

NEW: Find **great deals** on the latest gadgets and more in the **ScienceDaily Store!**

Science News

from research organizations



Single photon light emitting diodes for on-chip integration

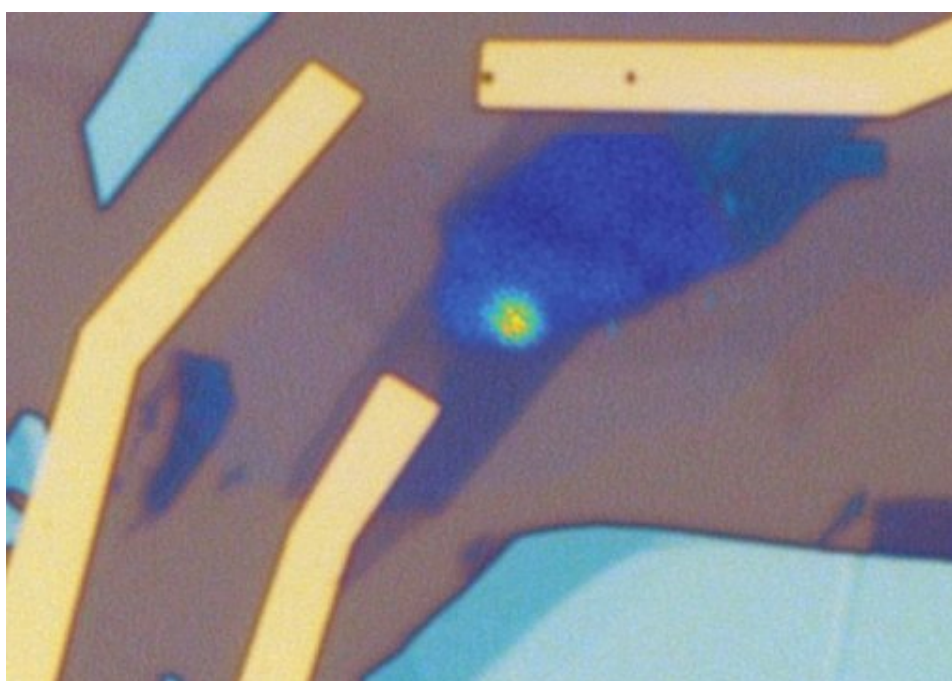
Date: September 26, 2016

Source: Graphene Flagship

Summary: Researchers have used layered materials to create an all-electrical quantum light emitting diodes (LED) with single-photon emission. These LEDs have potential as on-chip photon sources in quantum information applications.

Share:

FULL STORY



An overlay of the microscope image of a quantum LED device and the photoluminescence image from the active area of WSe₂. The isolated bright spot corresponds to a quantum emitter generating a stream of single photons.

Credit: Mete Atatüre

Researchers from the Graphene Flagship use layered materials to create an all-electrical quantum light emitting diodes (LED) with single-photon emission. These LEDs have potential as on-chip photon sources in quantum information applications.

Atomically thin LEDs emitting one photon at a time have been developed by researchers from the Graphene Flagship. Constructed of layers of atomically thin materials, including transition metal dichalcogenides (TMDs), graphene, and boron nitride, the ultra-thin LEDs showing all-electrical single photon generation could be excellent on-chip quantum light sources for a wide range of photonics applications for quantum communications and networks. The research, reported in *Nature Communications*, was led by the University of Cambridge, UK.

The ultra-thin devices reported in the paper are constructed of thin layers of different layered materials, stacked together to form a heterostructure. Electrical current is injected into the device, tunnelling from single-layer graphene, through few-layer boron nitride acting as a tunnel barrier, and

Related Stories



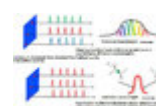
Photons Open the Gateway for Quantum Networks

Oct. 23, 2015 — There is tremendous potential for new information technology based on light (photons). Quantum technology based on photons -- called quantum photonics, will be able to hold much more information than ... [read more »](#)



Quantum Networks: Back and Forth Are Not Equal Distances

July 27, 2015 — Quantum technology based on light (photons) has great potential for radically new information technology based on photonic circuits. Now researchers have discovered a new type of photonic channels, ... [read more »](#)



