Workshop at KTH

Stockholm, Sweden, May 19, 2022

Project NanoMedTwin under Horizon-2020

Research topics at the National Center for Materials Study and Testing in Moldova

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1. Introduction. GaN and related wide-band-gap materials

2. Surface charge lithography: 2D photonic crystals and networks of memristors

3. GaN/ZnO hollow nanoparticles for biomedical applications

4. Aerogalnite – the first artificial nanomaterial with dual hydrophilic-hydrophobic properties

5. New aeromaterials: aero-ZnS; aero-Ga_2O_3, aero-TiO_2

6. 2D materials (SnS, SnS_2, SnSe)

7. International Conferences on Nanotechnologies and Biomedical Engineering

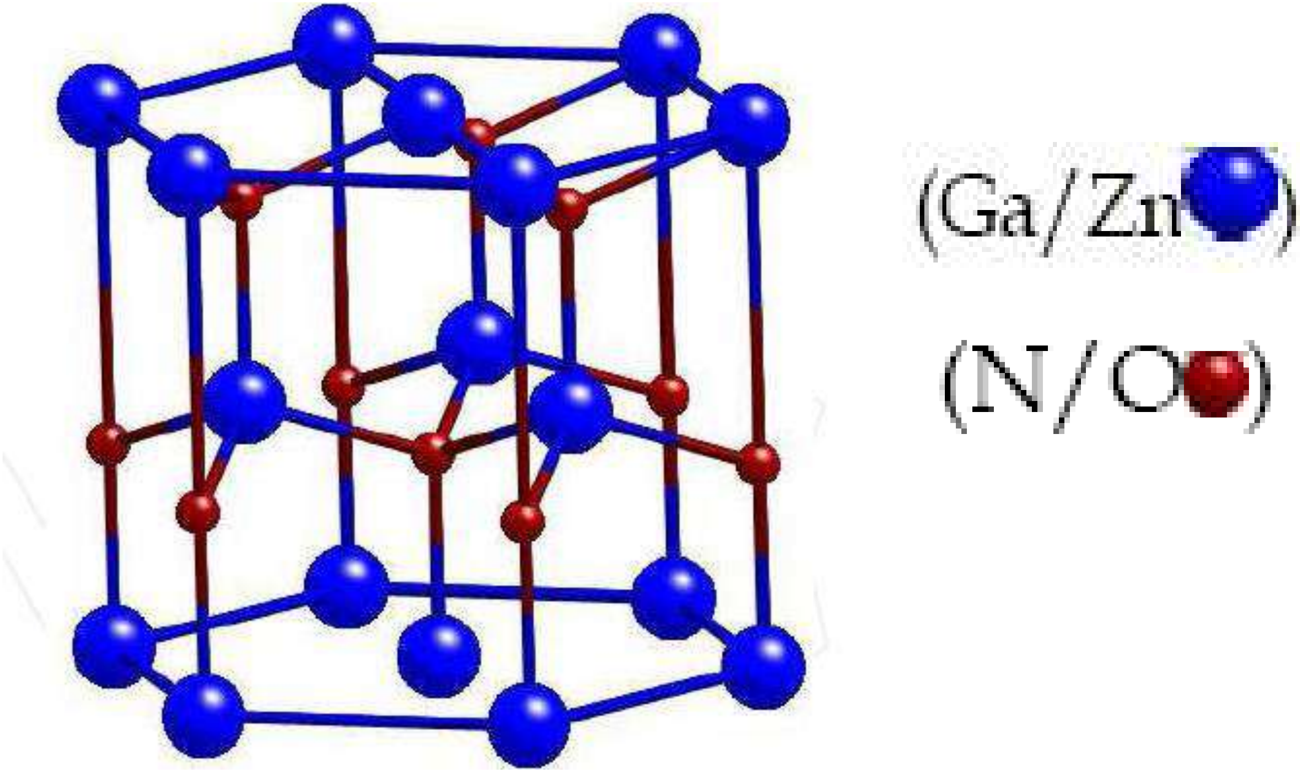
8. Conclusions

Gallium Nitride

Gallium Nitride

GaN

$E_g = 3.4$ eV



Why we have chosen GaN ?

- Semiconductor with direct and wide bandgap
- High chemical stability, stable at high T
- Biocompatible material
- Lighting technologies, blue light emitters
- Transistors withstand extreme heat
- High frequencies and high power levels

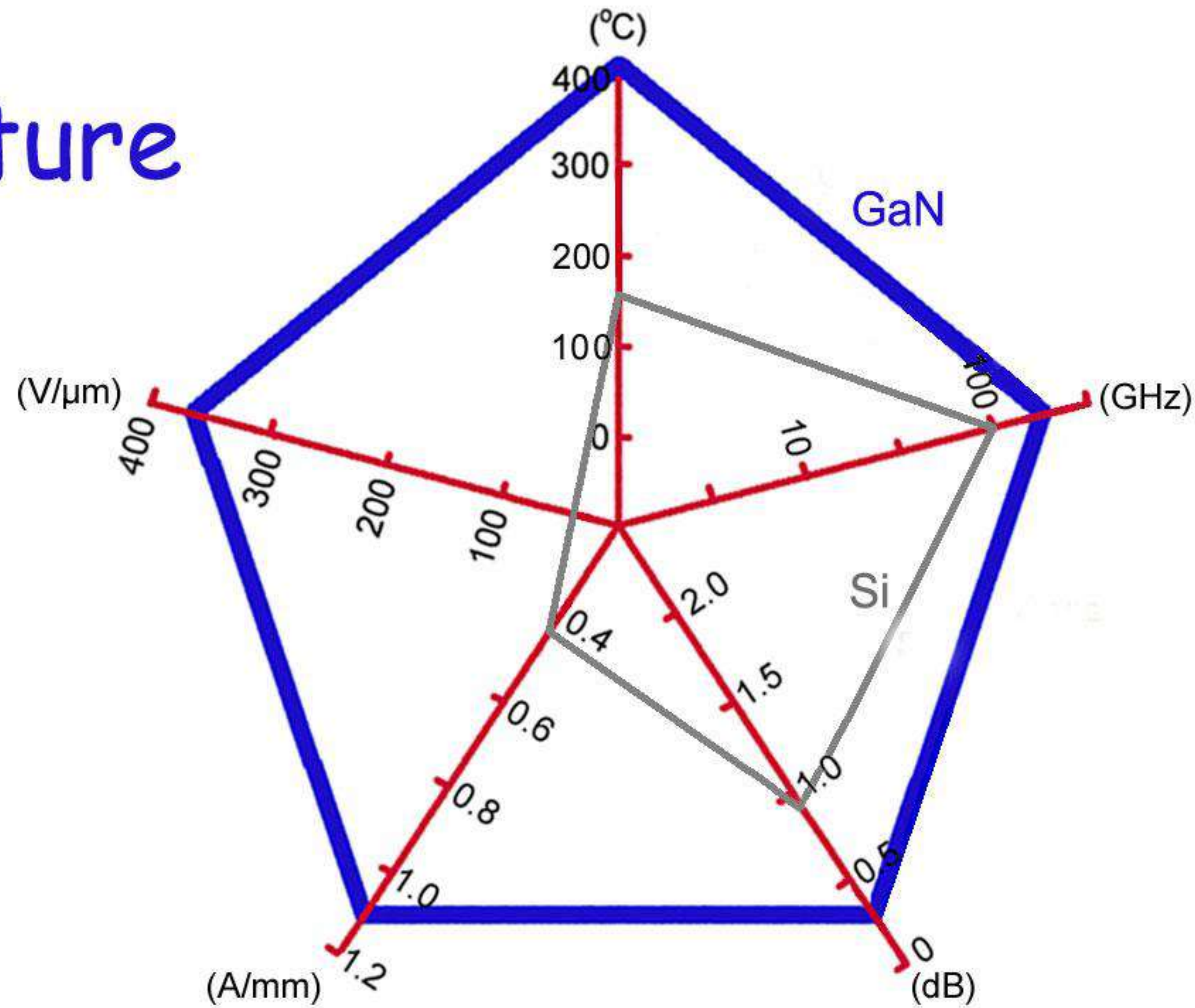
GaN - the next important semiconductor material after silicon

