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Polarization Electronics – A Path to Multifunctional Materials

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Multifunctional materials are those which will lead to new and innovative devices that can serve multiple functions within a given system. An oft-overlooked parameter in devices is the presence of induced or spontaneous polarization which provides an added degree of freedom for fabrication of structures for electronics and photonics. We present two approaches – spontaneous polarization in GaN for nanoscale photonic structures, and the integration of complex oxides with GaN for induced polarization electronics. The Group III-Nitrides lack inversion symmetry that leads to a large crystal polarization resulting in both spontaneous and piezoelectric polarization. This has been viewed as a problem since built-in fields due to polarization can produce Stark shifts in devices, or charge build-up at heterojunctions. However, this also brings the potential for designing new device types. Polarization discontinuities can be used to produce regions of localized charge, allowing electronic devices to be fabricated without the need for adding extrinsic doping impurities. Combination with other materials such as ferroelectrics provides an induced polarization discontinuity that can be tunable, leading to variable and controllable polarization charge densities.