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 O₂ value of inner sol. at (+) pressures.
  - Convergence to 20% value (air-sat. value) at (-) pressures.

- With a microsensor array;
  - Reflecting O₂ 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.

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