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Comments on "Piezoresistive Effect in SiOC Ceramics for Integrated Pressure Sensors"

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This comment is on the paper "Piezoresistive Effect in SiOC Ceramics for Integrated Pressure Sensors", by Riedel *et al.*[1] The experimental method of testing the piezoresistive behavior is flawed in this paper, as explained below. A similar flaw exists in Zhang *et al.*[2] which is referenced by the subject paper. Due to this flaw, the piezoresistive results are not reliable.

Piezoresistivity refers to the effect of strain (which relates to the stress) on the electrical resistivity of a material.[3–5] This effect allows the sensing of strain (stress) by electrical resistance measurement. The correct measurement of the electrical resistance of a specimen requires that the resistance associated with the electrical contacts that are used to probe the specimen be excluded from the measured resistance. Even though the electrical contact material may be a material of low electrical resistivity, the interface between the electrical contact material and the specimen tends to be associated with a substantial resistance. Unless the specimen resistance is so high that it overshadows the contact resistances, the inclusion of the contact resistance in the measured resistance results in inaccurate measurement of the specimen resistance.

The four-probe method of electrical resistance measurement is effective for the essential exclusion of the contact resistances from the measured resistance. This method involves four electrical contacts—the outer two contacts for passing a current and the inner two contacts for measuring the voltage. This configuration results in the essential absence of current though the voltage contacts, hence the essential absence of a potential drop at the voltage contacts.

The four-probe method has been previously used to study the piezoresistivity of silicon carbide fiber.[6] There are variations of the electrical contact configuration of the four-probe method,[7] which depend on the specimen geometry. In contrast, the two-probe method of resistance measurement involves only two electrical contacts, each of which is for both current passing and voltage measurement. Thus, current goes through the voltage contacts, resulting in the presence of a potential drop at each voltage contact. The inferiority of the two-probe method compared with the four-probe method is well established.[8,9]

In the subject paper,[1] the electrical resistance is measured by using the two-probe method. As a result, the measured resistance includes the contact resistance. Each of the two electrical contacts is in the form of a pressure contact between a metal block and dried silver paint. There is substantial resistance associated with this interface. In addition, the resistance is substantial for the interface between the dried silver paint and the specimen being studied. In other words, both metal-silver and silver-specimen interfaces contribute to the resistance of each of the two contacts. The substantial contact resistance makes the measured resistance not reliable for reflecting the behavior of the specimen. The two-probe method is reliability only when the contact resistance is negligible compared with the specimen resistance. The measured resistance (3.3 kΩ) is not very high, suggesting that the contact resistance is not negligible.

The two-probe method suffers even more in piezoresistivity testing. The application of pressure tends to cause the contact resistance to decrease (due to the tightening of the interfaces) and this effect can be reversible upon unloading. Thus, the observed piezoresistive effect may be substantially changed by the effect of pressure on the contact resistance. As a consequence, the true gage factor that describes the piezoresistivity of the specimen is expected to be considerably lower than the value reported.

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