Advantages of GaN versus Si

Temperature

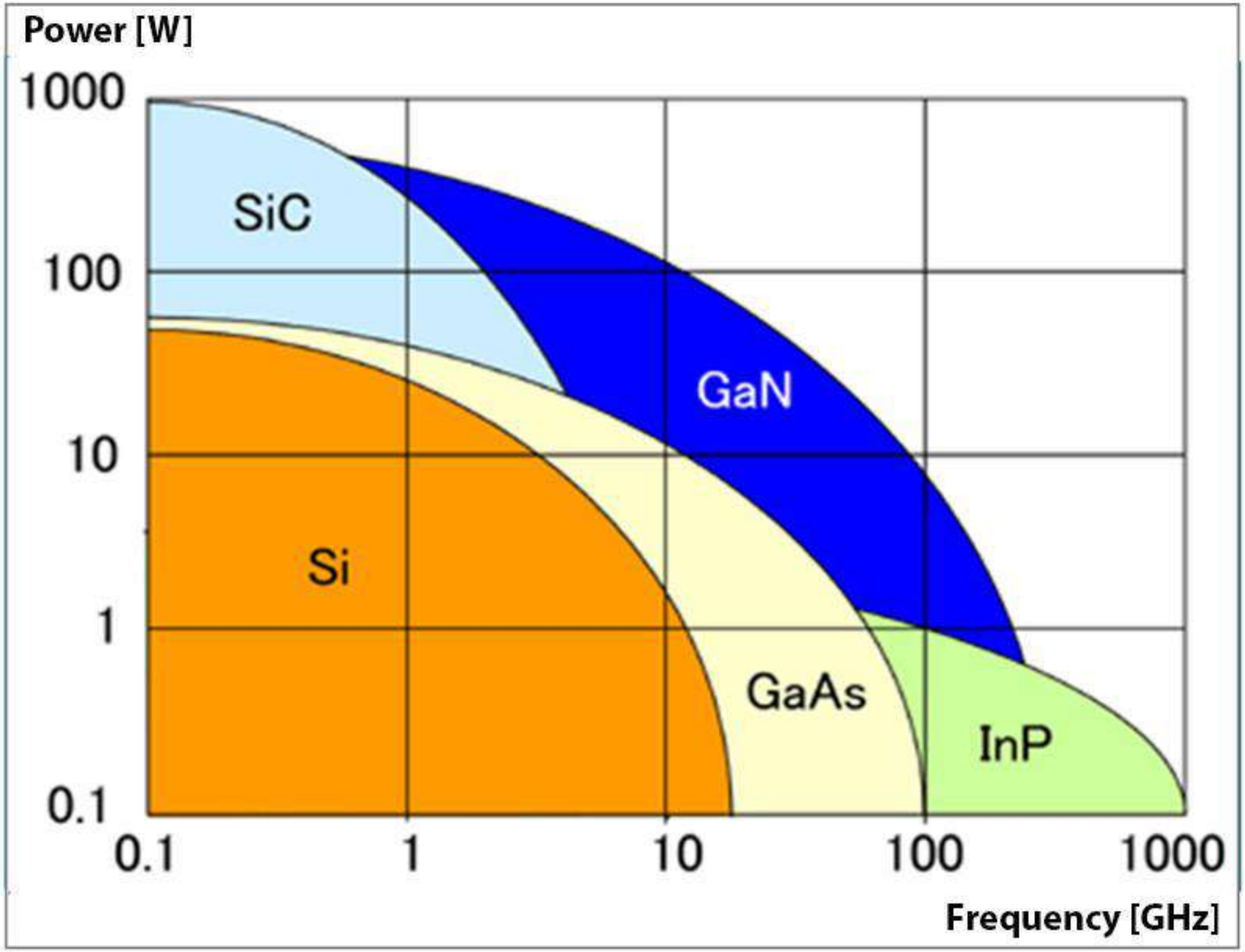
Voltage

Current

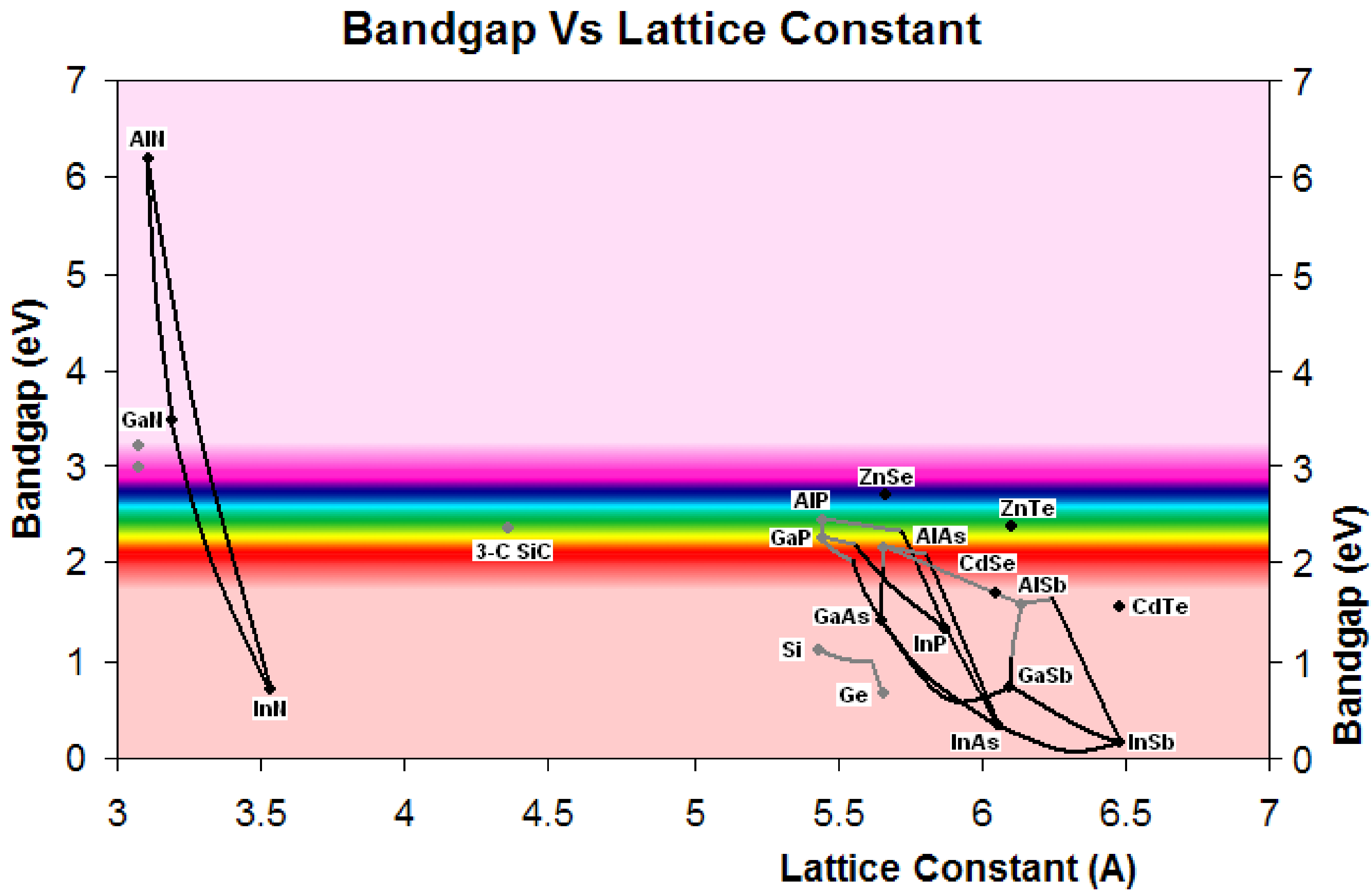


http://www.gansystems.com/why_gallium_nitride_new.php

Advantages of Gallium Nitride



Robert Dwilinski. AMMONO: www.slideserve.com/jane/outstanding-quality-gallium-nitride-gan-enabler-for-new-industries



Bandgap versus lattice constant of different material systems commonly available for LEDs covering the visible range.

History of GaN

- **1969 - First epilayer by vapour transport – Murusk and Tietjen; Growth rate - 0.5 μm/min; High background n-type carrier density ~10^{19} cm^{-3};**
- **1991 - first p-n junction GaN LED created;**
- **1993 - Commercial blue GaN LEDs (Nichia);**
- **1996 - Room temperature nitride LDs developed (Nichia);**
- **1999 - Commercial nitride LDs introduced (Nichia);**
- **2014 - The first room temperature electrically injected bulk-GaN microcavity based polariton laser.**

2014 - Nobel Prize in Physics awarded to professors Isamu Akasaki, Hiroshi Amano, Shuji Nakamura for „the invention of efficient blue light-emitting diodes"

Main growth techniques

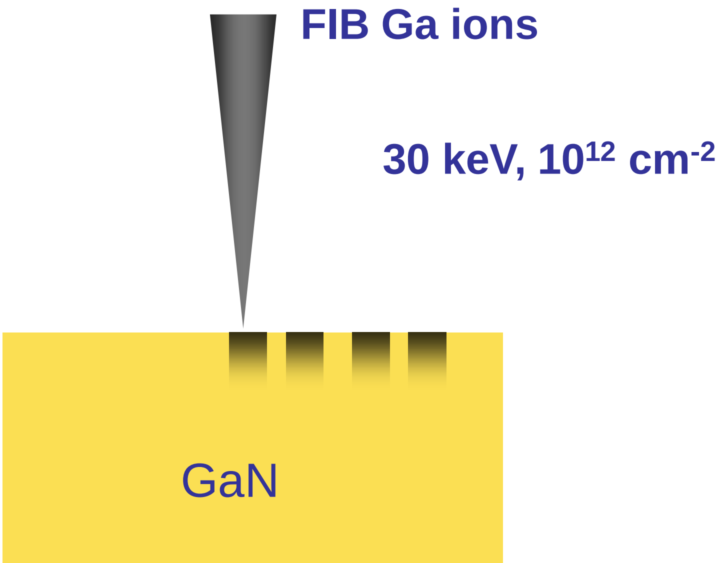
GaN Layers: MOCVD, MBE

GaN bulk: ammonothermal growth and hydride vapor phase epitaxy

Surface Charge Lithography

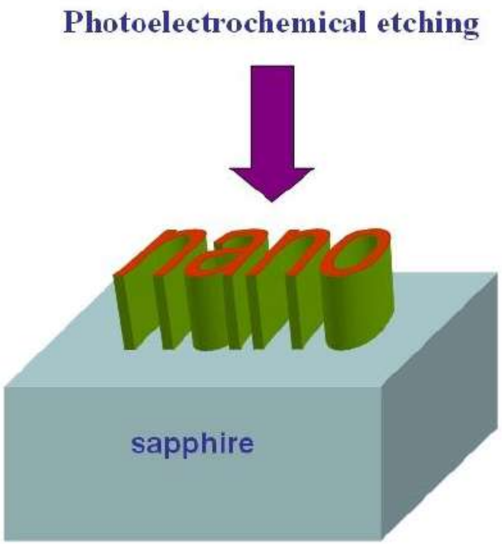
Surface Charge Lithography

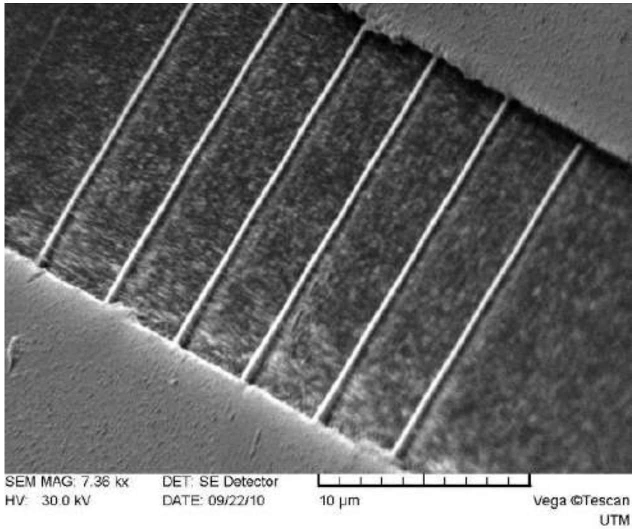
Direct Writing of Negative Charge
+
Photoelectrochemical Etching



