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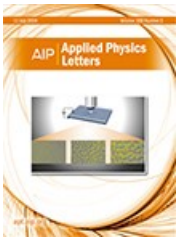

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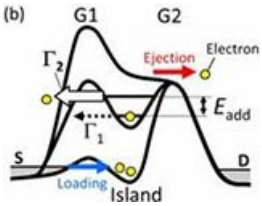
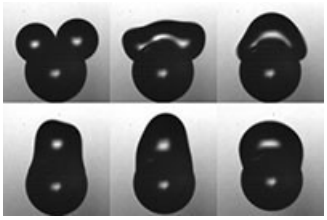
Editor's Picks



Gigahertz single-electron pumping in silicon with an accuracy better than 9.2 parts in 10^7

http://dx.doi.org/10.1063/1.4953872

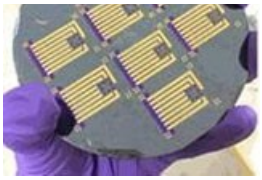
High-speed and high-accuracy pumping of a single electron is crucial for realizing an accurate current source, which is a promising candidate for a quantum current standard. Here, using a high-accuracy measurement system traceable to primary standards, we evaluate the accuracy of a Si tunable-barrier single-electron pump driven by a single sinusoidal signal. The pump operates at frequencies up to 6.5 GHz, producing a current of more than 1 nA. At 1 GHz, the current plateau with a level of about 160 pA is found to be accurate to better than 0.92 ppm (parts per million), which is a record value for 1-GHz operation. At 2 GHz, the current plateau offset from 1ef (~320 pA) by 20 ppm is observed. The current quantization accuracy is improved by applying a magnetic field of 14 T, and we observe a current level of 1ef with an accuracy of a few ppm. The presented gigahertz single-electron pumping with a high accuracy is an important step towards a metrological current standard.



Capillary-inertial colloidal catapults upon drop coalescence

http://dx.doi.org/10.1063/1.4955085

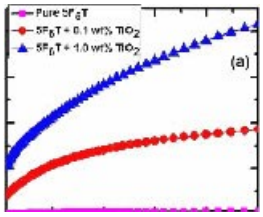
Surface energy released upon drop coalescence is known to power the self-propelled jumping of liquid droplets on superhydrophobic solid surfaces, and the jumping droplets can additionally carry colloidal payloads toward self-cleaning. Here, we show that drop coalescence on a spherical particle leads to self-propelled launching of the particle from virtually any solid surface. The main prerequisite is an intermediate wettability of the particle, such that the momentum from the capillary-inertial drop coalescence process can be transferred to the particle. By momentum conservation, the launching velocity of the particle-drop complex is proportional to the capillary-inertial velocity based on the drop radius and to the fraction of the liquid mass in the total mass. The capillary-inertial catapult is not only an alternative mechanism for removing colloidal contaminants, but also a useful model system for studying ballistospore launching.



Quantifying the intrinsic surface charge density and charge-transfer resistance of the graphene-solution interface through bias-free low-level charge measurement

http://dx.doi.org/10.1063/1.4955404

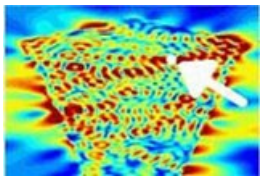
Liquid-based bio-applications of graphene require a quantitative understanding of the graphene-liquid interface, with the surface charge density of adsorbed ions, the interfacial charge transfer resistance, and the interfacial charge noise being of particular importance. We quantified these properties through measurements of the zero-bias Faradaic charge-transfer between graphene electrodes and aqueous solutions of varying ionic strength using a reproducible, low-noise, minimally perturbative charge measurement technique. The measurements indicated that the adsorbed ions had a negative surface charge density of approximately −32.8 mC m^{-2} and that the specific charge transfer resistance was 6.5 ± 0.3 MΩ cm^2. The normalized current noise power spectral density for all ionic concentrations tested collapsed onto a $1/f^{\alpha}$ characteristic with α = 1.1 ± 0.2. All the results are in excellent agreement with predictions of the theory for the graphene-solution interface. This minimally perturbative method for monitoring charge-transfer at the sub-pC scale exhibits low noise and ultra-low power consumption (~fW), making it suitable for use in low-level bioelectronics in liquid environments.



Analog switching in the nanocolloids of ferroelectric liquid crystals

http://dx.doi.org/10.1063/1.4955023

Nanoparticle (NP) dispersion in liquid crystals (LCs) results in significant changes in the physical properties of the existing LC mixtures. Two ferroelectric liquid crystals (FLCs), $5F_6T$ and $6F_6T$, have been studied for analog switching. The $5F_6T$ sample is doped with titanium dioxide (TiO_2) NPs of two different concentrations of the same average particle size and another FLC $6F_6T$ is systematically doped with barium titanate $(BaTiO_3)$ NPs of two different average particle sizes at the same concentration. The frequency and temperature dependence of the coercive voltage of FLC nanocolloids has been studied. The V-shaped switching was observed in the case of nano-doped FLCs. The value of inversion frequency for the $5F_6T + 1.0\ \text{wt.}\%$ TiO 2 doped sample is 30 Hz while it is 24 Hz for the $6F_6T + 0.5\ \text{wt.}\%$ BaTiO 3 (particle size 5–10 nm) doped sample. The conductivity measurements show that the conductivity of doped samples is higher than the conductivity of their parental FLCs and can be considered the main reason for the V-shaped switching in the FLC nanocolloids, which was initially absent in their parental FLCs.



Disentangling nonradiative recombination processes in Ge micro-crystals on Si substrates

http://dx.doi.org/10.1063/1.4955020

We address nonradiative recombination pathways by leveraging surface passivation and dislocation management in μm-scale arrays of Ge crystals grown on deeply patterned Si substrates. The time decay photoluminescence (PL) at cryogenic temperatures discloses carrier lifetimes approaching 45 ns in band-gap engineered Ge micro-crystals. This investigation provides compelling information about the competitive interplay between the radiative band-edge transitions and the trapping of carriers by dislocations and free surfaces. Furthermore, an in-depth analysis of the temperature dependence of the PL, combined with capacitance data and finite difference time domain modeling, demonstrates the effectiveness of GeO2 in passivating the surface of Ge and thus in enhancing the room temperature PL emission.