Scientists Fabricate Single-Photon Sources in Solid Matter

Sep. 11, 2014 — A breakthrough in quantum information processing was achieved using state-of-the-art diamond growth technology. A research group has successfully fabricated for the first time in the world ... [read more »](#)



New Window Into Quantum Physics Opened With Superconductivity in LEDs

Mar. 18, 2014 — Physicists have proposed a novel and efficient way to leverage the strange quantum physics phenomenon known as entanglement. The approach would involve combining light-emitting diodes with a ... [read more »](#)

Strange & Offbeat

SPACE & TIME



Observable Universe Contains Two Trillion Galaxies, 10 Times More Than Previously Thought

Thought



Tatooine Worlds Orbiting Two Suns Often Survive Violent Escapades of Aging Stars

Stars

into the mono- or bi-layer TMD material, such as tungsten diselenide (WSe₂), where electrons recombine with holes to emit single photons. At high currents, this recombination occurs across the whole surface of the device, while at low currents, the quantum behaviour is apparent and the recombination is concentrated in highly localised quantum emitters.

All-electrical single photon emission is a key priority for integrated quantum optoelectronics. Typically, single photon generation relies on optical excitation and requires large-scale optical set-ups with lasers and precise alignment of optical components. This research brings on-chip single photon emission for quantum communication a step closer. Prof Mete Atatüre (Cavendish Laboratory, University of Cambridge, UK), co-author of the research, explains "Ultimately, in a scalable circuit, we need fully integrated devices that we can control by electrical impulses, instead of a laser that focuses on different segments of an integrated circuit. For quantum communication with single photons, and quantum networks between different nodes -- for example, to couple qubits -- we want to be able to just drive current, and get light out. There are many emitters that are optically excitable, but only a handful are electrically driven" In their devices, a modest current of less than 1 μ A ensures that the single-photon behaviour dominates the emission characteristics.

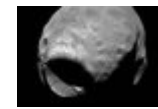
The layered structure of TMDs makes them ideal for use in ultra-thin heterostructures for use on chips, and also adds the benefit of atomically precise layer interfacing. The quantum emitters are highly localised in the TMD layer and have spectrally sharp emission spectra. The layered nature also offers an advantage over some other single-photon emitters for feasible and effective integration into nanophotonic circuits. Prof Frank Koppens (ICFO, Spain), leader of Work Package 8 -- Optoelectronics and Photonics, adds "Electrically driven single photon sources are essential for many applications, and this first realisation with layered materials is a real milestone. This ultra-thin and flexible platform offers high levels of tunability, design freedom, and integration capabilities with nano-electronic platforms including silicon CMOS."

This research is a fantastic example of the possibilities that can be opened up with new discoveries about materials. Quantum dots were discovered to exist in layered TMDs only very recently, with research published simultaneously in early 2015 by several different research groups including groups currently working within the Graphene Flagship. Dr Marek Potemski and co-workers working at CNRS (France) in collaboration with researchers at the University of Warsaw (Poland) discovered stable quantum emitters at the edges of WSe₂ monolayers, displaying highly localised photoluminescence with single-photon emission characteristics. Prof Kis and colleagues working at ETH Zurich and EPFL (Switzerland) also observed single photon emitters with narrow linewidths in WSe₂. At the same time, Prof van der Zant and colleagues from Delft University of Technology (Netherlands), working with researchers at the University of Münster (Germany) observed that the localised emitters in WSe₂ are due to trapped excitons, and suggested that they originate from structural defects. These quantum emitters have the potential to supplant research into the more traditional quantum dot counterparts because of their numerous benefits of the ultrathin devices of the layered structures.

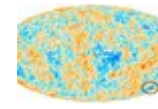
With this research, quantum emitters are now seen in another TMD material, namely tungsten disulphide (WS₂). Prof Atatüre says "We chose WS₂ because it has higher bandgap, and we wanted to see if different materials offered different parts of the spectra for single photon emission. With this, we have shown that the quantum emission is not a unique feature of WSe₂, which suggests that many other layered materials might be able to host quantum dot-like features as well."

