Near-Field Coupled RFID Tag for Carbon Dioxide Concentration Sensing

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Measuring carbon dioxide (CO_2) concentration plays an important role in environmental sciences, agri-food, medicine, packed food, and oil and chemical industry (R. Ali, T. Lang, S.M. Saleh, R.J. Meier and O.S. Wolfbeis, Analytical Chemistry, 83, 2846-2851, 2011). Spoilage of grain can be 3-10% in developed countries and as high as 30% in developing countries. Increased levels of CO_2 in a stored grain bulk indicate that insects, mould, or excessive respiration is present. A wireless sensor that is able to monitor the evolution of excessive CO_2 from a stored grain mass would be an inexpensive reliable indicator of deteriorating grain and lead to significant reduction in food loss. Conducting polymer, colorimetric pH indicator and metal-oxide based sensors have previously been applied to sense CO_2. These approaches require custom electronics in order to be integrated with RFID technology. In this work we present a new CO_2 sensor based on a hydrogel-pH-sensitive electrode pair. This sensor provides a direct voltage measurement depending on the CO_2 concentration in the surrounding environment. We have integrated this sensor into a chipless near-field coupled RFID tag.

The tag employs a voltage dependant frequency shift approach using a LC resonator comprised of a spiral inductor in parallel with a varactor. The carbon dioxide detector comprises of a hydrogel coated pH-sensitive electrode pair connected in parallel with the varactor. The hydrogel is utilized as an absorptive medium for carbon dioxide and acts to contain the electrolyte. On the absorption of the carbon dioxide, the hydrogel pH decreases, which in turn changes the voltage across the pH-sensitive electrode pair shifting the resonant frequency of the tag. An interrogator coil is inductively coupled to the tag inductor and remotely tracks the resonant frequency of tag. The sensor has a linear response to the logarithm of carbon dioxide concentration and a detection limit of 1000 ppm, suitable for spoilage detection in grain. The tag is amenable to implementation using printed electronics techniques.