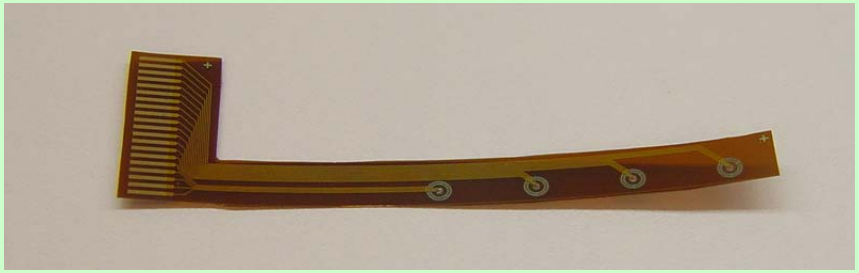
Microsensor Technologies for Plant Growth System Monitoring

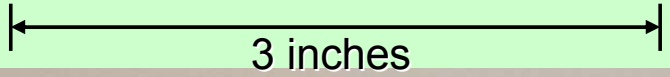
Chang-Soo Kim
Depts. of Electrical & Computer Eng. and Biological Sciences
Univ. of Missouri-Rolla

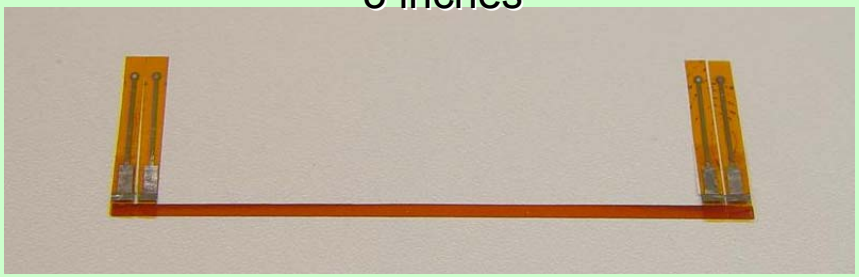
- Critical need of precise control of root zone; wetness, oxygen, nutrients, temperature.
- Ideal sensor configuration; miniaturization, multiple, array, low power, robustness.
- Thin film flexible microsensor strips for dissolved oxygen and wetness detection.
- Flexible microfluidic substrate for rhizosphere monitoring and manipulation.

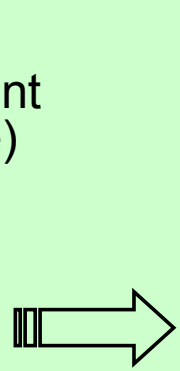
Experimental setup with a porous tube growth system

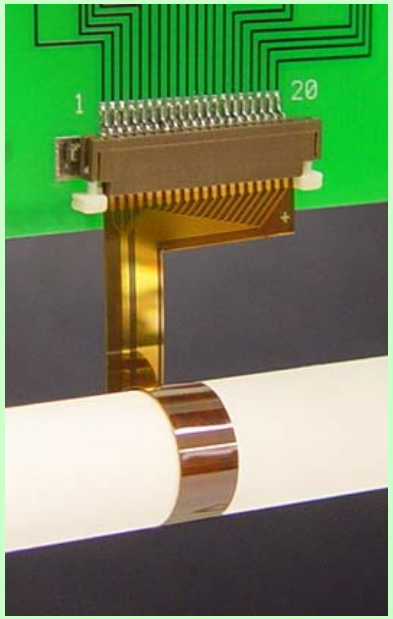
- Dissolved oxygen microsensor strip
  (3-electrode amperometric measurement by enwrapping the porous tube surface)