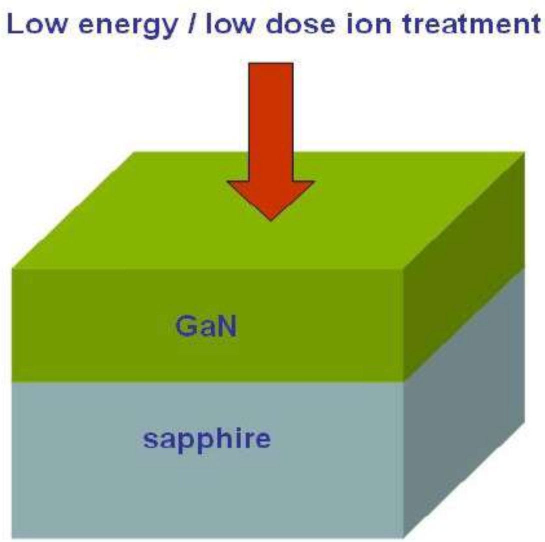
Gold Medal, Pittsburgh

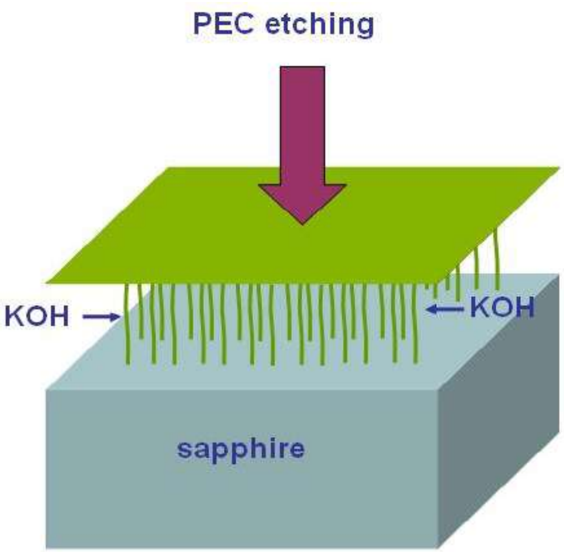
GaN nanostructures

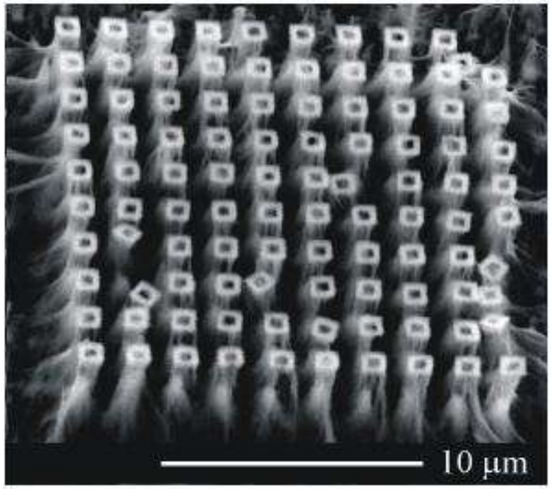




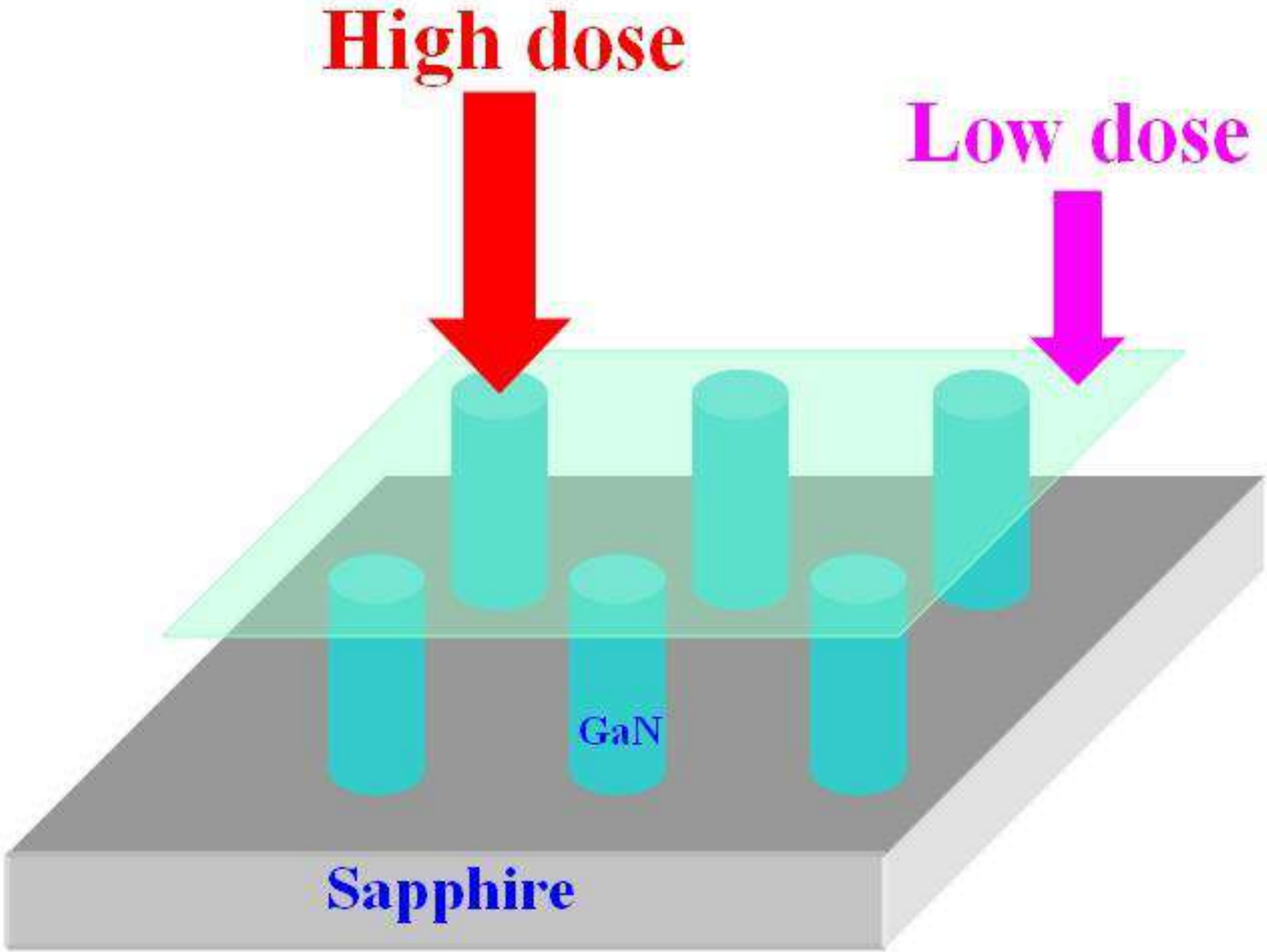
GaN ultrathin membranes







Surface Charge Lithography



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LATEST NEWS ARTICLES

- Surface writing produces designer nanostructures
- Nanomachines could benefit from superlubricity
- Graphene capsule helps image nanocrystal growth
- Heterostructures make better solar cells
- Polymer helps separate CNT mix

RELATED STORIES

- Nano-roof reveals dislocations (Jan 2011)
- Temperature orders TiO2 nanotubes (Apr 2010)
- Salty water puts metal nanotubes in order (Jun 2008)
- Gallium nitride nanopyramids resist radiation (May 2007)

RELATED LINKS

- Ion Tiginyanu

RESTRICTED LINKS

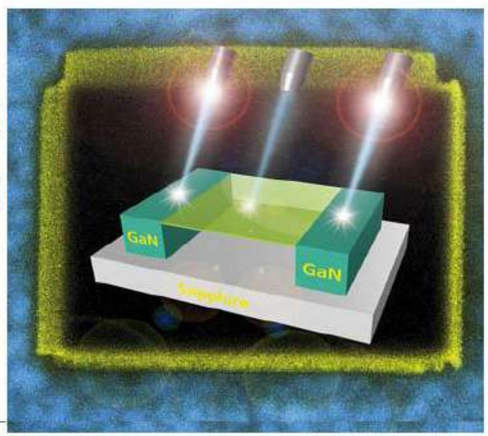
- *Physica Status Solidi - Rapid Research Letters* DOI: 10.1002/pssr.201206020

