Distributed Wireless Monitoring of Carbon Dioxide Concentrations in Grain Bins

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Abstract: We propose to develop low cost wireless sensors that can map out the local concentration of carbon dioxide (CO_2) in large volume grain bins. Microbial respiration can thereby be monitored via changes in the CO_2 concentration over time. The sensors will be slightly larger than the size of a corn kernel and able to be mass manufactured at a relatively low cost per individual sensor ($5 to $10 per sensor). The low cost and recoverability of the sensors will enable farmers and elevator manager to randomly distribute a hundred or more such sensors directly in the bin's interior during bin filling for local distributed sensing. The sensors can be recovered when the bin is emptied by size (screening) or use of a magnet. Since each sensor is unique, it will be easy to identify any missing sensors and identify its location by triangulation. Technically the proposed concept is applicable to storage of all perishable bulk foods.

Concept: Metal oxides, polymers, and ceramics have each been studied as functionalized materials to act as chemical to electrical transducers. The permittivity and/or conductivity of these materials change in the presence of select gases. Prior research has identified $BaTiO_3$ and multiwall carbon nanotubes as promising materials for sensing CO_2 and has focused on demonstration of individual sensor elements. Here, we propose adapting device design results from the prior literature to create a distributed sensor network that can provide not only CO_2 concentration but also the associated positional information of each sensor. As shown in Fig. 1, the approach will be to fabricate sensors with unique resonance frequencies and passively interrogate each sensor by tuning the frequency of the radio frequency (RF) excitation signal. The concentration of CO_2 gas will shift this resonance frequency and thus the local CO_2 concentration as well as the sensor position can be obtained by triangulating the signal that reaches a surrounding receiver array.

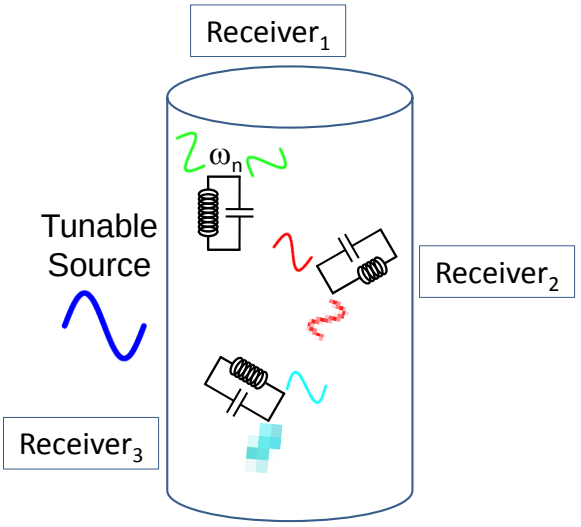

Fig. 1. CO_2 sensors are randomly distributed in a grain bin. Each responds to a unique source frequency. Multiple receivers enable triangulation of each sensor's position and CO_2 concentration.

Why We are Requesting Funding Now: The principle investigators feel that we can within 3 months be able to prove feasibility of the technology and have a better understanding of any additional development time and cost required in advance of the General Call for Proposals being proposed by The ADM Institute for Post-Harvest Loss Prevention board. The additional 3 months funded period is to allow for more in depth analysis and assessment of the project and keep the team of researcher working together. We have three students identified to work on the project, one in ABE and two in ECE who will work on this project during the summer and fall.