Wireless ~~R~~evolution in IoT

You say you want a revolution, Well, you know, We all want to change the world…
- John Lennon

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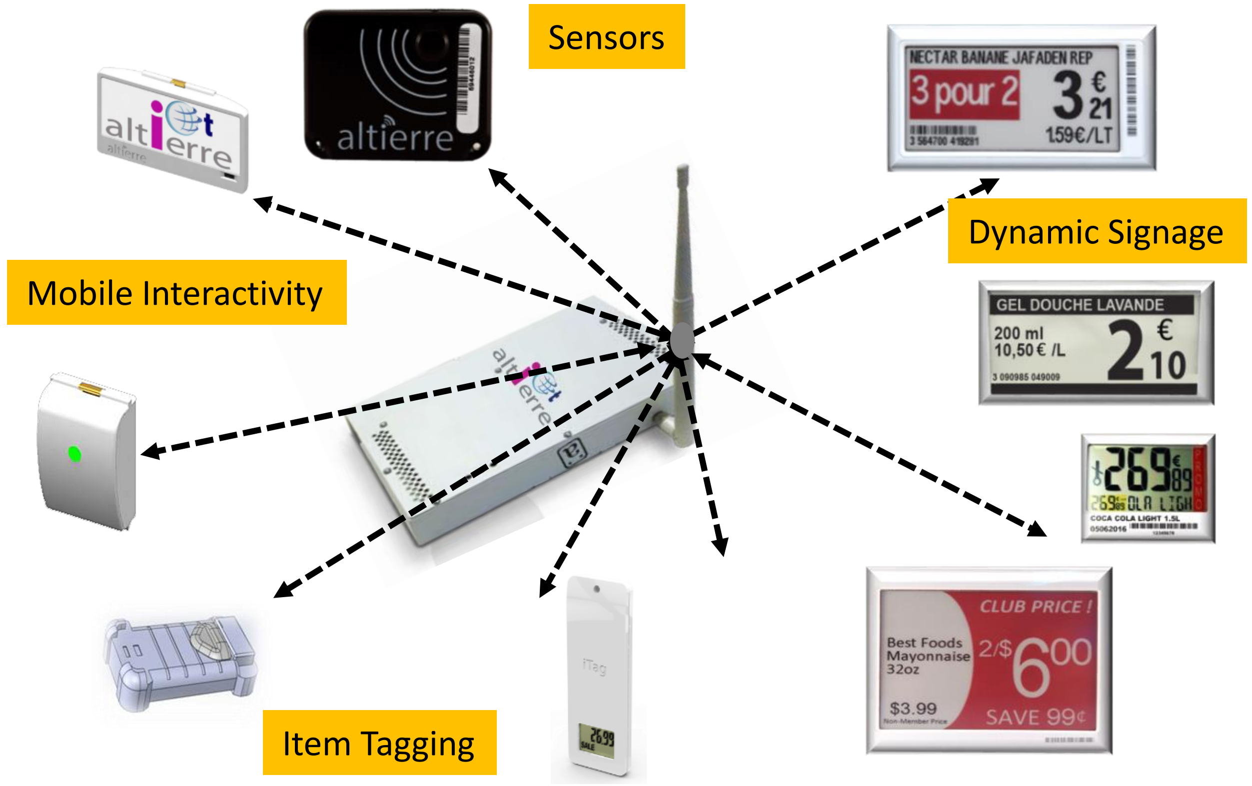
Altierre

- Mixed Signal Chip Development
- Deep Digital & RF expertise
- Display technology
- System Architecture expertise
- Solutions Architecture expertise
- Systems & Software expertise
- Far East Manufacturing & Ops.
- Global Sales & Support teams
- Established and growing market leadership

Current Solutions



Connected eSigns

11 Million eSigns deployed in 1500 US cities

Smart Factory IoT Applications

- Factory Visibility Online – 100K+ sensors!
- Unique Digital Identity for Parts/Assets
- Asset Tracking Across Supply Chain
- Parts Inventory Management/Optimization
- Assembly Line Monitoring
- Digital Signage for Workflow Orchestration
- Presence Detection
- Perimeter Access Control
- Environmental Monitoring (O2, Ozone, CO, CO2, Humidity, Dust)
- Lighting Conditions
- M2M communications