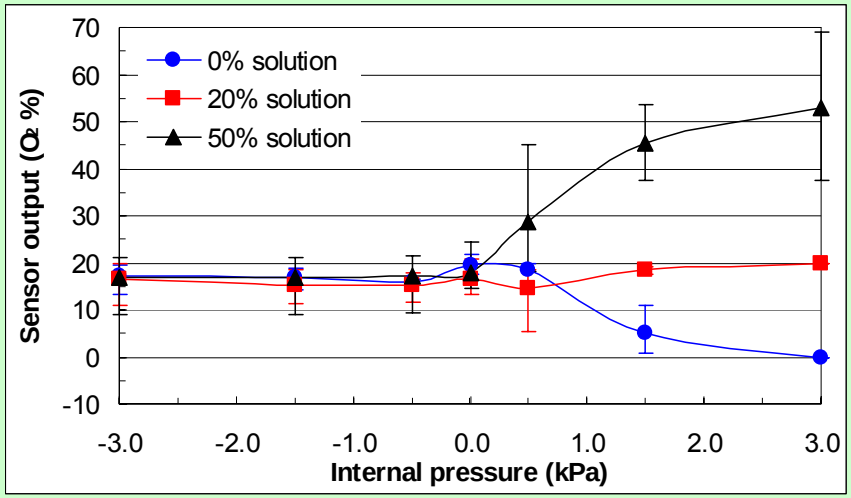




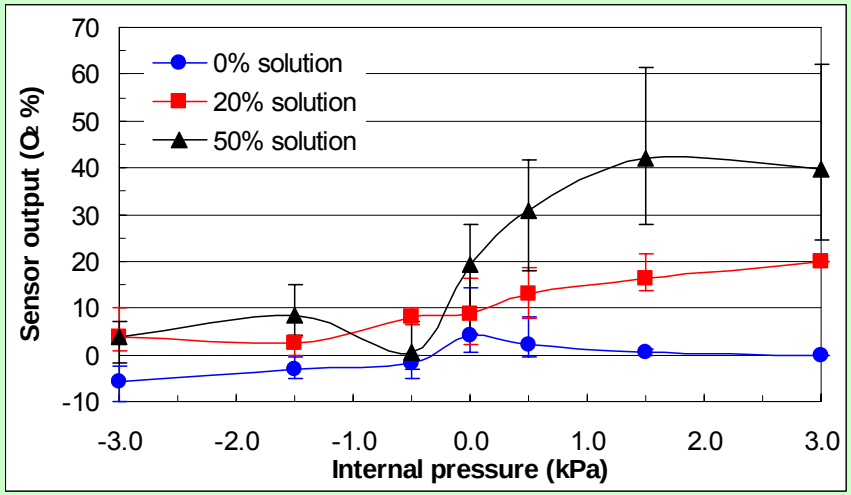


- Wetness sensor strip (4-electrode conductivity measurement along the porous tube surface)

