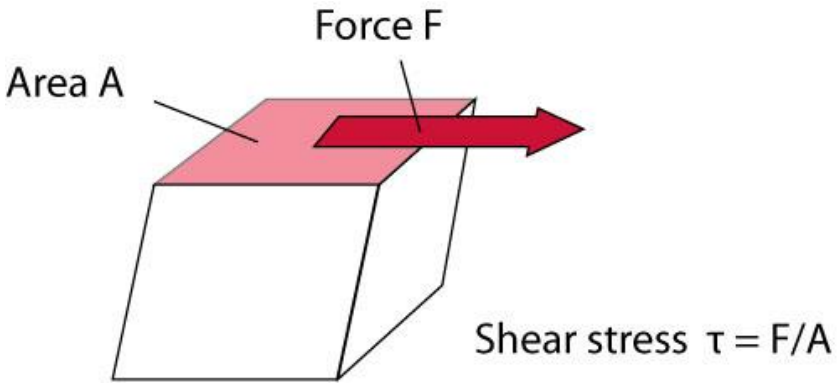
1. Shear Stress Calculations

The shear stress is the mechanical force input onto the cells attached to the channel walls. To calculate the shear stress, use the formulas in table 1. The relation between shear stress, flow rate and viscosity is given by a simple formula with a slide-specific coefficient. This coefficient already includes the conversion of the units.
To use the formula, insert the values in the indicated units and the resulting unit will be as indicated.

Φ	Flow rate	ml/min
τ	Shear stress	dyn/cm²
η	Dynamical viscosity	dyn·s/cm²

Table 1: Shear stress calculations in ECIS® Flow Arrays

Slide	Channel Height (mm)	Channel Volume (µl)	Formula
ECIS Flow Array 1E | 10E (µ-Slide I 0.1 Luer)	0.36	90	$\tau = \eta \cdot 161.7 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide I 0.2 Luer)	0.46	115	$\tau = \eta \cdot 100.3 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide I 0.4 Luer)	0.66	165	$\tau = \eta \cdot 50.0 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide I 0.6 Luer)	0.86	215	$\tau = \eta \cdot 30.3 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide I 0.8 Luer)	1.06	265	$\tau = \eta \cdot 20.5 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide VI 0.4)	0.66	40	$\tau = \eta \cdot 67.8 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide y-shaped, single channel)	0.66	185	$\tau = \eta \cdot 88.6 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide y-shaped, branched channel)	0.66		$\tau = \eta \cdot 44.3 \cdot \Phi$



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2. Shear Rate Calculations

The shear rate is a measure for the velocity profile of the flow inside a channel. To calculate the shear rate use the formulas in table 2. The relation between shear rate and flow rate is given by a simple formula with a slide-specific coefficient. This coefficient already includes the conversion of the units. To use the formula, insert the values in the indicated units and the resulting unit will be as indicated.

Φ	Flow rate	ml/min
γ	Shear rate	1/s

Table 2: Shear rate calculations in ECIS® Flow Arrays

Slide	Channel Height (mm)	Channel Volume (µl)	Formula
ECIS Flow Array 1E | 10E (µ-Slide I 0.1 Luer)	0.36	90	$\gamma = 161.7 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide I 0.2 Luer)	0.46	115	$\gamma = 100.3 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide I 0.4 Luer)	0.66	165	$\gamma = 50.0 \cdot \Phi$
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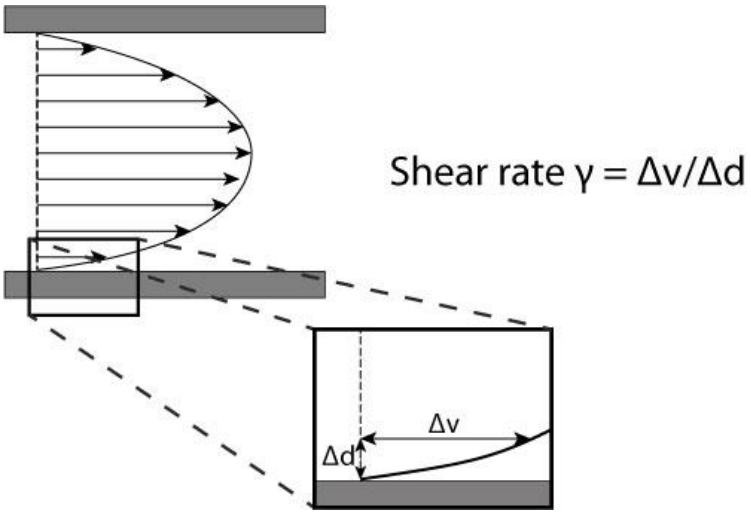
ECIS Flow Array 1E | 10E (µ-Slide y-shaped, single channel)	0.66	185	$\gamma = 88.6 \cdot \Phi$
ECIS Flow Array 1E | 10E (µ-Slide y-shaped, branched channel)	0.66		$\gamma = 44.3 \cdot \Phi$