Factory Sensor Networks

- Humidity/Temperature/Pressure
- Ultrasonics
- Air Quality
- CO2
- Dust
- Flow
- Gyro/Accelerometer/9-Axis Sensing
- Thermal/IR/Image
- Light/Color/UV
- Current
- Magnetometer
- Occupancy/Motion/Radar/Proximity
- Rotary/Linear/Position Encoders

History Logging Applications

- RF Devices roaming outside network can log Quality of Shipment conditions:
  - Temperature
  - Vibration
  - Other environmental conditions
  - Container tampering/opening
  - GPS Location
  - Time

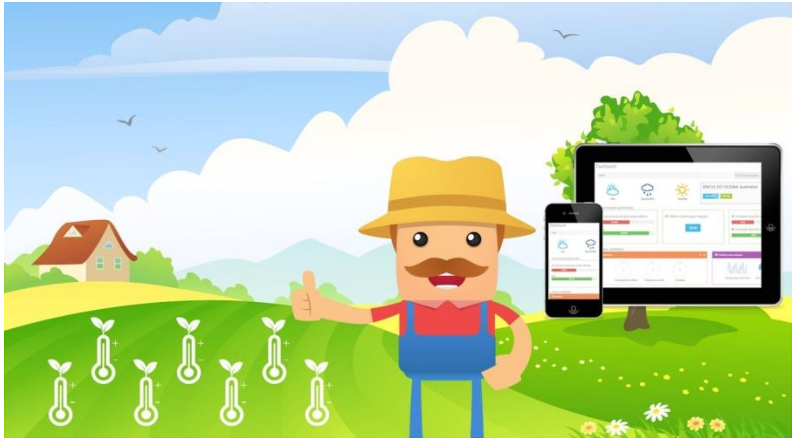
- Tamper proof logs
- History is uploaded to cloud at waypoints and destinations

Smart Building Applications

- Room Occupancy Monitoring & Lighting control
- Appliances energy usage monitoring
- Security/Motion Detection/Perimeter Control
- Light Fixtures monitoring
- HVAC effectiveness monitoring

Smart Farming Applications

- Moisture Monitoring/Irrigation Control
- Green House Environmental Monitoring
- Livestock Tracking
- Toxic Gas Level Monitoring on Animal Farms



Requirements for an IOT System

- Local IoT Gateways must connect to the Internet!
- IoT Gateways must connect to server in the cloud (static IP) for ease of remote accessibility
- IoT devices must use RF to communicate to Internet Gateway
- The IOT RF Layer must:
  - be separate from enterprise RF Layers for enterprise security reasons
  - not impact performance of enterprise RF Layers
  - not be impacted by enterprise RF Layers
  - be able to exist in RF noisy environments – factory floors, multiple RF protocol installations, around metals and liquids
  - support both STAR and MESH configuration of nodes:

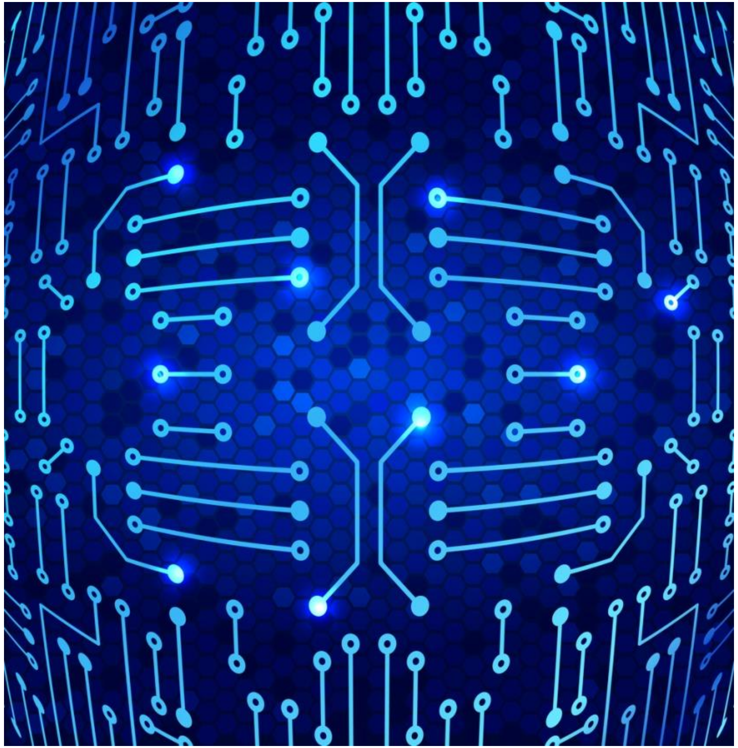
The Altierre IOT Solution meets all the requirements

IoT Protocols

Protocol	Type	Standard	Frequency	Range	Data Rate	# RF Clients	Security	Comments
BT Smart	IoT Application Protocol	BT 4.2	2.4GHz	50-150m	1 Mbps		High	IP through 6LowPAN
Zigbee	IoT Application Protocol	IEEE 802.15.4	2.45 GHz	10-100m	250 Kbps	Large #	High	Mesh
ZWave	IoT Application Protocol	Z-Wave	900 MHz	30m	100 Kbps	232	???	Mesh
6LowPAN	Network Protocol	RFC 6282	Multiple platforms	many	many	-	High	
Thread	Network Protocol	many	2.45 GHz	-	-	250	High	Mesh
WiFi	IoT Application Protocol	802.11n	2.45 GHz	50m	600 Mbps		High	
Cellular	Cellular	many	900-2100 MHz	35-200 Km	35 Kbps – 10 Mbps	Large #	High	High power
NFC	App. Protocol	ISO/IEC 18000-3	13.56 MHz	10 cm	100 – 420 Kbps	-	High	Payments
Sigfox	App Protocol	Sigfox	900 MHz	3-10 Km	10-1000 bps	-	High	50 uW power
Neul	App Protocol	Neul	900 MHz	10 Km	100 Kbps	-	High	30 uW power
LoRaWAN	App Protocol	LoRaWAN	Various	2-5 Km	0.3 – 50 Kbps	Millions	High	microwatts
Altierre	IoT Applcation Protocol	Altierre Frequency Hopping	2.45 GHz	60m	250 Kbps	Millions	Several Layers	Suited for high client density