Dissolved oxygen measurement on the porous tube surface

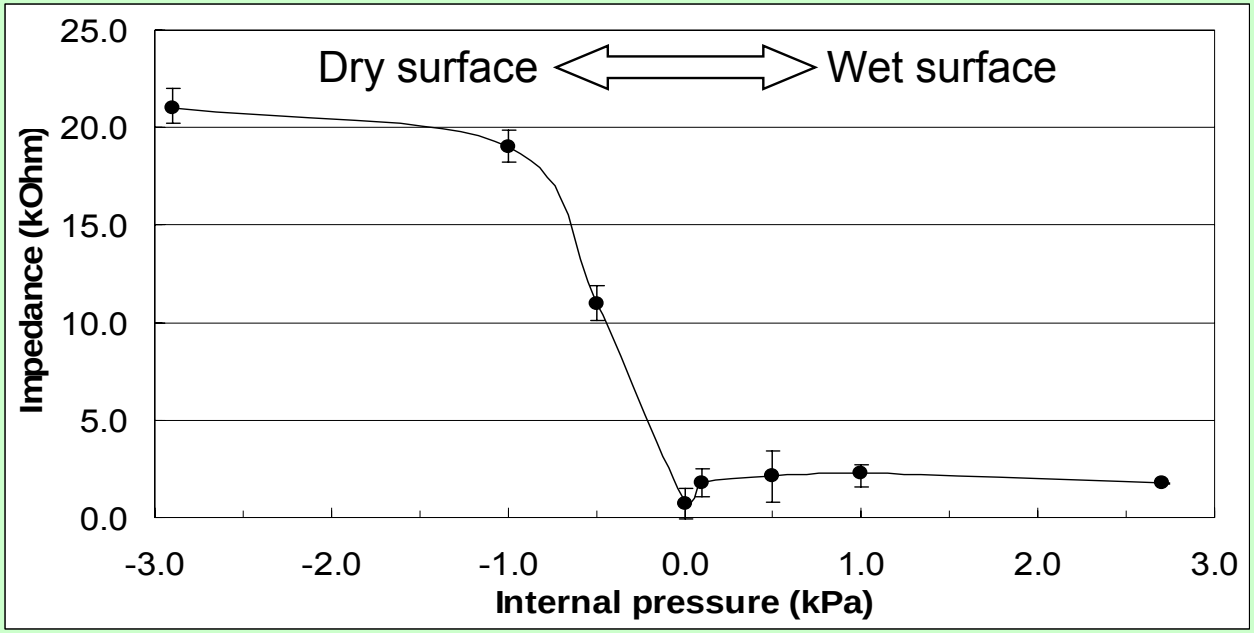


- With a commercial oxygen probe;
- Reflecting O_2 value of inner sol. at (+) pressures.
- Convergence to 20% value (air-sat. value) at (-) pressures.



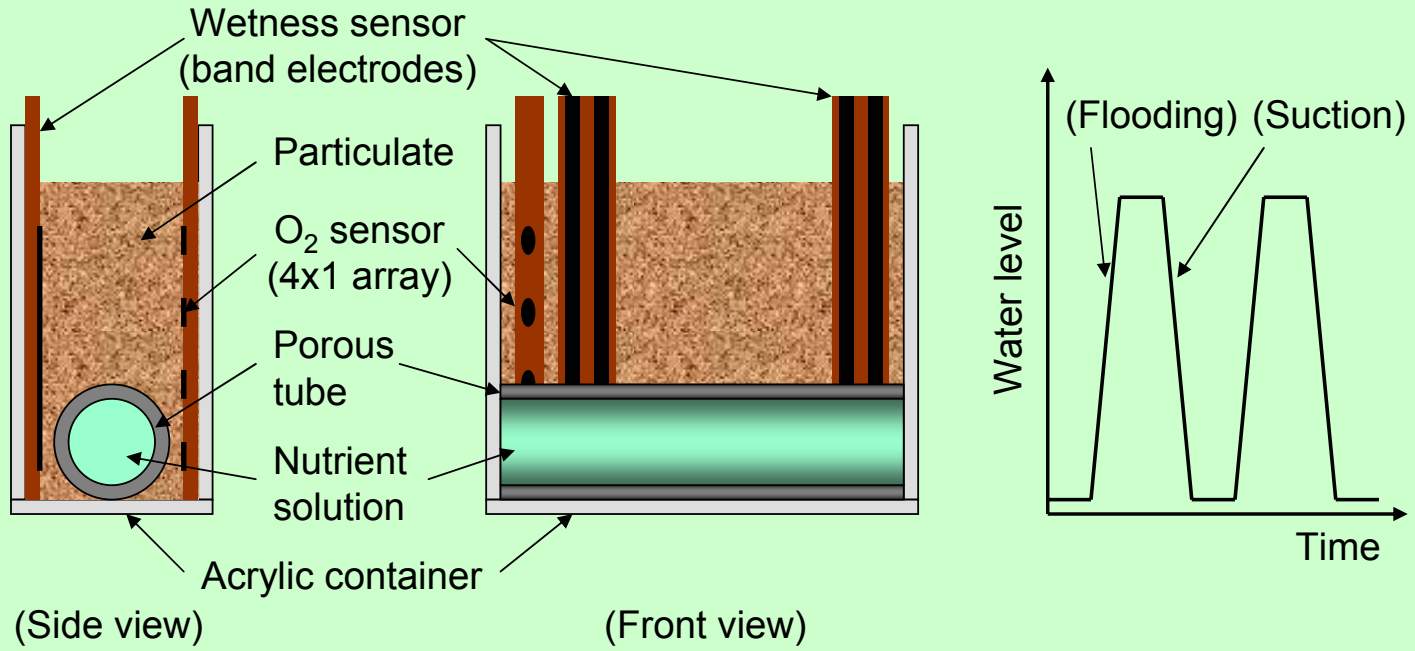
- With a microsensor array;
- Reflecting O_2 value of inner sol. at (+) pressures.
- Scattering around 0% value at (-) pressures (due to surface dryness and absence of sensor permeable membrane).