TECHNOLOGY UPDATE

Apr 12, 2012

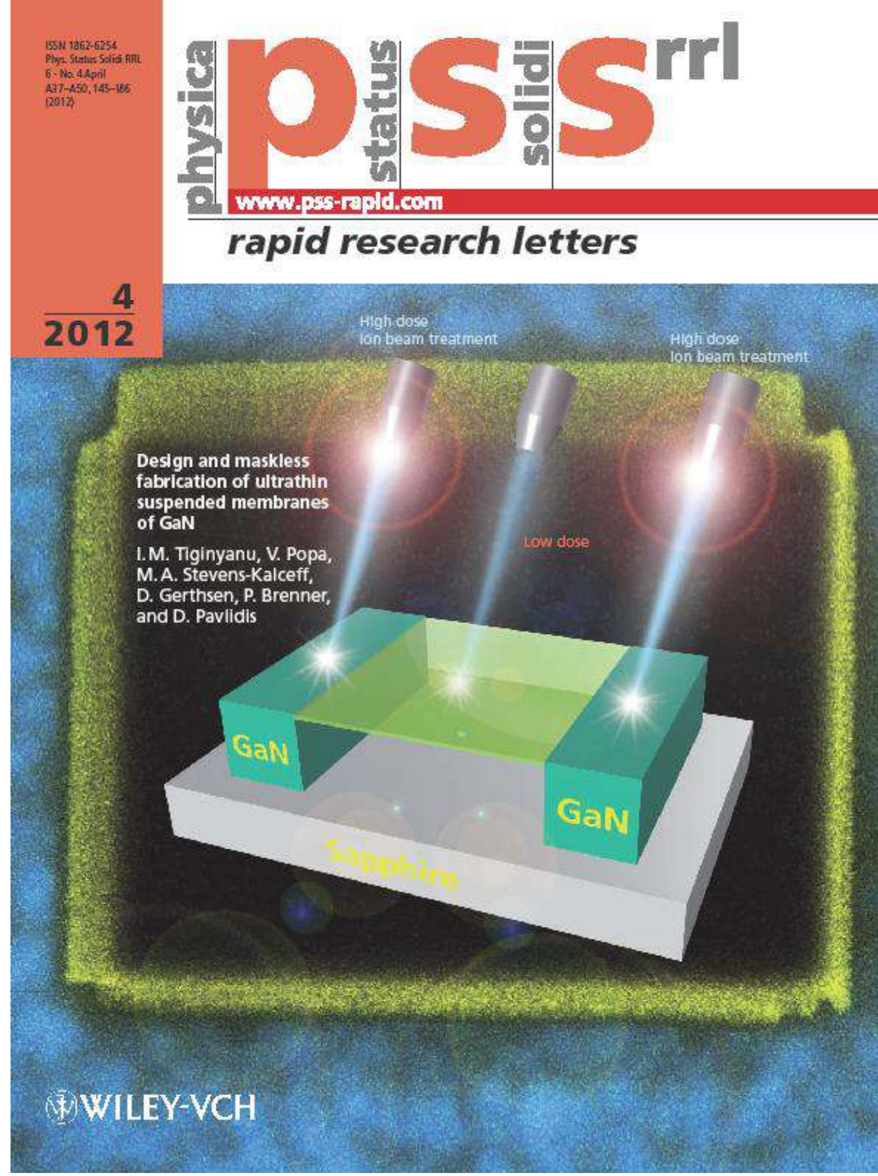
Surface writing produces designer nanostructures

A new way to fabricate 3D nanostructures from gallium nitride using a focused ion beam (FIB) has been developed by researchers in Moldova, Australia, Germany and France. The technique, which involves directly writing a negative charge on the surface of GaN with the FIB and then photoelectrochemically etching the sample, allows ultrathin membranes and supporting nanocolumns to be fashioned in a controlled way. GaN is a large-bandgap semiconductor widely used in electronics applications such as high-temperature, high-power electronics and optoelectronics for light-emitting diodes and lasers. The material is also piezoelectric, so bridge-like GaN membranes might even find use in applications like nanoelectromechanical systems (NEMS).

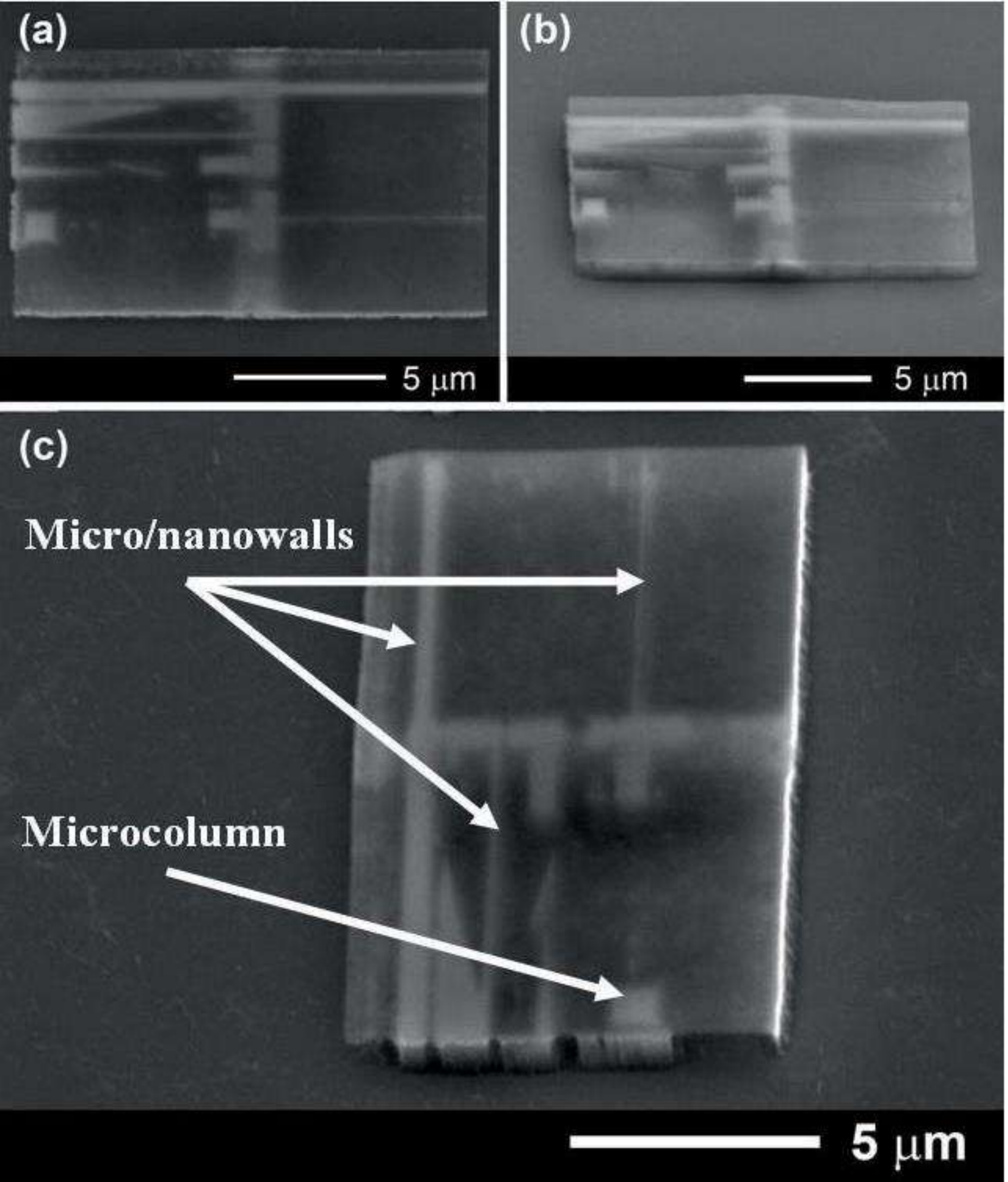


Making GaN 3D nanostructures

Ion Tiginyanu and colleagues of the Moldova Academy of Sciences and Technical University of Moldova recently put forward a new way to make nanometre-thin membranes of gallium nitride hanging over a network of GaN threading-dislocation "whiskers" that act as a support. Their fabrication technique was based on etching away highly crystalline material from the GaN bulk epilayers, leaving behind only the negatively charged dislocation networks and a thin surface film to which the dislocations remain attached.