New Displays Enabling Technologies

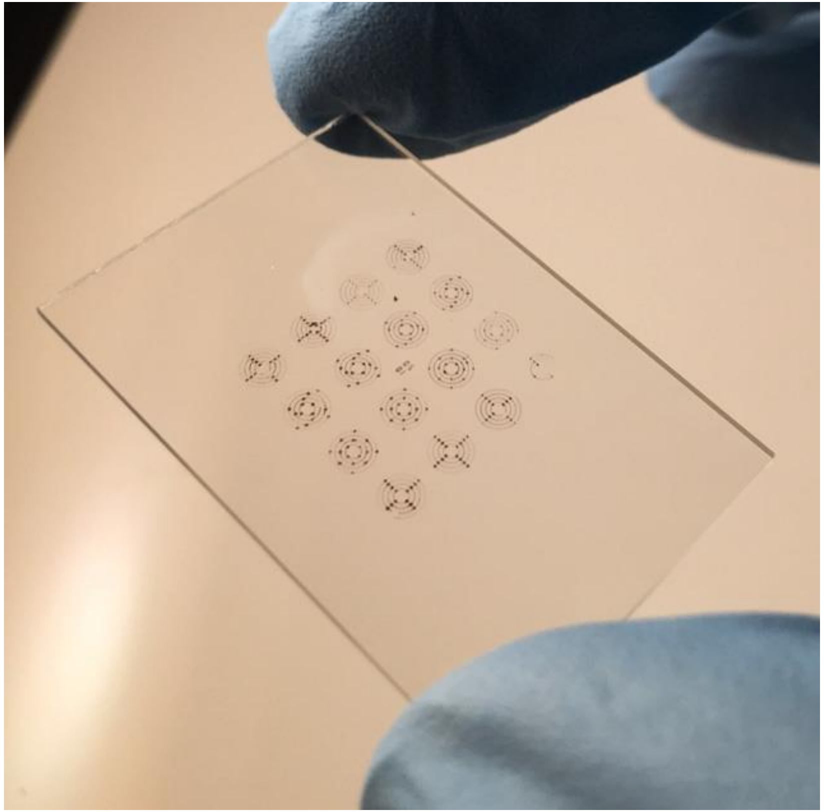
Liquid Metal Printing



- New 2D printing technique : **creating many layers of incredibly thin electronic chips on the same surface dramatically increases processing power and reduces costs**
- **Production of large wafers around 1.5 nanometres in depth** (a sheet of paper, by comparison, is 100,000nm thick)
- **Ga and In are used**, which have a low melting point
- Atomically thin layer of oxide on their surface
- By rolling the liquid metal, oxide layer transferred on to an electronic wafer, which is then sulphurised
- The surface of the wafer can be pre-treated to form individual transistors
- This novel method has been used to **create transistors and photo-detectors of very high gain and very high fabrication reliability on large scale**

http://www.rdmag.com/news/2017/02/liquid-metal-nano-printing-could-revolutionize-electronics

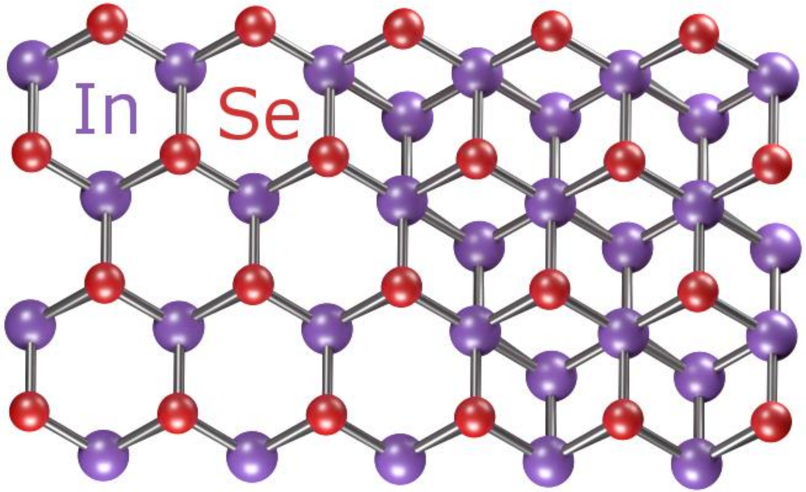
Stamping functional nanoscale features



- Nanoporous stamps made from forests of carbon nanotubes
- Electronic ink containing nanoparticles such as silver, zinc oxide, or semiconductor quantum dots
- Able to print electronic inks onto rigid and flexible surfaces
- Other stamping techniques produce "coffee ring" patterns where ink spills over the borders, or uneven prints leading to incomplete circuits
- **Able to print transistors small enough to control individual pixels in high-resolution displays and touch screens**

https://phys.org/news/2016-12-technique-functional-features-nanoscale-dimensions.html