Wetness measurement on the porous tube surface



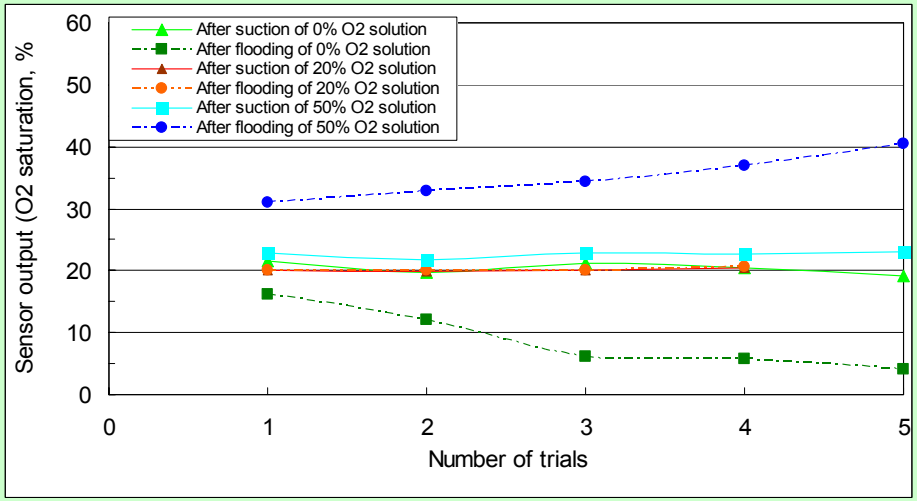
- A steep decrease of surface impedance at the transition from (-) to (+) pressure.

Experimental setup with a particulate growth system (Turface® 1-2 mm size particulate)

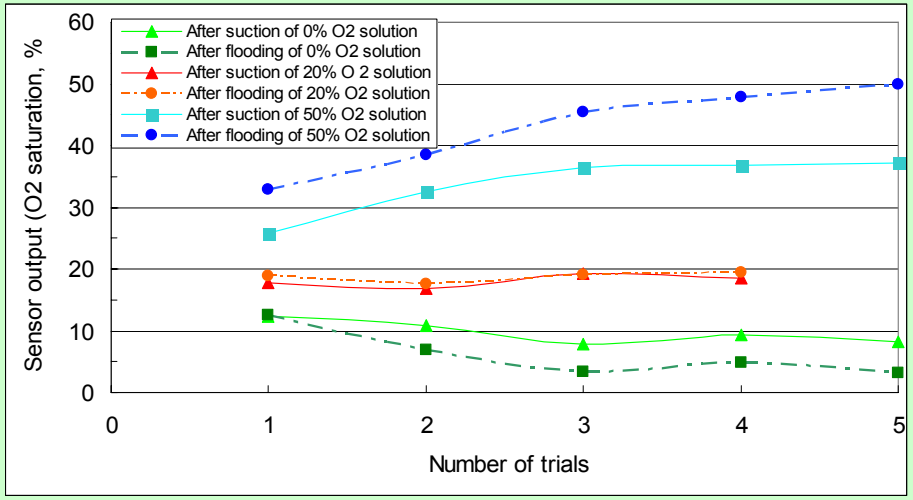


- Dissolved oxygen and wetness measurements within an unsaturated Turface® media.
- Repeated flooding and suction of nutrient solution using the embedded porous tube.