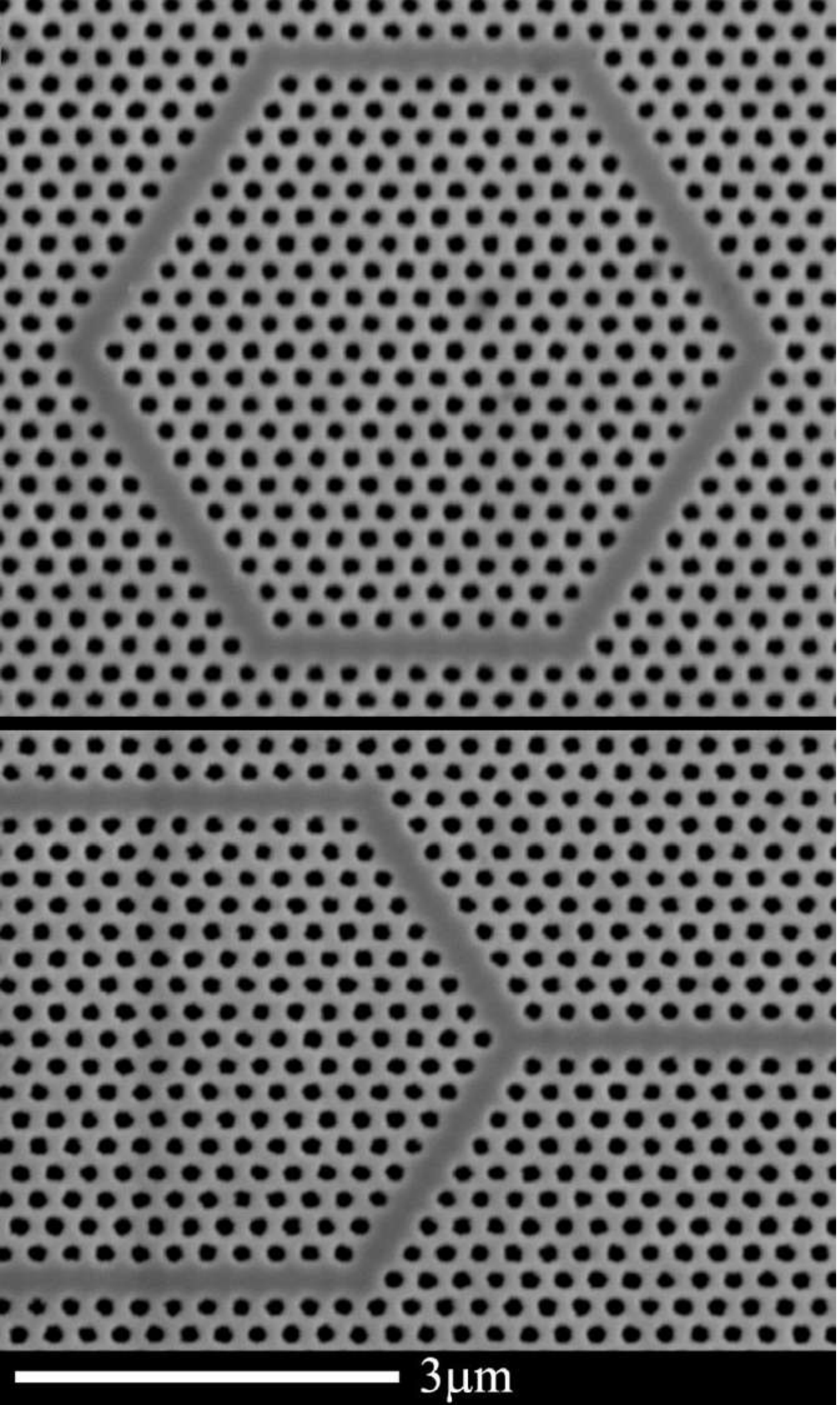


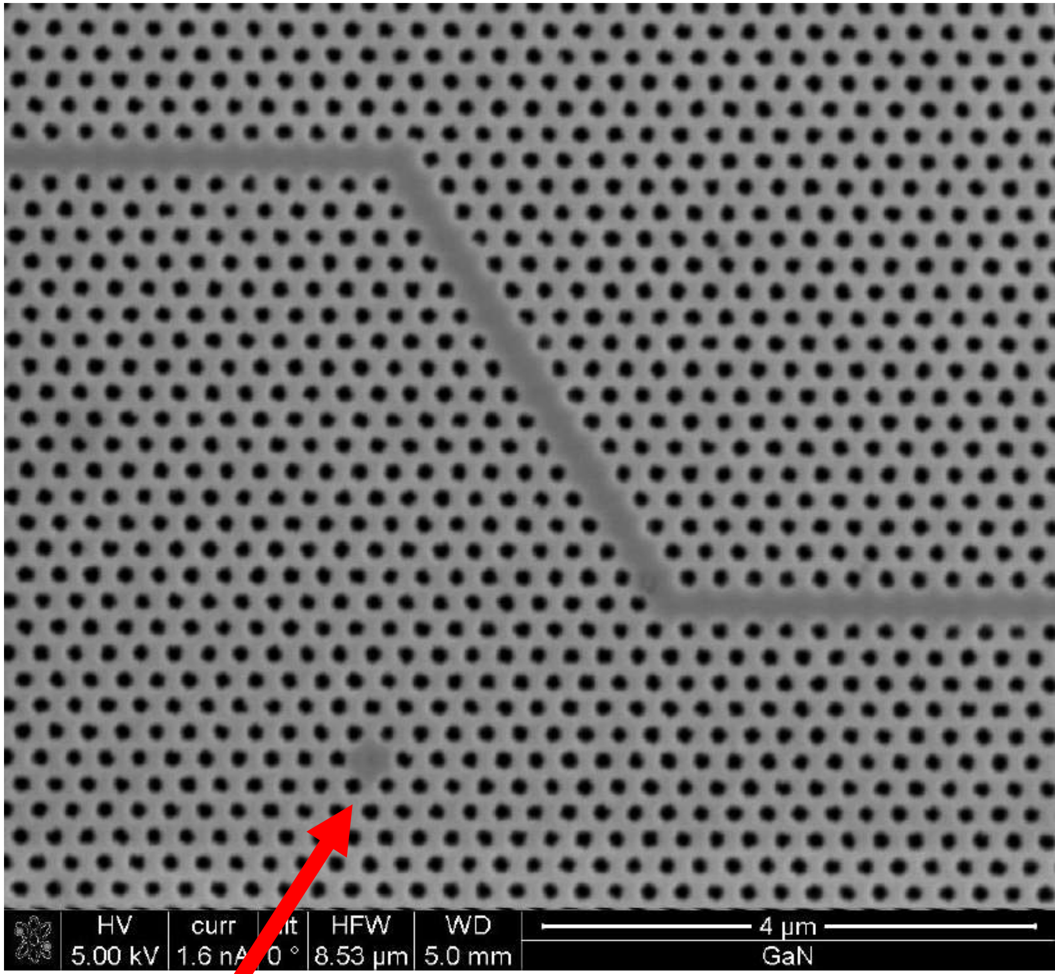
***Physica Status Solidi – RRL*, Vol. 6, no 4, pp. 148-150 (2012).**



