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Nanocomposite Thin Films as Sensor Material for Strain Gauges

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For force and load measurements strain gauges are commonly used. Different applications have specific requirements on the material development of thin film strain gauges. In some cases high strain sensitivity is essential to reach high precision of measurements. In other cases harsh or hot ambient conditions require particularly stable sensors whereas the typically metallic strain sensitivity with gauge factors of approximately 2 is sufficient. Since strain gauges use the linear correlation between resistance and elongation for strain measurement it is necessary to have a temperature-independent resistance. In general a low temperature coefficient of resistance (TCR) of a few 100 ppm/K will be compensated using a bridge circuit. Current material developments for thin film strain gauges often use compositions of nano-sized metal clusters in a dielectric matrix to increase the strain sensitivity. The correlation between strain and change of resistance can be separated into a geometric and a physical effect. The geometric effect is based on the resistance change due to modification of the cross section of the conducting lines and is limited to a gauge factor of two. The physical effect is based on the change of resistivity due to the deformation of the thin film itself. The physical reasons for the resistivity change are quantum mechanical effects (tunnelling, hopping). The charge transport is carried out between conducting clusters in a dielectric matrix. The combination of metal clusters (positive TCR) and a semiconducting matrix (negative TCR) offers additionally the chance to tailor the TCR close to zero.
Several sputtered nanocomposite materials were investigated for their ability as thin film strain gauges under various application conditions. Composites of nickel and diamond-like carbon with gauge factors up to 20 and a TCR close to zero are interesting for applications under ambient conditions ($T \leq 500$ K). For high temperature applications compounds of metal and indium tin oxide (ITO) as well as M-A-X films are investigated. Here, the stability in harsh environments is of particular interest.

Keywords
nanocomposites
strain gauge
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gauge factor