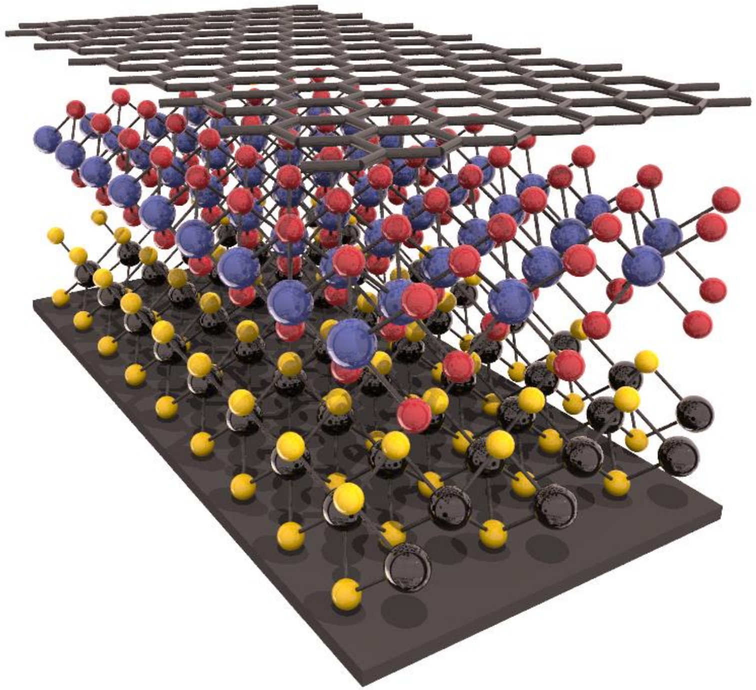
Extending Life of Moore’s Law



- Graphene has no energy gap: it behaves more like a metal rather than a normal semiconductor
- InSe crystals can be made only a few atoms thick, nearly as thin as graphene
- Electronic quality higher than that of silicon: **Ultra-thin InSe has a large energy gap**
- **Transistors can be easily switched on and off, allowing for super-fast next-generation electronic devices**
- InSe grown in Argon atmosphere to prevent damage from oxygen and moisture

https://phys.org/news/2016-11-ultra-thin-semiconductor-life-law.html

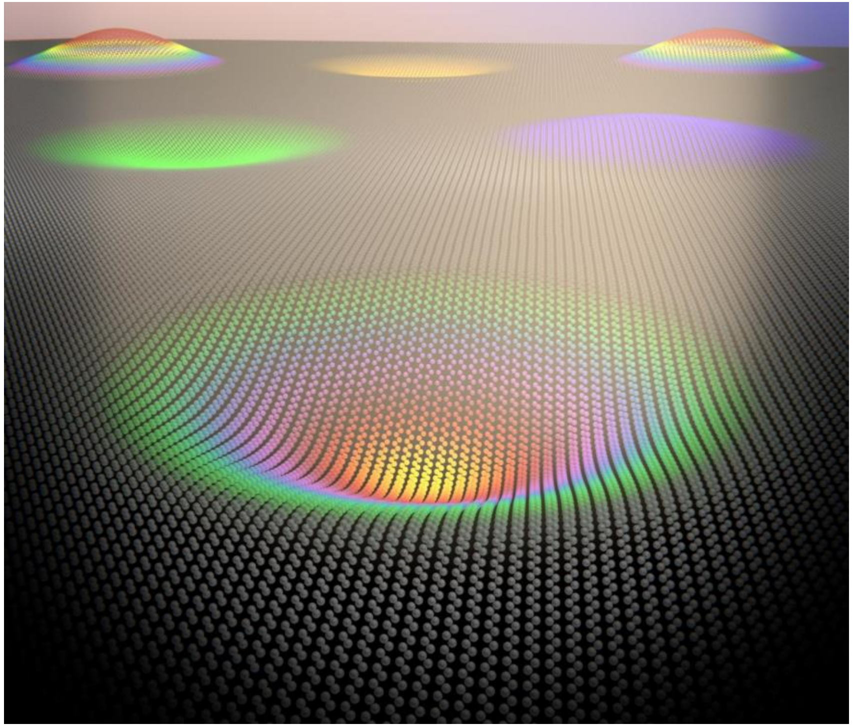
Heterostructures



- **Multiple stacked layers of 2-D materials** – known as **heterostructures** – create highly efficient optoelectronic devices with ultrafast electrical charge, which can be used in nano-circuits, and are **stronger than materials used in traditional circuits**
- New technique measures the electronic properties of each layer in a stack, allowing **optimal structure for the fastest, most efficient transfer of electrical energy**
- The technique uses the photoelectric effect to directly measure the momentum of electrons within each layer and shows how this changes when the layers are combined