Design and maskless fabrication of suspended membranes

GaN ultrathin photonic crystals



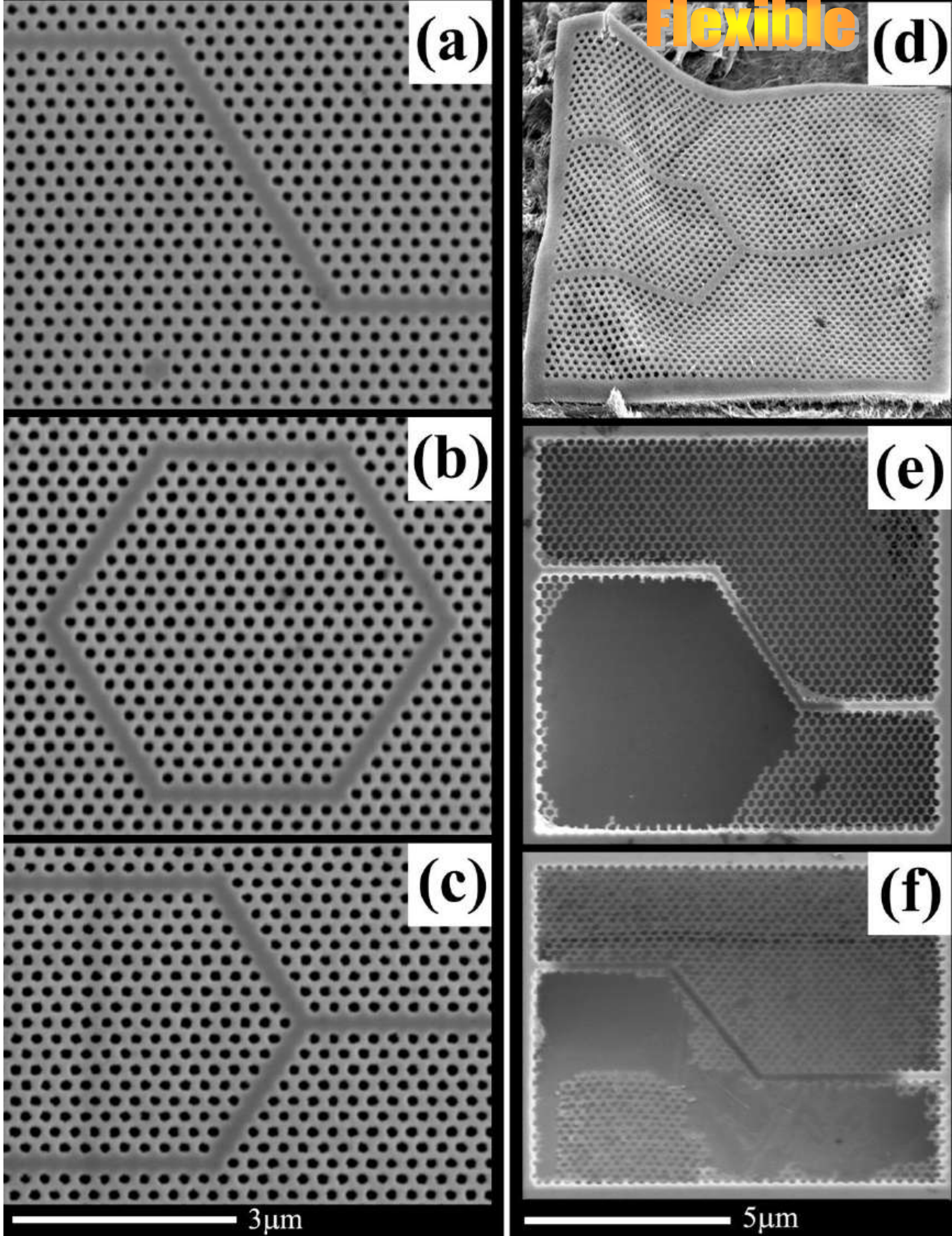


Absence of one hole

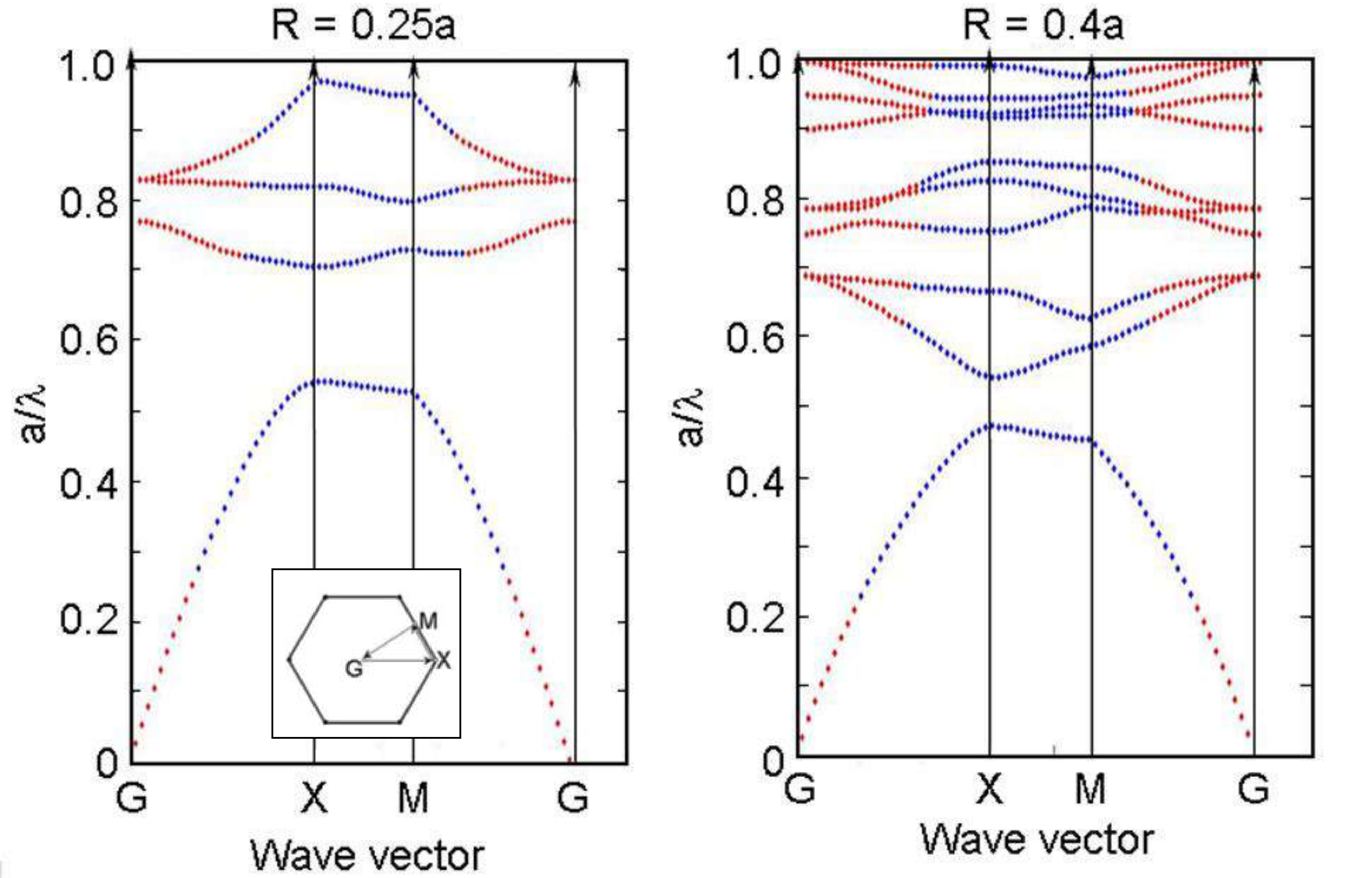
Two-dimensional GaN-based Flexible Photonic Structures

15-nm thick

Journal of Nanoelectronics and Optoelectronics, Vol. 9, no 2, pp. 271-275 (2014).



2D Ultrathin Photonic Crystals



Band structure of a photonic crystal slab with d/*a* = 0.05 (lattice constant a=250 nm) and two different values of hole radius R. The pure surface modes are marked in blue color. The calculations are indicative of the occurrence of surface and bulk modes.

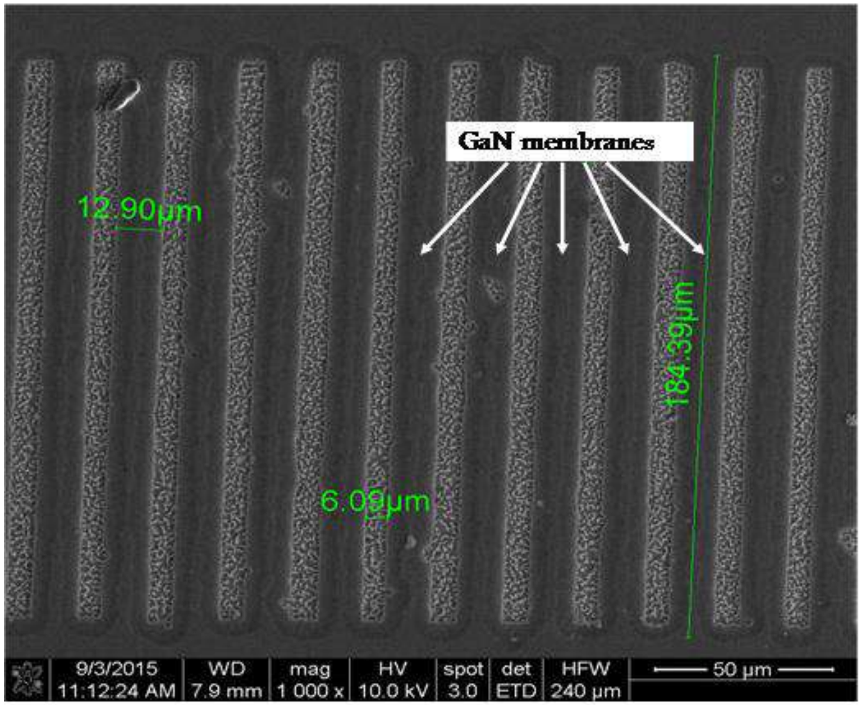
J. Nanoelectronics & Optoelectronics, Vol. 9, 271-275 (2014).

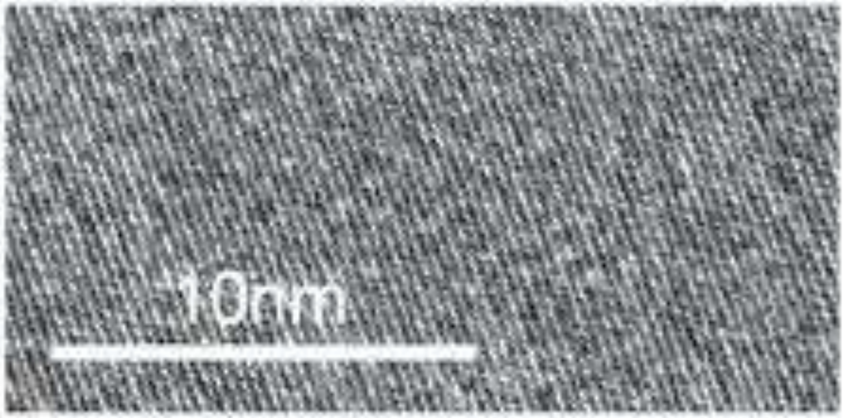
Memristive devices based on GaN nanomembranes and their habituation to a stimulus

Mimicking Brain Activities: Artificial Synapses and Learning using GaN Membranes

In collaboration with the Institute of Microtechnologies, Bucharest, Romania

Memristive GaN ultrathin suspended membrane array

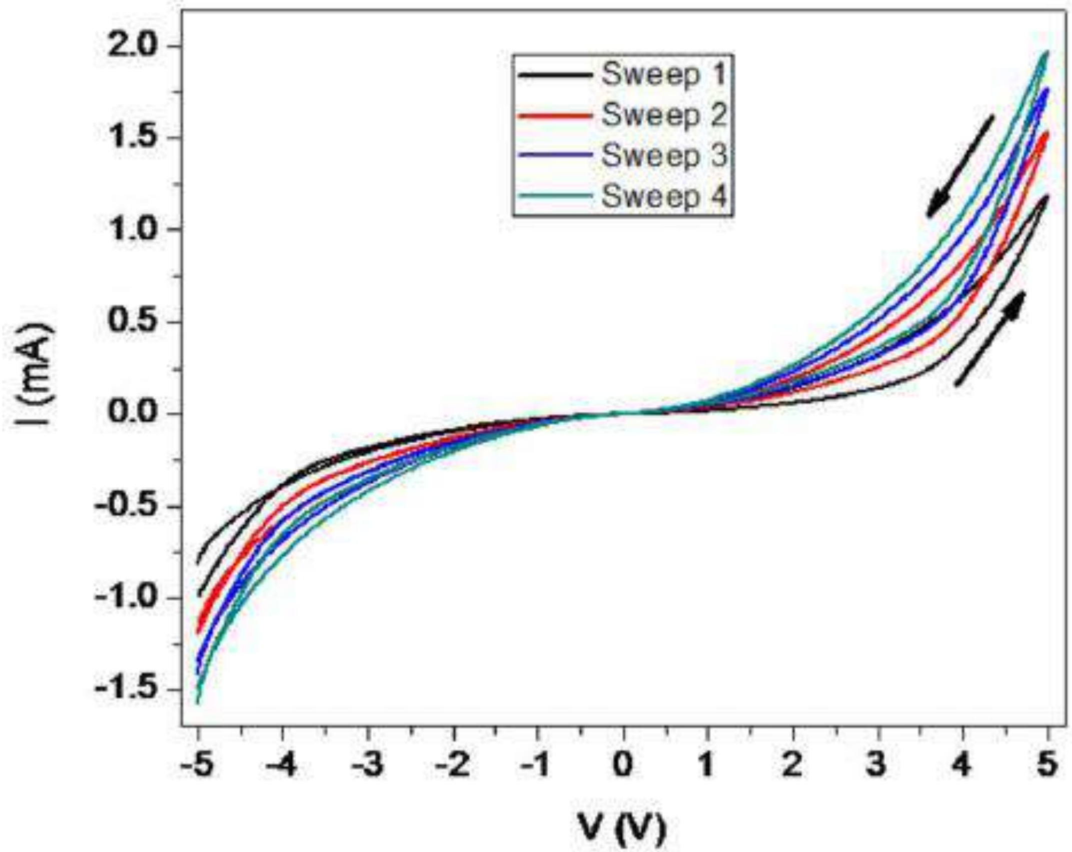




STEM

Memristive GaN ultrathin suspended membrane array,
M. Dragoman, I. Tiginyanu, Daniela Dragoman, Tudor Braniste, Vladimir Ciobanu, ***Nanotechnology,*** **Vol. 27, 295204 (2016).**

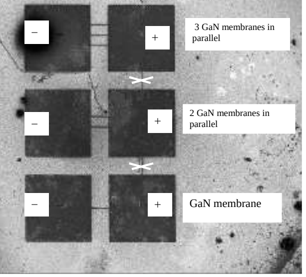
Memristive GaN ultrathin suspended membrane array



Increases of the current at successive voltage sweeps were explained by a trap-controlled space charge limited current mechanism, see *Nanotechnology,* Vol. 27, 295204 (2016).