Dissolved oxygen measurements within the particulate

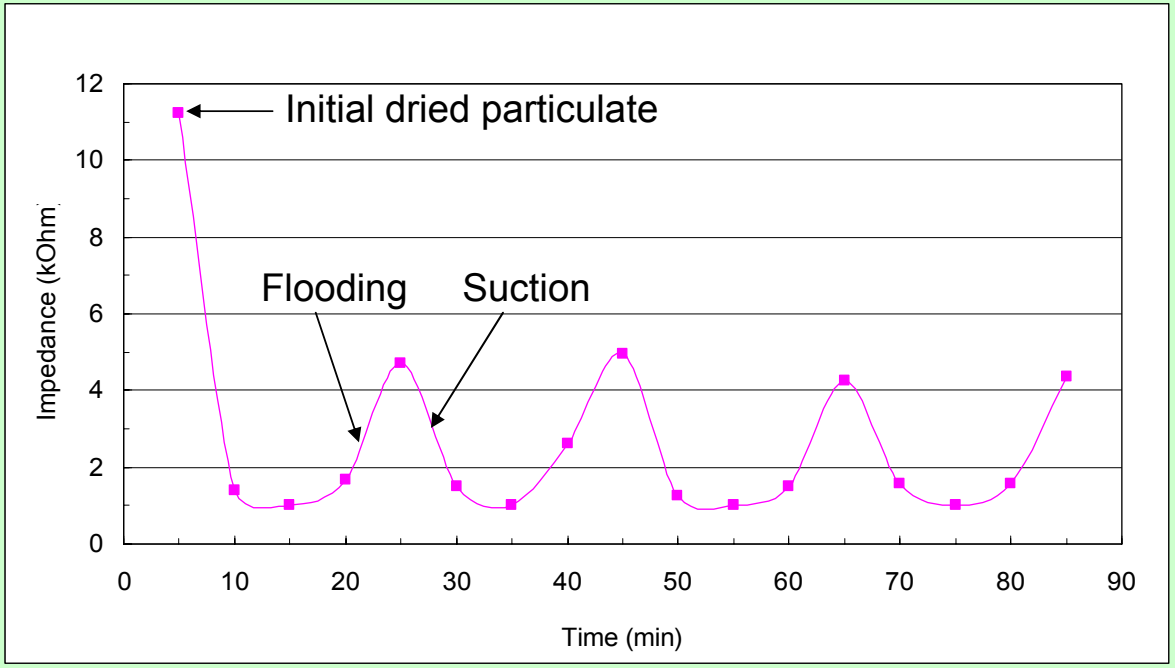


- With a commercial oxygen probe;
- Convergence to O_2 value of inner sol. with repeated flooding.
- Convergence to 20% value (air-sat. value) with suction.



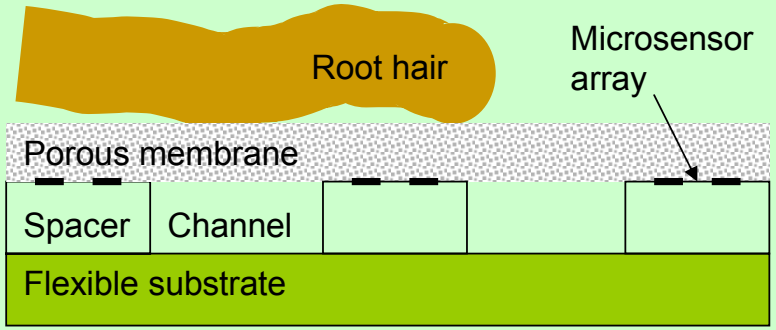
- With a microsensor array;
- Better reflection of O_2 value of inner sol. with repeated flooding.
- Better reflection of O_2 value of inner sol. with repeated suction.

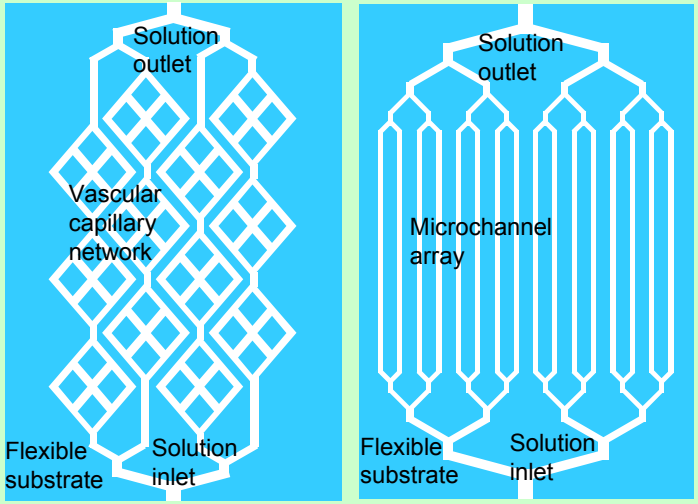
Wetness measurement within the particulate



- Variations of the impedance due to repeated solution flooding and suction.

