

### EPSILON™ SKIN HYDRATION MEASUREMENT: THE POWER OF THE ε-FILTER

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## What is Epsilon?

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The Epsilon - an instrument for mapping near-surface dielectric permittivity of materials in contact with its sensing surface.



- Semiconductor fingerprint array sensor.
- 256 x 300 array of 76800 individual capacitance sensors.
- Capacitance depends on the Dielectric Permittivity ε.
- Epsilon is the name of the instrument, because it measures  $\mathcal{E}$ .
- Provides both image and hydration data simultaneously.
- Suitable for both in vivo + in vitro measurements.
- Pixel spacing is 50 $\mu$ m, sensing depth ~5 $\mu$ m.



Material	3
Air	1.0
Petroleum Jelly	2.1
Ethyl Acetate	6.0
Ethylene Dichlorate	10.4
Isopropyl Alcohol	17.9
Ethanol	24.5
Propylene Glycol	30.0
Nitrobenzene	34.8
Ethylene Glycol	37.0
DMSO	46.7
Glycerol	47.0
Water	80.1

## What is Contact Imaging?

Capacitance and Dielectric Permittivity

The Epsilon uses Capacitance Sensors that respond to the material they touch. Capacitance is proportional to Dielectric Permittivity *E*.

**Capacitance** is a <u>device</u> property.

*ɛ* is a <u>material</u> property.

The Epsilon is calibrated using *E* for **Air & Water**.

### **BioX** The Epsilon – Main Characteristic SCIENCE OF PRECISION – Main Characteristic



This linearisation & calibration is unique to the Epsilon. It enables the Epsilon to **measure** as well as **visualise**.



## **The Epsilon – Hardware**

Hand-held Probe & Parking Base



Spring-loaded sensor for consistent contact force. USB connection for signal & power.

Parking base to protect the sensor.

In-vitro Stand.



## **The Epsilon – Software**

Overview - Image display - Live Streaming



Hydrat	ion scale:		
Wet	(High <i>E</i> )	=	Light Colour
Dry	(Low <i>E</i> )	=	Dark Colour

- Live streaming for instant preview.
- Whole image & Region of Interest (RoI) readout.
- Live Mean *ɛ* and Histogram displays.
- Numerical readouts of Mean *ɛ* & StDev.



## **The Epsilon – Software**

ε-Filtering for Hydration Measurement

#### *E***-Filtering:**

- Remove low *ɛ* pixels to correct for bad contact, lines & wrinkles.
- Remove high *ɛ* pixels to correct for surface water from topical products & insensible perspiration.
- Filtered pixels are shown in grey.
- User control of filter settings.



## **The Epsilon – Software**



Video Analysis: ε-Filtering with Hydration or Area Dynamics



- Burst & Video Analysis.
- Time dependence of  $\boldsymbol{\varepsilon}$  or Area.
- *E* -filtering to eliminate artefacts.
- Whole image & RoI.



Using *E* -filtering for removing artefacts



In each case, *E*-filtering can be used to remove artefacts of bad contact, lines, wrinkles, surface water, etc.

Removing non-SC pixels gives more accurate SC hydration measurements.

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### Hydration Measurement of Curved Surface



This is an image of a thumb joint. It has areas of:

- Bad contact (black) around the edges, lines, wrinkles & hair.
- Surface water (white) from insensible perspiration.



#### *ɛ* **-Filtering**

- Remove low-*ɛ* (black) pixels = bad contact.
- Remove high-*E* (white) pixels = surface water.
- You get a more realistic measure of mean hydration.

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#### Hydration Measurement of Scalp without Shaving



These are two images of hairy scalp. Note that the brightness & contrast are enhanced. It has areas of:

- No contact (dark red) in many places.
- Hair Contact (fine red lines).
- Scalp Contact (bright areas).



#### *ɛ* **-Filtering**

- Remove low-*ɛ* (No contact & hair).
- There is no surface water in these cases.
- What remains is scalp. Despite the poor contact, plenty of scalp pixels remain for measuring mean hydration.



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Correction for Skin/Sensor Contact

Female ventral forearm image.
Bad skin/sensor contact is black.
Bad contact (air & hair) has low *ɛ*.
Histogram peaks at low *ɛ*.

Software filter removes low  $\boldsymbol{\varepsilon}$  pixels. Mean hydration increases from  $\boldsymbol{\varepsilon} = 3.91$  to  $\boldsymbol{\varepsilon} = 6.03$ .

RoI: from  $\epsilon$  = 4.92 to  $\epsilon$  = 7.15.

*ɛ***-Filtering:** Corrects for bad contact (low *ɛ*) and surface water (high *ɛ*) under user control.



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Correction for Skin Surface Water

Non-contact (low  $\epsilon$ ) removed by  $\epsilon$  -filtering. But bright spots (insensible perspiration) remain.

Surface water ( $\boldsymbol{\varepsilon} > 60$ ) removed by  $\boldsymbol{\varepsilon}$  -filtering. RoI hydration changes from  $\boldsymbol{\varepsilon} = 17.44$  to  $\boldsymbol{\varepsilon} = 10$ . Whole image hydration changes from  $\boldsymbol{\varepsilon} = 12.70$  to  $\boldsymbol{\varepsilon} = 9.39$ .

E-Filtering: Removing non-SC pixels gives more accurate SC hydration measurements.



### Conclusions

*The power of the ε-Filter* 

The *E*-Filter is an analysis tool for selecting pixels within a range of  $\boldsymbol{\varepsilon}$  values between and including  $\boldsymbol{\varepsilon}_{\min}$  and  $\boldsymbol{\varepsilon}_{\max}$ .

*ε*-Filtering can be used to remove artefacts of bad contact, lines, wrinkles, surface water, etc.

After **filtering**, <ε> readout of the selected pixels will better represent the permittivity (hydration) of the sample material.

*E***-Filtering:** Corrects for bad contact (low  $\boldsymbol{\varepsilon}$ ) and surface water (high  $\boldsymbol{\varepsilon}$ ) under user control.



# Thank you!

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