https://phys.org/news/2017-02-breakthrough-materials-paves-flexible-tech.html

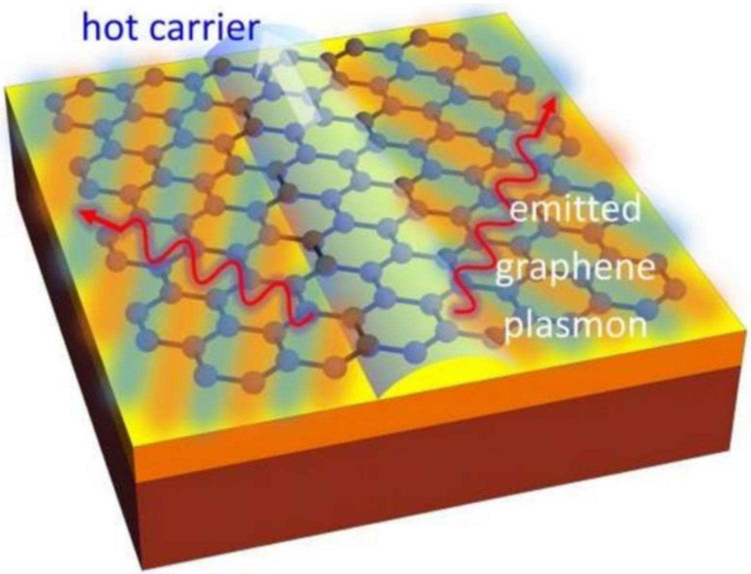
Graphene Mechanical Pixels



- A **double layer of graphene** two atoms thick is deposited on top of circular indents cut into silicon
- Relative membrane position changed by applying pressure
- **Newton rings** form due to **interference between light waves** reflected from the bottom of the cavity and the membrane on top

https://phys.org/news/2016-11-graphene-balloons.html

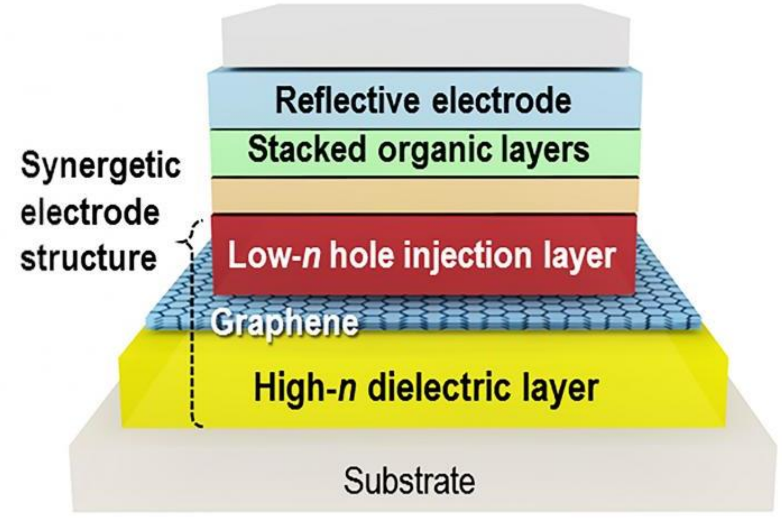
Surface Plasmons in Graphene



- Photons & electrons travel at about the same speed in graphene
- Under certain circumstances, photons can exceed the speed of photons and produce a kind of optical "boom": an intense, focused beam of light
- **This new plasmon-based approach could be part of more efficient, more compact, faster, and more tunable alternatives for converting current to light**

http://www.energyharvestingjournal.com/articles/9730/new-way-to-turn-electricity-into-light-using-graphene