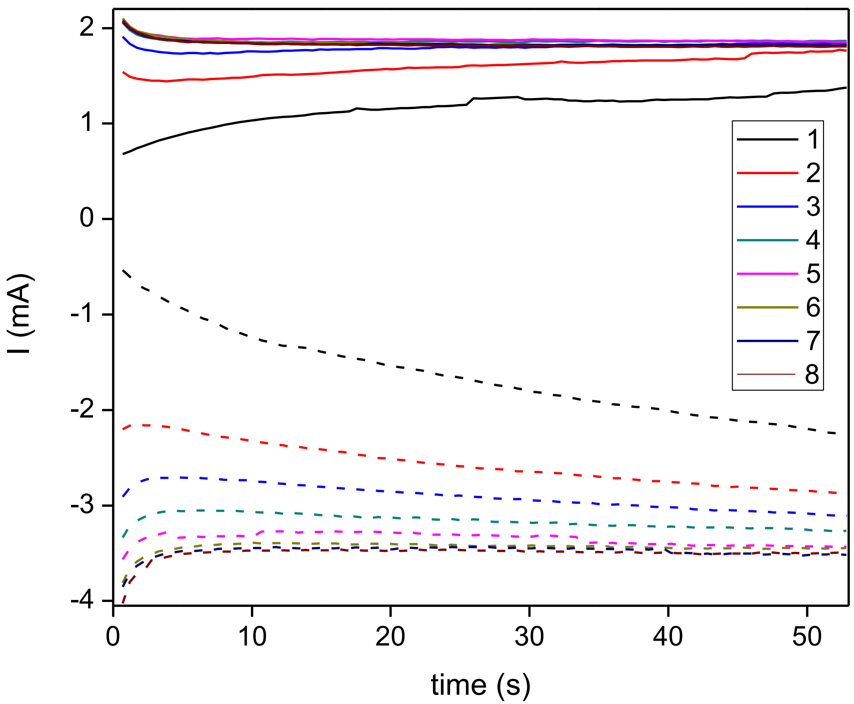
The memristive behaviour is due to the migration of negatively-charged deep traps, which form in the volume of the GaN membrane during the fabrication process, towards the unoccupied surface states of the suspended membranes.

A single GaN membrane can support currents as high as 60 mA at 9 V, and thus a <u>power of 540 mW</u>, with no signs of failure.

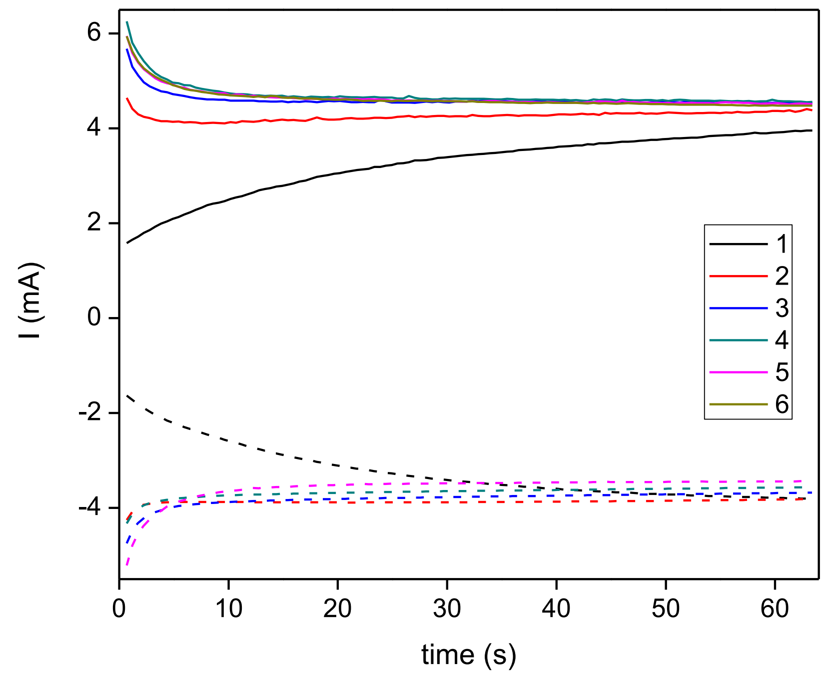


Memristor habituation to a stimulus

A single memristor

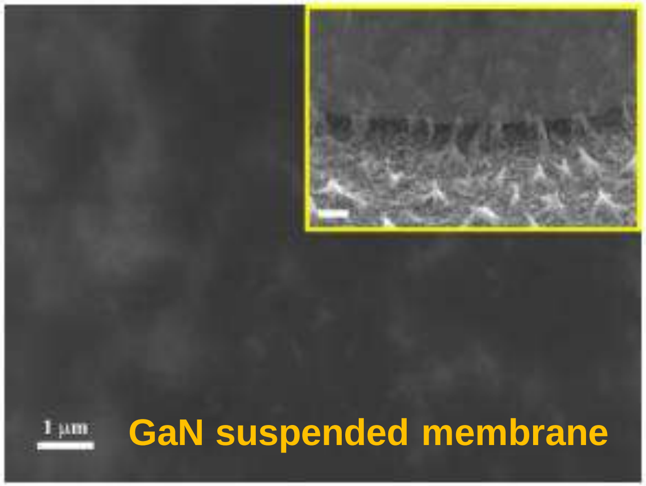


A network of memristors

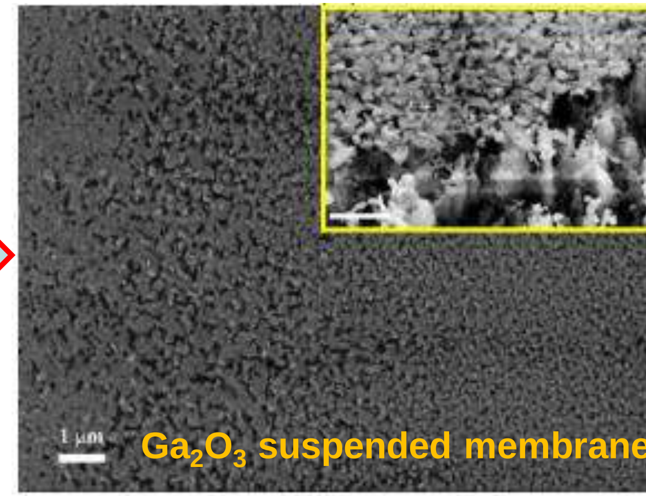


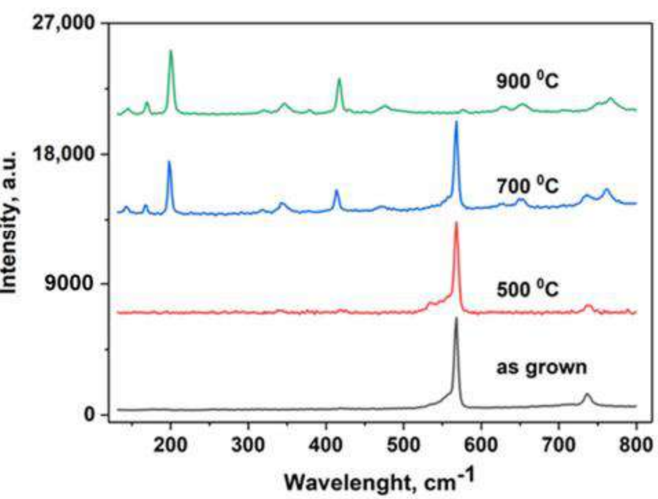
Irrespective of the polarity of the DC voltage, the current-time dependence reaches a steady state after 7 voltage cycles for a single memristor, and after 4 voltage cycles for three parallel memristors on GaN nanomembranes. The dynamics of the current-time dependence mimics the biological habituation-dishabituation non-associative learning. Mircea Dragoman, Ion Tiginyanu, Daniela Dragoman, Adrian Dinescu, Tudor Braniste, Vladimir Ciobanu, Learning mechanisms in memristor networks based on GaN nanomembranes, Journal of Applied Physics, Vol. 124, 152110 (2018).

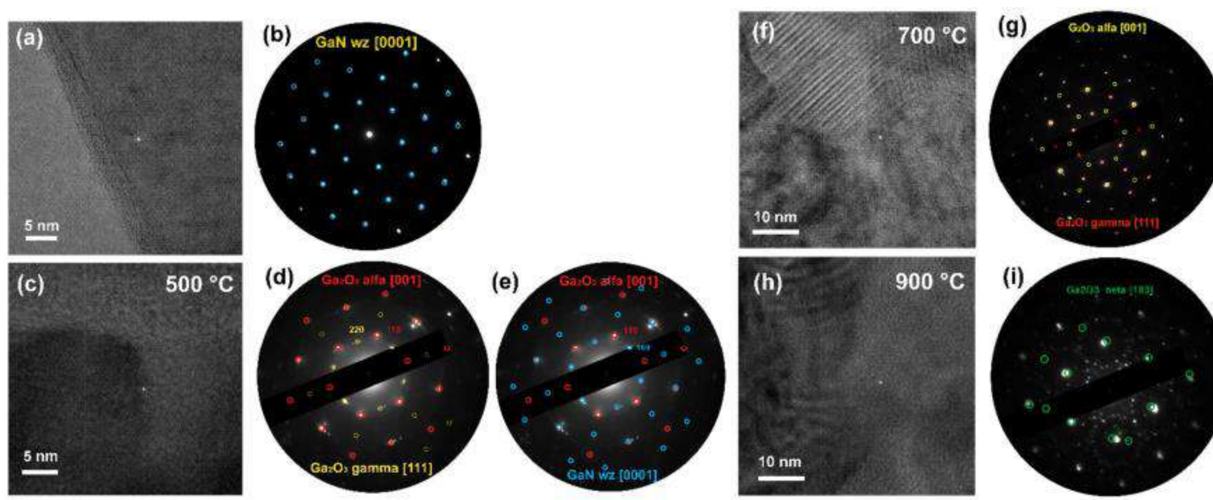
Nanocrystalline Ultrathin β-Ga_2O_3 Membranes Fabricated by SCL



