Project Report **February 26th 2008**

Fabrication of Corrosion Monitoring Cantilever Sensors

By Leanne Andruszkiewicz and Peter J. Hesketh
Woodruff School of Mechanical Engineering,
Georgia Institute of Technology

Submitted to William England, Purafill Inc., 2654 Weaver Way, Doraville, GA 30340

Cantilever Sensor

Figure 1 shows a SEM micrograph of an array of cantilever sensors with piezoresistive strain gauges. These sensors are described fully in the papers published by our group [1], [2] and in the dissertation of Arnab Choudhury [3]. Several sensors have been coated with a thin layer of copper or silver to accommodate corrosion sensing principle. The thickness of the copper and silver is approximately <100nm.

The sensor resistance values were measured prior to delivery to Purafill. They are listed in table 1. Some of the sensors on each die are not functional; the devices highlighted in yellow are working devices.

An instrument box has been loaned to Purafill for measurement of the cantilever sensors. Figure 3 shows schematic diagram of the circuit building blocks. A constant current of approximately 200uA is supplied to each sensor. A buffer outputs a voltage in proportion to the resistance value of the sensor, as indicated in Figure 4. This calibration curve was measured with the instrument box supplied.

Finally the temperature of the sensor (and its resistance) is a function of the flow rate, see Figure 5. However, by monitoring a coated sensor and uncoated sensor (silica surface) the difference in resistance for surface stress and temperature compared to just temperature changes can be distinguished. The coated sensor responds to surface stress and temperature, while the uncoated sensors just respond to just temperature.

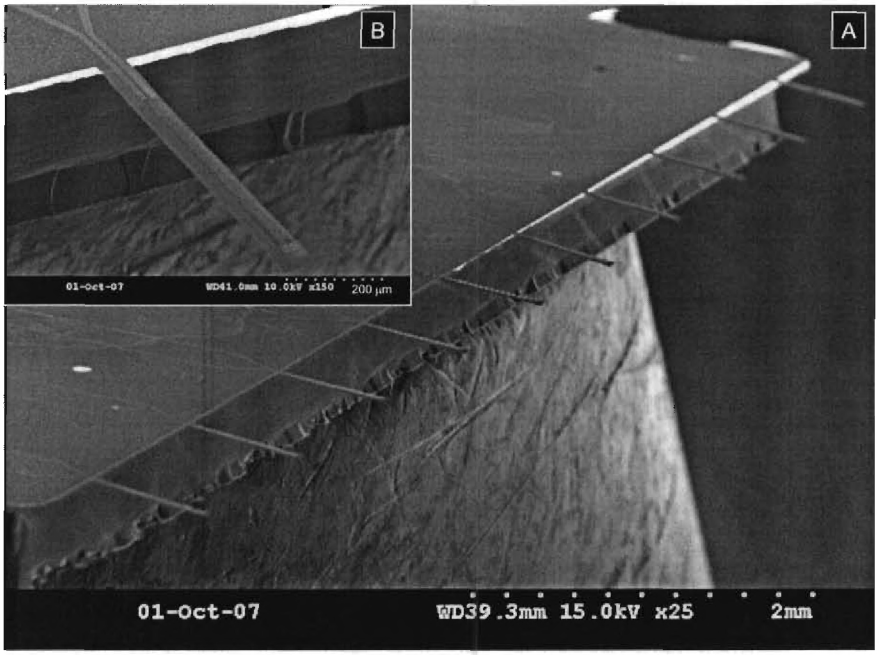

Figure 1: SEM picture of (A) sensor array and (B) individual cantilever sensor.