Prof Andrea Ferrari (University of Cambridge, UK), Chair of the Graphene Flagship Management Panel, and the Flagship's Science and Technology Officer, also co-authored the research. He adds "We are just scratching the surface of the many possible applications of devices prepared by combining graphene with other insulating, semiconducting, superconducting or metallic layered materials. In this case, not only have we demonstrated controllable photon sources, but we have also shown that the field of quantum technologies can greatly benefit from layered materials. We hope this will bring synergies between the Graphene Flagship and its researchers, and the recently announced Quantum Technologies Flagship, due to start in the next few years. Many more exciting results and applications will surely follow."

Story Source:



How This Martian Moon Became the 'Death Star'



Cosmological Mystery Solved by Largest Ever Map of Voids and Superclusters

MATTER & ENERGY



'DarkLight' Enables Visible Light Communication in the Dark



New Kind of Local Food Grows in Your Own Kitchen

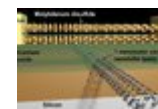


Soft Robots That Mimic Human Muscles

Brewery Wastewater Transformed Into Energy Storage

COMPUTERS & MATH

Computers Should Be Named on Patents as Inventors, for Creativity to Flourish



Smallest. Transistor. Ever.



3-D-Printed Robots With Shock-Absorbing Skins



Your Next Nurse Could Be a Robot

Materials provided by **Graphene Flagship**. Original written by Sophia Lloyd. *Note: Content may be edited for style and length.*

Journal Reference:

1. Carmen Palacios-Berraquero, Matteo Barbone, Dhiren M. Kara, Xiaolong Chen, Ilya Goykhman, Duhee Yoon, Anna K. Ott, Jan Beitner, Kenji Watanabe, Takashi Taniguchi, Andrea C. Ferrari, Mete Atatüre. **Atomically thin quantum light-emitting diodes**. *Nature Communications*, 2016; 7: 12978 DOI: 10.1038/NCOMMS12978

Cite This Page:

 MLA

 APA

 Chicago

Graphene Flagship. "Single photon light emitting diodes for on-chip integration." ScienceDaily. ScienceDaily, 26 September 2016. <www.sciencedaily.com/releases/2016/09/160926095808.htm>.

Recommended Articles

Defects in atomically thin semiconductor emit single photons

University of Rochester, ScienceDaily , 2015

Compact, efficient single photon source that operates at ambient temperatures on a chip

The Hebrew University of Jerusalem, ScienceDaily , 2016

New method points to compact, cheap and efficient sources of quantum information bits

Hebrew University of Jerusalem, ScienceDaily , 2016

Graphene's high-speed seesaw

Manchester University, ScienceDaily , 2013

Nano-photonics meets nano-mechanics

ICFO-The Institute of Photonic Sciences, ScienceDaily , 2016

Optoelectronic Devices Based on Atomically Thin Transition Metal Dichalcogenides

Pospischil, Andreas ; Mueller, Thomas et al., Appl Sci , 2016

Kavli Institute Researchers Translocate DNA Through Graphene Nanopore

GenomeWeb , 2010

NHGRI Awards More than \$50M for Low-Cost DNA Sequencing Tech Development

GenomeWeb , 2009

Long-Wavelength InAs/GaAs Quantum-Dot Light Emitting Sources Monolithically Grown on Si Substrate

S. Chen et al., Photonics , 2015

Colloidal quantum dot light-emitting devices.

Vanessa Wood et al., Nano Rev , 2010

Powered by

Free Subscriptions

Get the latest science news with ScienceDaily's free email newsletters, updated daily and weekly. Or view hourly updated newsfeeds in your RSS reader:

 Email Newsletters

 RSS Feeds

Mobile Apps

Follow Us

Keep up to date with the latest news from ScienceDaily via social networks:

 Facebook

 Twitter


 Google+

 LinkedIn

Have Feedback?

Get the latest news from ScienceDaily via our free mobile apps, available for download on the following platforms:

 iPhone/iPad

 Android

Tell us what you think of ScienceDaily -- we welcome both positive and negative comments. Have any problems using the site? Questions?

 Leave Feedback

 Contact Us

[About This Site](#) | [Editorial Staff](#) | [Awards & Reviews](#) | [Contribute](#) | [Advertise](#) | [Privacy Policy](#) | [Terms of Use](#)

Copyright 2016 ScienceDaily or by third parties, where indicated. All rights controlled by their respective owners. Content on this website is for information only. It is not intended to provide medical or other professional advice. Views expressed here do not necessarily reflect those of ScienceDaily, its staff, its contributors, or its partners.