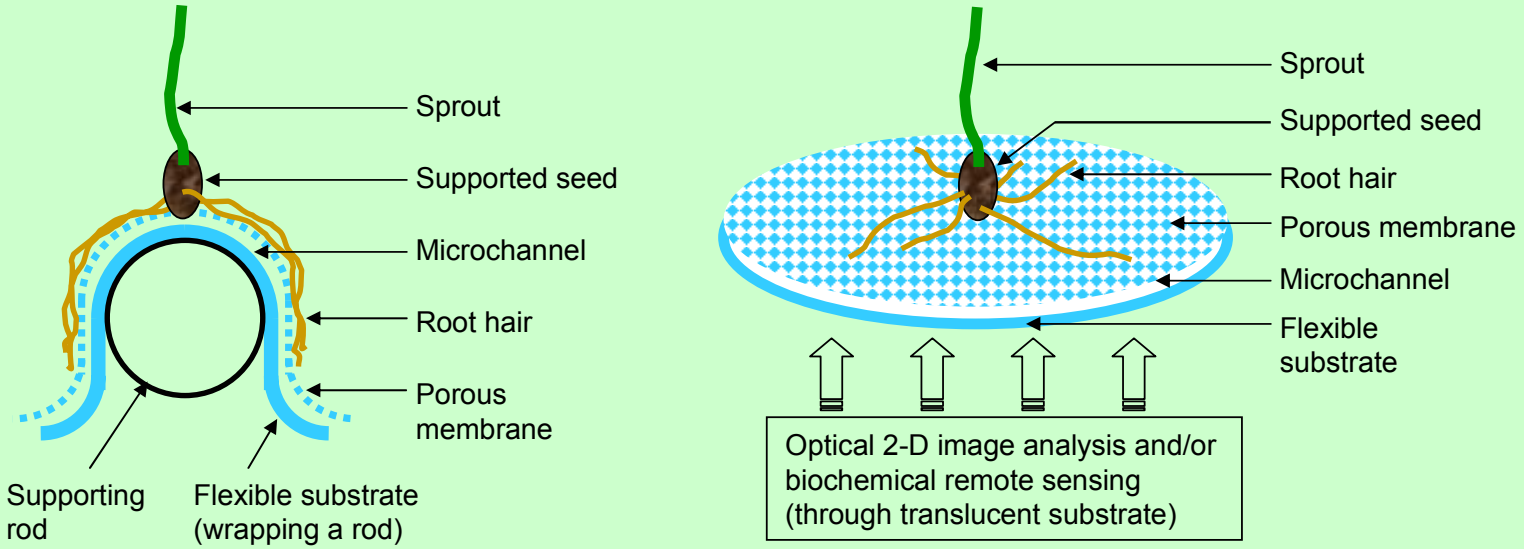
Flexible microfluidic substrate for rhizosphere monitoring and manipulation





- Root hair growth on the surface of a porous membrane with underlying microfluidic channels and microsensor arrays.
- Exemplary layout of planar microfluidic substrates.

Conceptual growth system using flexible microfluidic rhizosphere substrate



- Rhizosphere manipulation using embedded microchannels (e.g. change of nutrient solution composition).
- Rhizosphere *in situ* monitoring using embedded microsensor arrays or remote optical sensors.
- Root growth pattern analysis using optical imaging.

Summary

- Demonstration of feasibility of microsensor for porous tube and particulate growth systems.
  - Dissolved oxygen.
  - Wetness.

- Flexible microfluidic substrate with microfluidic channels and microsensor arrays.
  - Dynamic root zone control/monitoring in microgravity.
  - Rapid prototyping of phytoremediation.
  - A new tool for root physiology and pathology studies.

Acknowledgement: NASA grant NAG9-1423