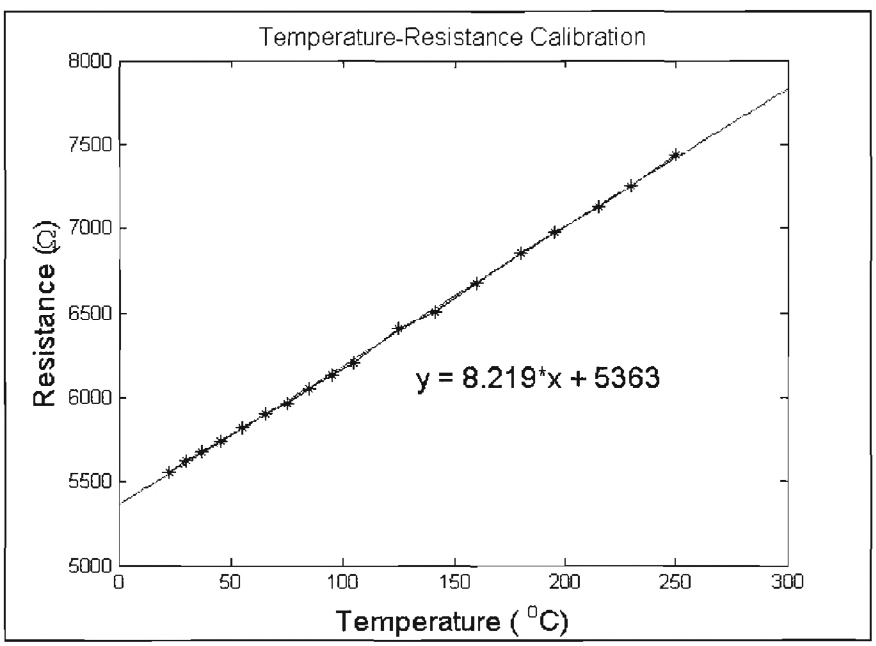

Figure 2: Temperature calibration for a typical cantilever sensor.

Table 1: List of sensor resistance values.

Device Number	Cantilever										
	1	2	3	4	5	6	7	8	9	10	
19											
Exp Reistance	300	300	300	300	300	300	300	300	300	300	
Actual Resistance	x	x	x	x	x	x	x	x	x	x	
26											
Exp Reistance	550	500	400	350	300	550	500	400	350	300	good
Actual Resistance	x	x	x	x	3.78	x	5.84	4.4	x	3.3	
12											
Exp Reistance	300	300	300	300	300	300	300	300	300	300	
Actual Resistance	x	4.71	x	4.8	4.85	2.6	4.82	2.6	x	x	
32											
Exp Reistance	400	400	400	400	400	400	400	400	400	400	good
Actual Resistance	2.17	2252	2190	4.3	4.33	4.3	4.25	4.3	x	4.4	
28											
Exp Reistance	400	400	400	400	400	400	400	400	400	400	good
Actual Resistance	4.36	4.26	4.23	4.2	4.21	4.2	2.14	4.2	x	x	
22											
Exp Reistance	200	200	200	200	200	200	200	200	200	200	good
Actual Resistance	2.21	2.23	2.22	2.1	2.14	2.2		2.2		2.3	
23											
Exp Reistance	300	300	300	300	300	300	300	300	300	300	good
Actual Resistance	x	x	x	x	x	3.1	3.15	3.2	3.4	3.2	
18											
Exp Reistance	425	375	300	260	225	425	375	300	260	225	good
Actual Resistance	x	4.12	3.6	2.9	2.46	4.6	4.12	3.3	2.9	2.5	
31											
Exp Reistance	275	250	200	175	150	275	250	200	175	150	good
Actual Resistance	1.68	x	1.24	x	x	3.1	2.74	2.3	1.9	1.7	
33											
Exp Reistance	300	300	300	300	300	300	300	300	300	300	
Actual Resistance	x	x	x	x	x	x	x	x	x	x	
30											
Exp Reistance	200	200	200	200	200	200	200	200	200	200	good
Actual Resistance	2.1	1.34	2.23	2.2	2.2	2.2	2.2	x	x	x	
33											
Exp Reistance	300	300	300	300	300	300	300	300	300	300	
Actual Resistance	cracked										