Graphene Electrodes for flexible OLEDs



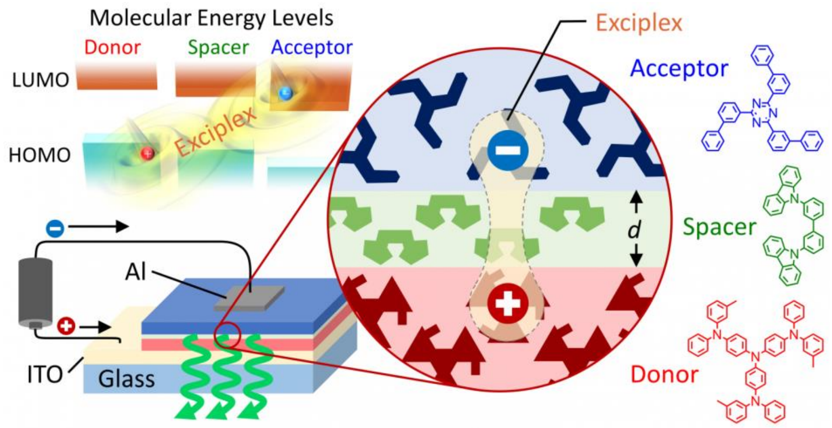
- In this architecture, OLEDs exhibited:
  - 40.8% of ultrahigh external quantum efficiency (EQE)
  - 160.3 lm/W of power efficiency
  - **Devices remained intact and operating well even after 1,000 bending cycles at a radius of curvature as small as 2.3 mm**

https://phys.org/news/2016-06-graphene-based-transparent-electrodes-highly-efficient.html

Inkjet printing OLEDs - Kateeva

- Large glass or plastic substrate sheets are placed on a long, wide platform
- OLED material is nozzle printed
- Thin film encapsulation and yield enhancement tools

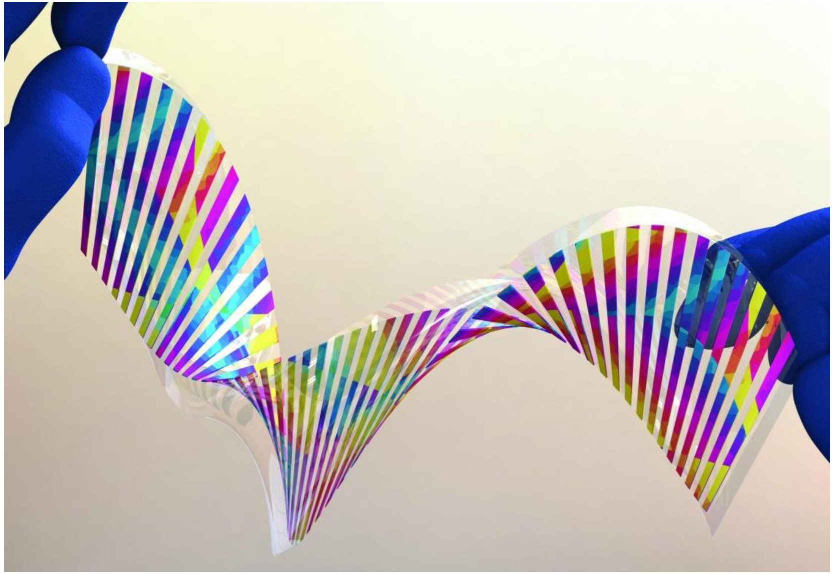
Exciplexes – tunable excitons for OLEDs



- Excitons are commonly localized on a single organic molecule and tightly bound with binding energies of about 0.5 eV
- Entirely new molecules must usually be designed and synthesized to obtain different properties from these Frenkel-type excitons, such as red, green, or blue emission for displays
- **Different type of exciton called an exciplex is formed by a hole and electron located on two different molecules instead of the same molecule**

https://phys.org/news/2016-02-artificial-exciplexes-possibilities-electronics.html

Force activated chameleon skin



- Precise etching of features smaller than a wavelength of light onto a silicon film one thousand times thinner than a human hair
- Grating bars/**Pixels formed using a semiconductor layer of silicon approximately 120 nanometers thick**
- Flexibility imparted by embedding the silicon bars into a flexible layer of silicone
- **Material reflects different colors based on tiny stresses and strains**

