Printed Low Power Amperometric Gas Sensors Employing RF Energy Harvesting

M. T. Carter<sup>a</sup>, J. R. Stetter<sup>a</sup>, J. R. Smith<sup>b</sup>, A. N. Parks<sup>b</sup>, Y. Zhao<sup>b</sup>, M. W. Findlay<sup>a</sup> and V. Patel<sup>a</sup>

a KWJ Engineering, Inc.
8440 Central Avenue
Newark, CA 94560 USA

<sup>b</sup>Depts. of CSE & EE University of Washington Box 352350 Seattle, WA 98195-2350, USA

We will report on some new types of low power amperometric gas sensors developed at KWJ Engineering and coupled with energy harvesting approaches at the University of Washington. These sensors exploit printed electronics strategies to produce high performance gas sensors in a scalable process at very low cost. The printed electrochemical sensor shows great promise to provide a high-performance, low-cost monitoring option for many toxic gases. The platform has high sensitivity, high selectivity, low detection limit, long-life and durability in a wide variety of applications. Its performance surpasses what is possible with other typical low-cost sensors, such as heated metal oxide semiconductor (HMOS) platforms. There is typically a significant performance gap between small, low cost, mass-producible gas sensors with low selectivity and low sensitivity and high cost sensors, which provide better performance at a price premium. The work to be discussed here seeks to bridge this costperformance gap. High performance systems also typically require significant power, making battery powered unattended operation or energy harvesting operation impractical or impossible.

The screen-printed devices described here make high performance gas sensing more widely available than has been possible previously. Furthermore, we have recently embarked on novel work to show that these low power, printed platforms can use scavenged radio-frequency (RF) energy for operation, eliminating the need to replace and/or maintain batteries in certain sensing applications (Figure 1). The use of ambient RF energy, such as that produced by television transmitters, is enabled by the low-power nature of the sensor. This power scavenging capability will provide unprecedented flexibility for gas sensor implementation. The low power, energy scavenging mode will enable gas sensors to be used in environments and applications heretofore impossible or impractical to address.

This report will discuss new results for gas sensing using the screen-printed platform for monitoring carbon monoxide and other gases, in both conventionally powered and RF power scavenging modes.

## Acknowledgements:

This work is supported at KWJ Engineering by the National Science Foundation, Award No. 1058563 (NSF SBIR Phase II) and the National Institutes of Health, Grant No. 1R43ES019385-01 (NIH NIEHS SBIR Phase

I). At the University of Washington, work is supported by the Google Faculty Research Award.

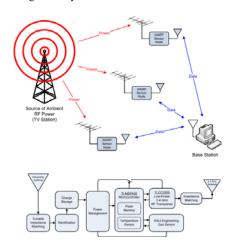


Figure 1. (top) Overview of the Wireless Ambient Radio Power (WARP) concept and (bottom) block diagram of an RF energy harvesting device incorporating a printed amperometric gas sensor.