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Dielectricity, electret, piezoelectret and piezoresistivity discovered in exfoliated-graphite-based flexible graphite, with comparison with isotropic graphite (Graphene and related materials)

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This paper reports the dielectric, electret, piezoelectret and piezoresistive behavior of flexible graphite (FG, compacted acid-intercalated-graphite-based exfoliated graphite with strong in-plane preferred orientation, tested in-plane in the elastic regime). The relative permittivity κ (2 kHz) is 1170, compared to 535 for isotropic graphite (IG). The DC resistivity ρ is 7.5×10^{-6} Ω.m, compared to 1.2×10^{-5} Ω.m for IG. The inherent DC electric field E of the electret is 2.5×10^{-5} V/m, compared to 1.2×10^{-4} V/m for IG. The E, ρ, κ and capacitance increase monotonically with increasing stress for both carbons. The E and ρ increase smoothly with increasing stress; the increases are totally reversible for stress ≤1.85 MPa and slightly irreversible for stress ≤3.18 MPa, in contrast to the slight irreversibility at ≥2.7 MPa for IG. The fractional increases in E and κ at ≤3 MPa are ≤110% and ≤73%, respectively, compared to ≤6% and ≤32%, respectively, for IG. The κ-stress curve abruptly increases in slope at 2.1 MPa (absent for IG), which is accompanied by the onset of some κ increase irreversibility. This 2.1-MPa slope increase is attributed to a microstructural change that does not affect the strain reversibility or ρ, but increases κ. The change possibly involves loosening an interface in FG, with the loosening promoting polarization without affecting conduction. For IG, some irreversibility of the κ increase occurs at all stresses. The piezoelectret coupling coefficient d_{33} is 3.7×10^{-8} pC/N, compared to 1.6×10^{-7} pC/N for IG. The gage factor is 50, compared to 3510 for IG.