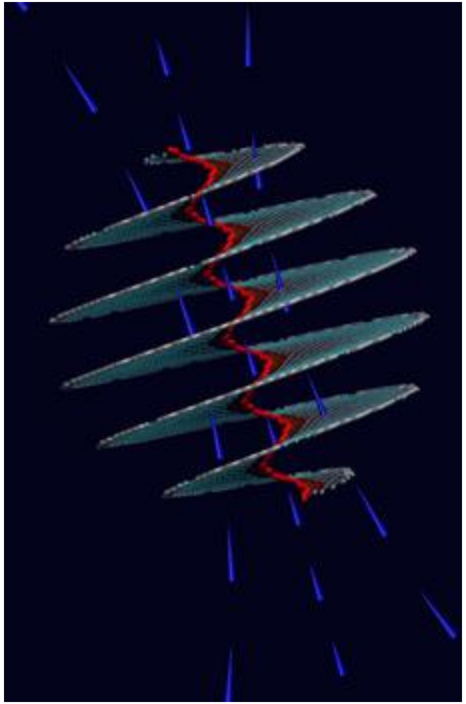
https://phys.org/news/2015-03-chameleon-like-artificial-skin-shifts-demand.html

Squeezing the color out of QDs

- “Band structure engineering via piezoelectric fields in strained anisotropic CdSe/CdS nanocrystals” – Nature Comm. July 2015
- **Strain induced electrical field inside the QDs achieved by growing a thick shell around them and squeezing**

https://m.phys.org/news/2015-09-quantum-dots-strain.html

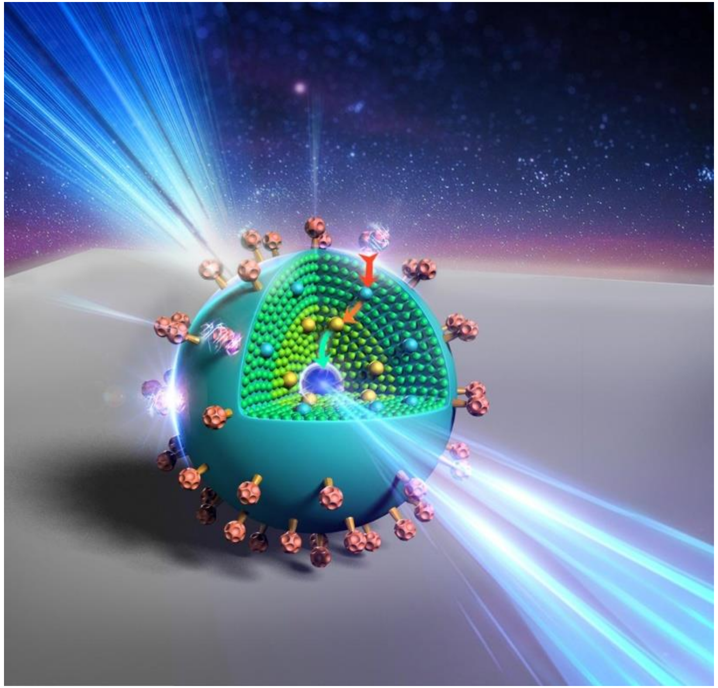
Electromagnets from Graphene coils



- Solenoids are too big
- Spiral form of atom-thin graphene can be found in nature
- **Magnetic field of > 1Tesla is possible**

http://www.rdmag.com/news/2015/10/graphene-nano-coils-are-natural-electromagnets

λ Upconverting Layered Nanoparticle



- **Layers**: a coating of organic dye, a neodymium-containing shell, and a core that incorporates ytterbium and thulium
- **Converts invisible near-infrared light to higher energy blue and UV light 100X more efficiently than previous nanoparticles**

http://www.rdmag.com/news/2015/11/onion-layers-help-efficient-new-nanoparticle-glow

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