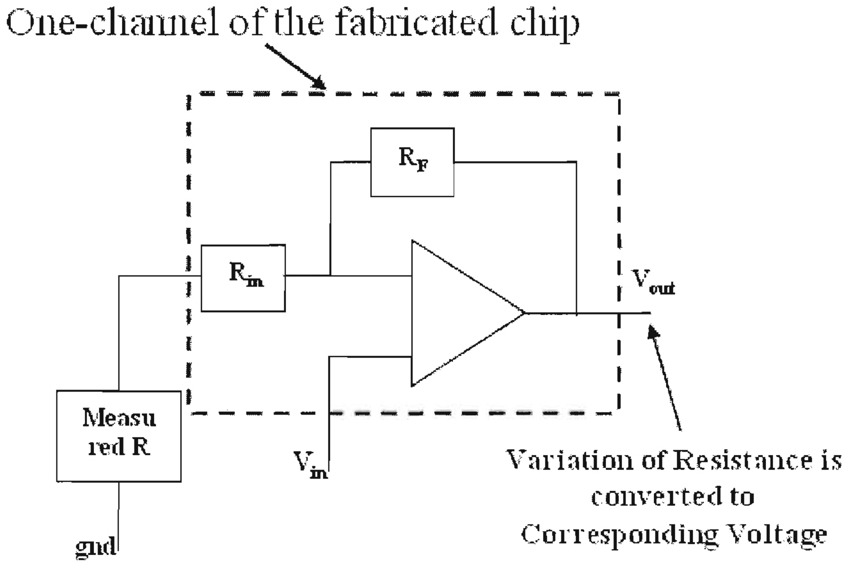

Figure 3: Block diagram of measurement interface for 10 sensors that converts the resistance to an output voltage. A constant DC current is supplied to each sensor of approx 200uA.

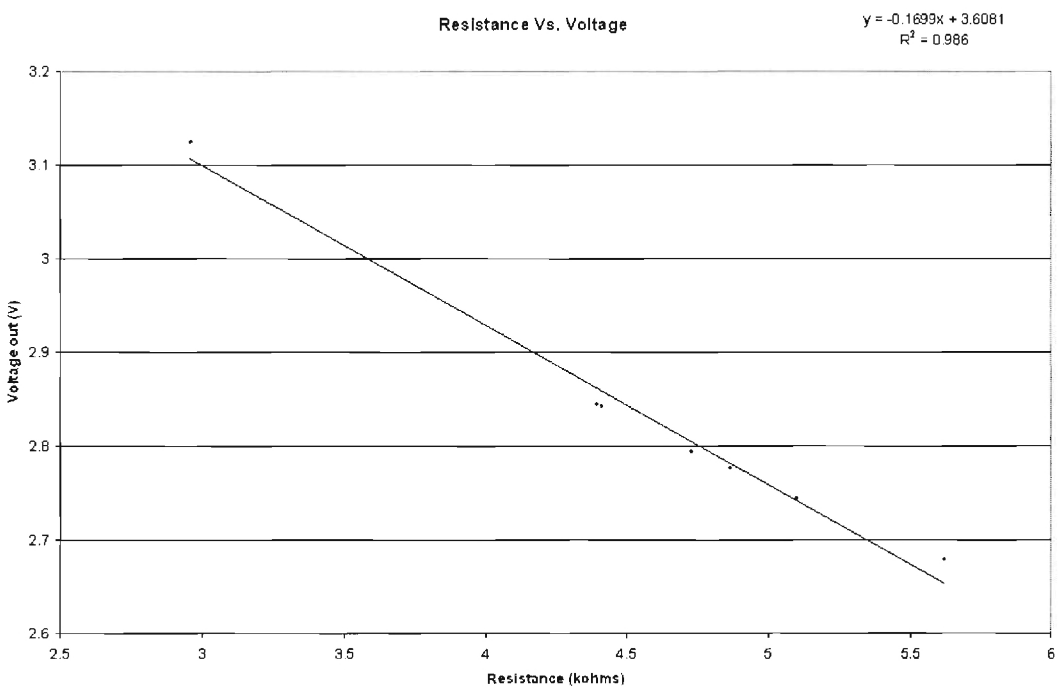

Figure 4: Calibration curve of instrumentation box.