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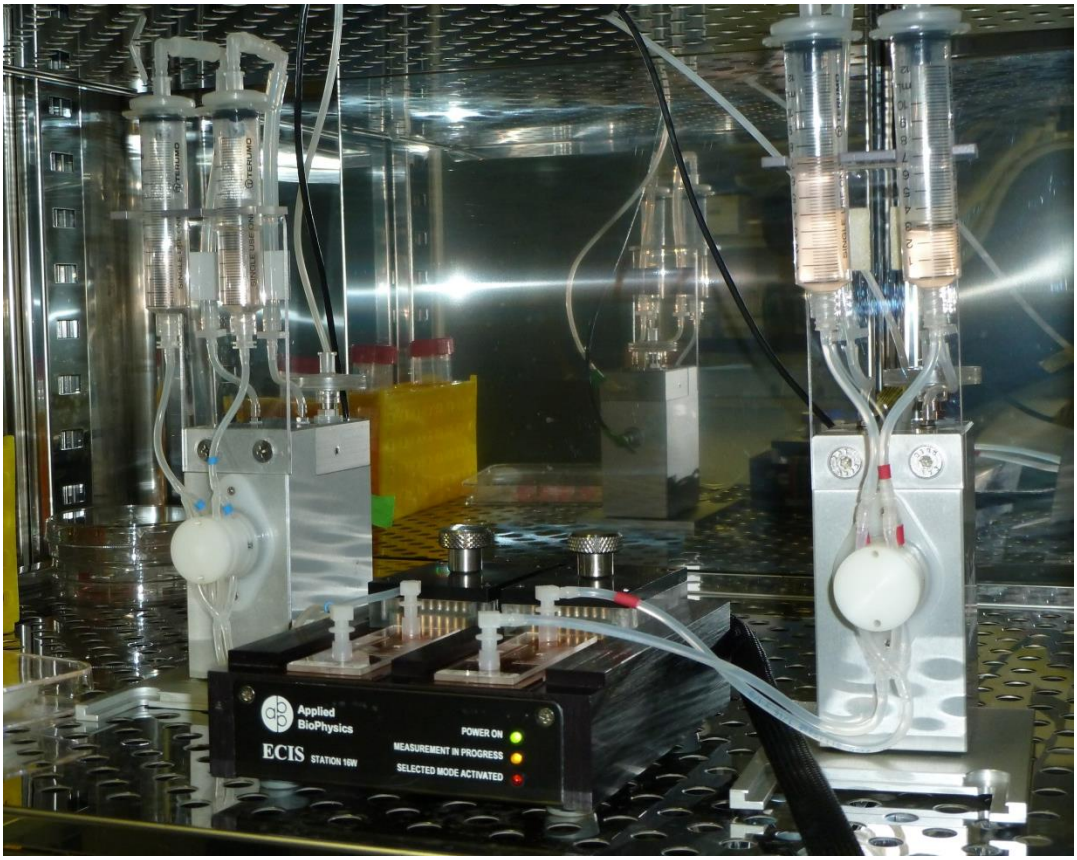
3. Application of ECIS® Flow Arrays with the ibidi Pump System

The ibidi Pump System can easily be combined with the ECIS® measurement. The fluidic Units with the connected channel slides are placed next to the array holder inside the incubator. The slides are fixed on the array holder and flow can be controlled with the Pump Control Software as in a standard setup.
The ECIS®-channel slides are not pre-calibrated in the software. To be able to predict the flow rate you must do your own calibration curve. This procedure is described in detail in the section “Working With Non-implemented Slides” of the ibidi Pump instructions.



ECIS® Array holder with two µ-Slides I Luer connected to the Perfusion Sets of the ibidi Pump System

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