ANALYSIS OF PIEZORESISTIVITY IN DIAMOND FILMS

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Piezoresistive materials have long been used in the sensor industry. Strain induced resistance change enables piezoresistive materials to be used for microelectromechanical (MEMS) sensors, e.g. pressure transducers and accelerometers. The material properties of diamond such as its strength and unmatched elastic modulus in excess of 350 GP make it an attractive sensor material candidate. Also, it is the most thermally conductive material, 22W/cm-K, as well as being piezoresistive and chemically inert in excess of 600°C. Undoped diamond films offer excellent electrical insulation while boron doped diamond exhibits p-type semiconducting properties. All of these properties provide a material with a large potential for sensor development, where strength, ruggedness, and electrical properties are the key elements for sensor performance.

Diamond is developed as a sensor material by taking advantage of its strength and semiconducting properties. Diamond MEMS (D-MEMS) were fabricated and will be described in this paper. Figure 1 shows the IC type layout design of one of several configurations of D-MEMS pressure sensors and accelerometers in this work. Figure 2 is the SEM of the "chip" physical realization of the sensor shown in the layout. Gauge factors for the diamond piezoresistors on these devices were measured over a range of strains and temperature up to 350 micro-strain and 400°C respectively. The dependence of these piezoresistors on temperature, resistivity, and strain was analyzed. The gauge factor of these piezoresistors was measured from 10 to over 1000. In some cases it is proposed that alternative effects cause change in resistivity rather than simple semiconductor piezoresistivity. Figure 3 compares gauge factors in two regimes of low and high strain, illustrating effect on GF. Deformation potential is suspected to play a role at large strains, specifically strain regimes that only diamond could sustain.

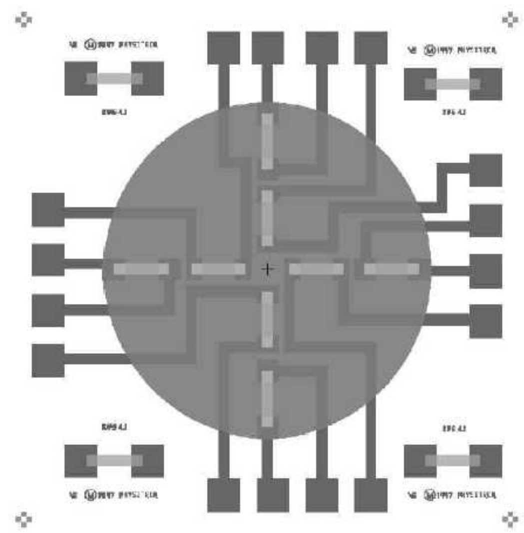

Figure 1. Layout of D-MEMS sensor
(circle depicts membrane 1mm in diameter)

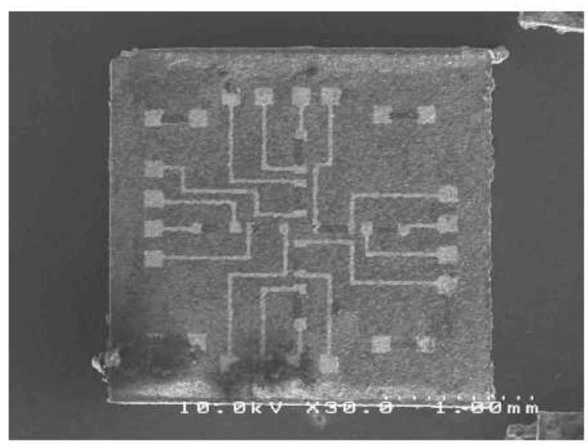

Figure 2. Low magnification of D-MEMS "chip" pressure sensor. Lighter stripes are metallization, darker stripes are diamond PZRs.

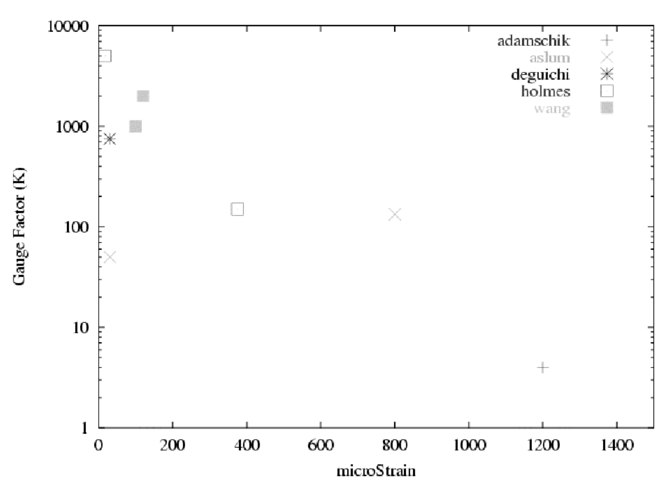

Figure 3. Gauge Factors of this and other works as function of strain across large range of strain.