Sign in Forgotten your password? Sign up **IOP** A community website from IOP Publishing Seeing at the Nanoscale 2012 BRUKER JULY 09-11, 2012 Bristol, UK Home | News | Journal | Multimedia | Events | Buyer's guide | White papers | Jobs | Links | Blog | Contact us Search Go LATEST NEWS ARTICLES **TECHNOLOGY UPDATE** NANO HIGHLIGHTS Nanotube variations affect Mar 30, 2012 **Download** your FREE transistor performance Nanotube variations affect transistor copy Electrons tunnel through performance NANOTECHNOLOGY ultrathin boron nitride Researchers at the University of Illinois at Urbana-Tomography technique breaks Herlets 2011 Champaign in the US have undertaken the first new record comprehensive study on how variations in the diameters Sol-gel makes nanostructured metallics and local densities of as-produced single-walled carbon Robot jellyfish fuelled by nanotubes (SWCNTs) affect the performance of transistors hydrogen made from arrays of these tubes. The results of the study show that the performance of the devices depends largely on how SWCNTs with varying diameters are spread **RELATED STORIES HEADLINES BY E-MAIL** throughout an array - a characteristic that could be Nano-radios move on (Jan To receive a free weekly improved on with better processes to grow and purify the 2008) news round-up via e-mail nanotubes. Graphene helps make a new kind of LED (Aug 2010) Nanotransfer makes largearea NIMs (Jun 2011) Gate Source **RELATED LINKS** Drain **Rogers Research Group at** Illinois SOG + HfO **RESTRICTED LINKS** J. Appl. Phys. 111 054511 **Quartz Substrate** SWNTs **RELATED PRODUCTS** The webinar "TERS. 10 µm Approaching 10 nm spatial resolution in Raman imaging" NT-MDT Aligned array of tubes Mar 13, 2012 The best, and probably only, way to integrate carbon nanotubes into high-quality transistors is to use horizontal, New Lake Shore Cryogen-free

Probe Stations from Elliot Scientific Elliot Scientific Ltd. Mar 16, 2012

8 Channel Fiber Optic Video Transceiver WT-S8V↑1D↓3-T/RF Wextra International Limited Mar 5, 2012

aligned arrays of tubes, says team leader John Rogers. "Although it is now possible to grow nanotubes in exactly such configurations, nearly ideal in their layouts, there is no known way to control their diameters and local densities precisely," he told *nanotechweb.org*. "Our work describes a systematic study of how variations in diameter and local density affect the performance of transistors built from such arrays."



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A single-walled carbon nanotube (SWCNT) is a sheet of carbon just one atom thick rolled up into a tube that has a diameter of about 1 nm. The atoms in the sheet are arranged in a hexagonal lattice. The relative orientation of the lattice to the axis of the tube determines whether the tube is a metal or a semiconductor and so what type of electronic properties it has.

Aligned arrays of SWCNTs are ideal for use in a variety of applications, such as high-performance sensors and transistors, thanks to their extremely high surface area and excellent charge transport properties, such as charge carrier mobilities as high as $10^4 \text{ cm}^2/\text{Vs}^{-1}$. However, in spite of these excellent properties, as-produced aligned arrays of SWCNTs contain a mixture of metallic and semiconducting nanotube with varying diameters and local densities (measured as the number of nanotubes per unit length perpendicular to the direction in which they are aligned). This fact leads to variations in the electronic properties across the arrays that are difficult to control.

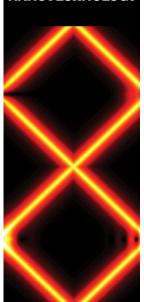
Understanding such variations means that researchers need to make detailed measurements on the structures to locate where the non-uniformities actually lie, which is no easy task.

Experiment and theory

The work undertaken by Rogers' team combines both experiment and theory. "The experiments involve making measurements on single-tube devices as well as those built with arrays that have various numbers of tubes in different regions across a substrate, made of quartz, for example," explained Rogers. "Then, theoretical models calibrated against the single-tube measurements are used to produce predictive tools to understand the behaviours of the array devices."

The team measured how various performance parameters, such as drain current, transconductance and threshold voltage, varied across the devices. Deviations from theoretical values for these parameters suggested significant variations in





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E	ne SWNT density and/or diameters across the substrate. xtensive atomic force microscopy on different areas of the ubstrates was subsequently employed to back up these ndings.
ui po fu	The results could help industry better understand the kind of niformity that is required in nanotube arrays to make high- erformance transistors," said Rogers. "Indeed, our work is unded entirely by companies interested in such pplications," he added.
pi va	he researchers are busy trying to come up with new ways to urify the nanotube arrays. "This should help reduce ariations in density and diameter to levels that allow ransistors to meet industry specifications."
	he work was reported in the <i>Journal of Applied Physics</i> . bout the author
Be	elle Dume is contributing editor at <i>nanotechweb.org</i>
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