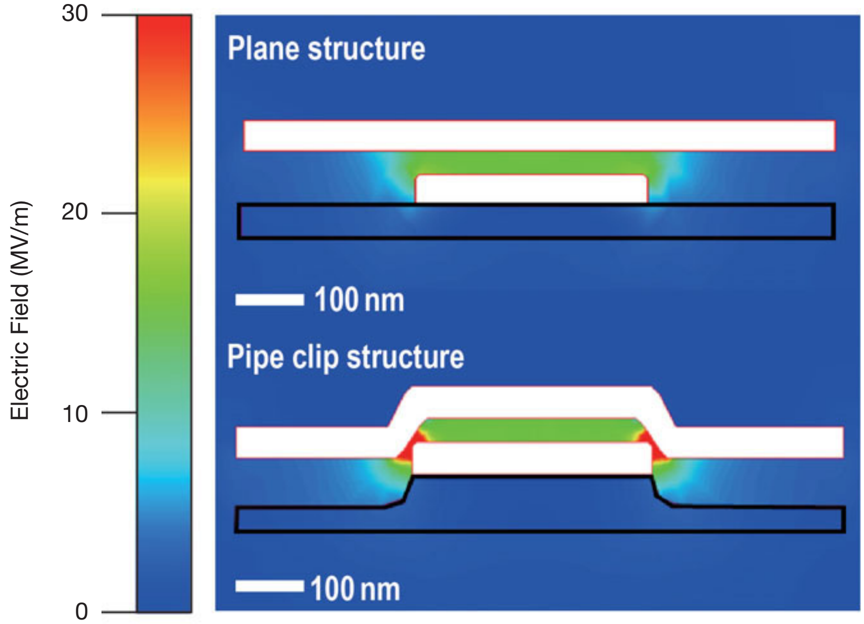
Nano Focus

"Pipe clip" interface structure for nanoelectromechanical switching device operates below 1 V

Nanoscale electromechanical (NEM) switches can be used as relays, transistors, logic devices, and sensors, and compared with conventional semiconductor switches offer reduced power consumption and improved ON/OFF ratios. NEM switches operate by controlling the contact between terminals, where a physical gap is typically overcome by applying large voltages (4–20 V) across the terminals. This prevents low-power applications and strong adhesion forces can occur that dominate over the restoring force. Overcoming these problems, a group of researchers at the Korea Advanced Institute of Science and Technology (KAIST) and the Korea National NanoFab Center (NNFC) recently fabricated NEM devices with ultrathin physical gaps by creating a curved or "pipe clip" suspended electrode structure. These operate below 1 V and exhibit negligible leakage current and on/off ratios of 1×10^6.

As described in a letter published online on November 25, 2012 in *Nature Nanotechnology* (DOI: 10.1038/NNANO.2012.208), Jeong Oen Lee of KAIST and co-researchers used a high-density plasma (HDP) method to deposit a sacrificial SiO_2 layer that was sandwiched between tungsten//tungsten/titanium electrodes. This resulted in an ultrathin gap of <10 nm between the electrodes.



Electric-field distribution of the traditional plane structure (upper) and the proposed pipe clip structure (lower) for a nanoscale electromechanical switching device. Reproduced with permission from *Nature Nanotech*. **8** (2013), DOI: 10.1038/nnano.2012.208; p. 36. © 2013 Macmillan Publishers Ltd.

The researchers used three-dimensional finite-element simulations to evaluate the electromechanical characteristics of the pipe clip structure, and to compare them with a plane structure. As shown in the figure, large forces exist near the small gap regions due to the quadratic nature of the electrostatic force. Electrical characterization showed repeatable switching near 400 mV with a very small subthreshold slope of 10 mV/dec.

This unique device structure addresses key requirements of low-voltage operated NEMs through a small physical gap (~4 nm), minimized physical contact to reduce adhesion forces, and straightforward fabrication using the sacrificial trenched-layer method.

Christopher J. Patridge

Photocurrent generation mechanism in biased graphene found to be PV or bolometric

Graphene has interesting optoelectronic properties due to its zero bandgap, electron–hole symmetry, and high carrier mobility. For example, graphene can convert absorbed light into photocurrent. The origin of this photoresponse in graphene junctions has been attributed to either thermoelectric or photovoltaic (PV) effects. However, identifying which photocurrent mechanism is dominant is challenging because the polarities of PV and thermoelectric currents measured in metal–graphene or graphene *p–n* junctions are the same.

Recently, M. Freitag, T. Low, F. Xia, and P. Avouris at IBM's T. J. Watson Research Center have investigated the mechanism of photocurrent response in biased, homogeneous graphene. By measuring the photoconductivity of the homogeneous graphene channel in a graphene field-effect transistor (FET) fabricated on Si/SiO_2, wherein photocurrent polarities due to PV and thermoelectric effects are opposite, the researchers determined that the dominant photocurrent generation mechanism at low electrostatic doping is photovoltaic, and that the thermoelectric effect is an order of magnitude smaller.

The researchers report in an article published online on December 16, 2012 in *Nature Photonics* (DOI: 10.1038/NPHOTON.2012.314) that they biased their graphene FET at one contact with a moderate drain voltage of about –1 V. Doping was controlled electrostatically with a global silicon backgate, and the alternating photocurrent amplitude and phase were measured while a chopped, focused laser beam at a wavelength of