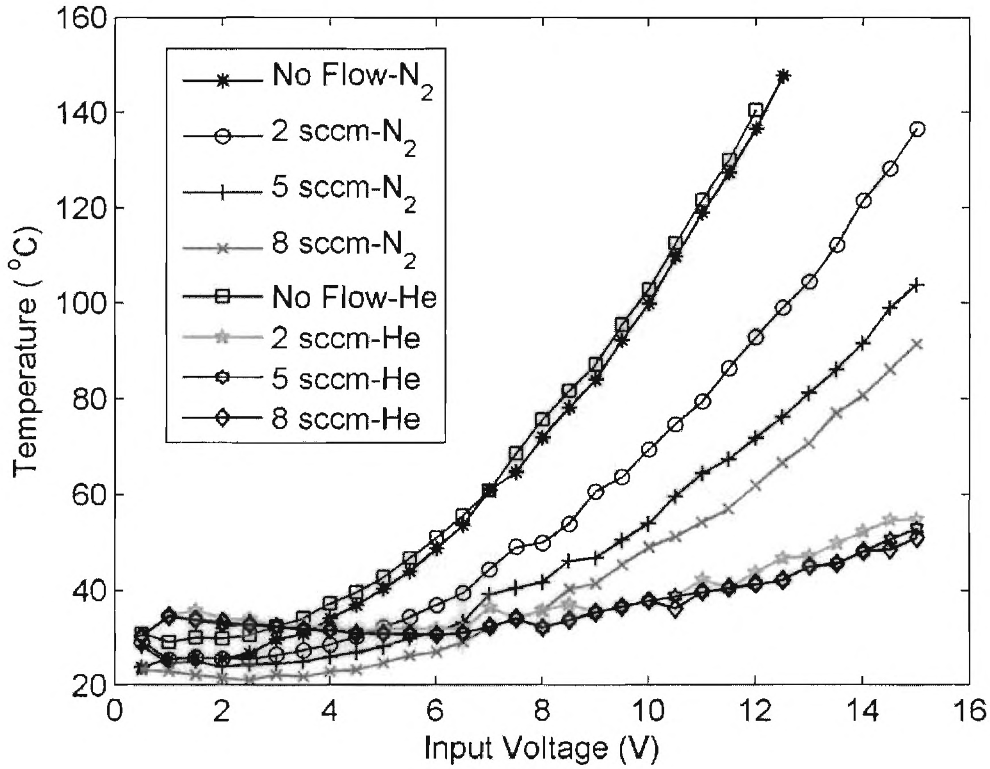

Figure 5: Temperature of sensor (calculated from resistance calibration curve, figure 2 above) as a function of nitrogen and helium flow rate.

References

[1] A. Choudhury, P. J. Hesketh, Z. Hu, T. Thundat, "A piezoresistive microcantilevers array for surface stress measurement: Curvature model and fabrication," *Journal of Micromechanics and Microengineering,* vol. 17, pp. 2065-2076, 2007.

[2] A. Choudhury, P. J. Hesketh, Z. Hu, T. Thundat, "Low noise chemical detection with a Piezoresistive Microcantilever," *Transactions of the ECS,* vol. 2, pp. 473-482, 2006.

[3] A. Choudhury, P. J. Hesketh, "A Piezoresistive Microcantilever Array for Chemical Sensing Applications," in *Mechanical Engineering.* vol. Ph.D. Atlanta: Georgia Institute of Technology, 2007, p. 178.