Flexoelectricity Induced from Interfacial Polarization in Silicon-based Barrier Layer Capacitors

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Flexoelectricity describes the electromechanical coupling between a strain gradient and electric polarization (direct effect) as well as between an electric field gradient and strain (converse effect.) Some perovskite-structured materials, such as barium strontium titanate, have high flexoelectric coefficients. However, in practice, measurement geometries are often limited to planar beams, in which the strain gradient places one side of the device under tensile stress. This, in turn, limits mechanical reliability. In this work, a truncated pyramidal device geometry is explored as a way to observe the flexoelectric effect without placing the device under tensile stress. An anisotropic wet etchant was used on a <100> silicon wafer to form arrays of micron-sized truncated pyramids which were capped with insulating layers to create a barrier layer capacitor. This approach utilizes space charge polarizability to amplify the flexoelectric coefficient. Cantilever beam analogues of the truncated pyramidal device stack were shown to have a direct flexoelectric coefficient of 4.9 ± 0.4 μC/m at frequencies below 100 Hz and truncated pyramidal devices were shown to have dielectric permittivity values in excess of 19,500 in the same frequency range. Further development of the fabrication process with a focus on reducing the size of the truncated pyramids and increasing the operational frequency range could provide a path to a lead-free alternative for many sensor applications, such as hydrophones and balance monitoring.