90 min @900°C in air







V. Ciobanu, G. Ceccone, I. Jin, T. Braniste, Fei Ye, F. Fumagalli, P. Colpo, J. Dutta, J. Linnros, I. Tiginyanu. Nanomaterials 2022, 12, 689

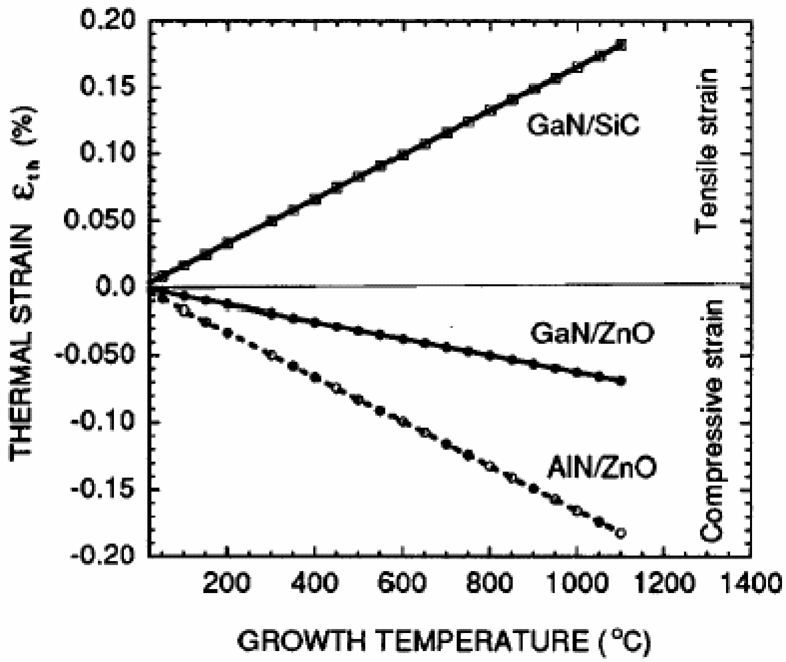
GaN / ZnO

Mismatch 1.8 %

GaN stabilizes the ZnO interface layer in a unique fashion

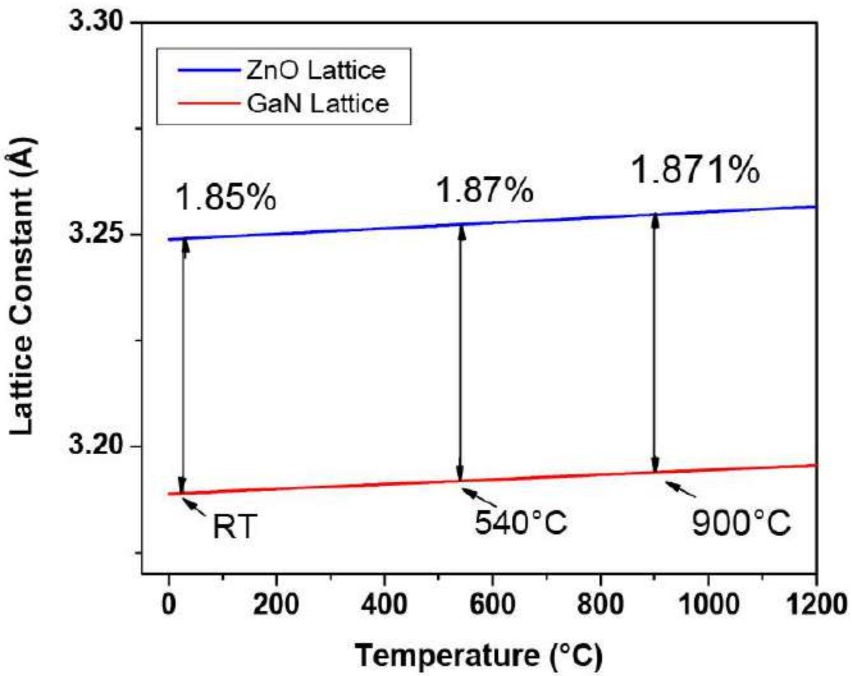
Nano Energy, Vol. 56, pp. 759-769 (2019)

Thermal strain versus growth temperature



Variation of thermal strain with growth temperature calculated for GaN/ZnO, AlN/ZnO, and GaN/SiC heterostructures.

Temperature dependence of lattice constants



Owing to the close thermal expansion coefficients between GaN and ZnO, the thermal strain in GaN/ZnO is about half that of GaN/SiC and AlN/ZnO, F.Hamdani et al, J. Appl. Phys., Vol. 83, 983 (1998).

GaN / ZnO

Exciton binding energy

GaN 23 meV

ZnO 60 meV

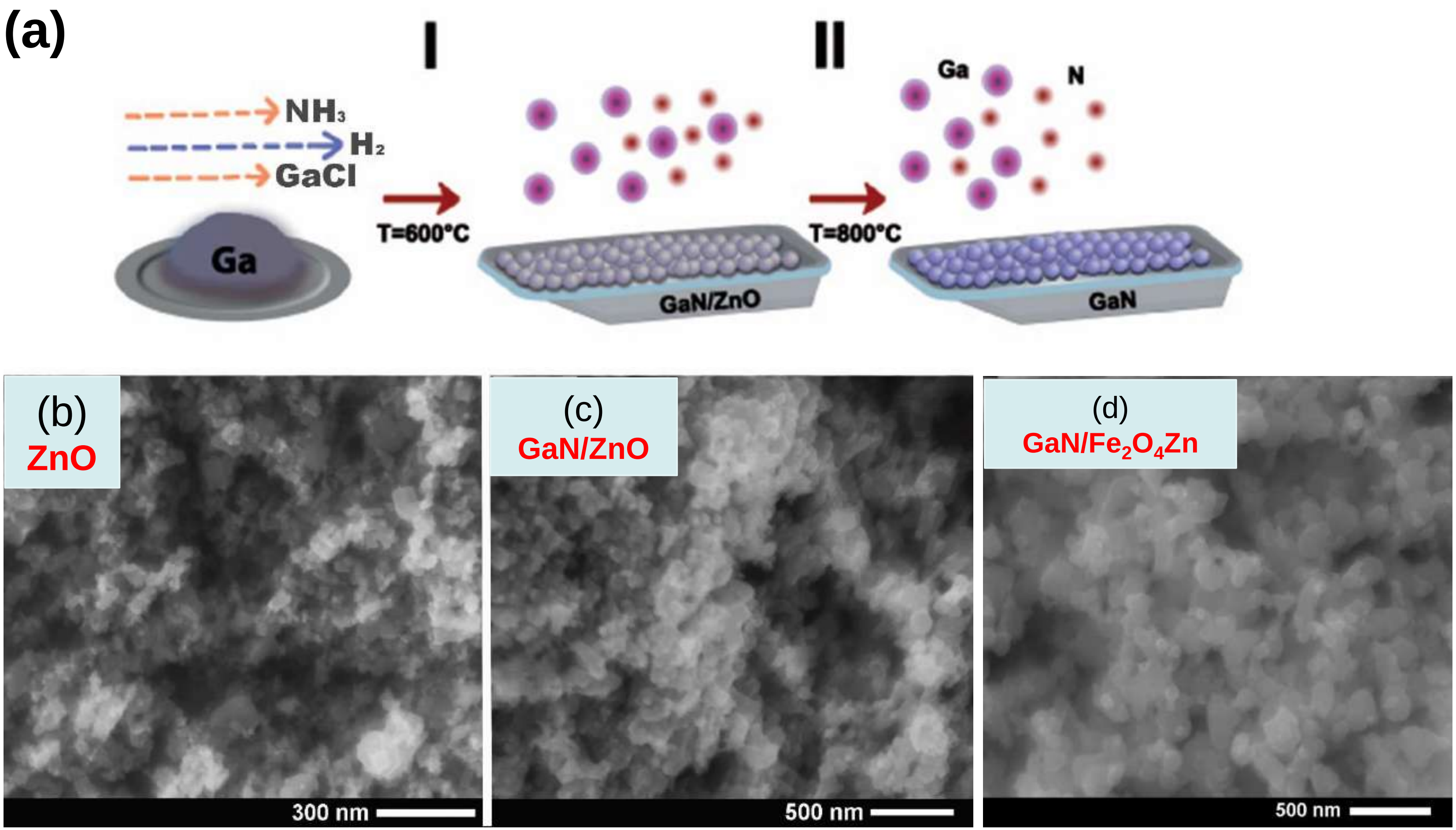
Compared to GaN, ZnO has a larger exciton binding energy: 60 meV, i.e. 2.4 times of the room temperature thermal energy

GaN/ZnO

hollow nanoparticles for biomedical applications

In collaboration with Hannover Medical School, Germany and State University of Moldova

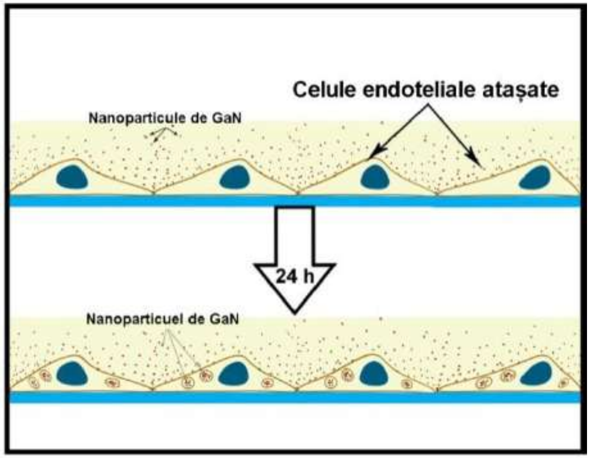
Synthesis of GaN/ZnO nanoparticles



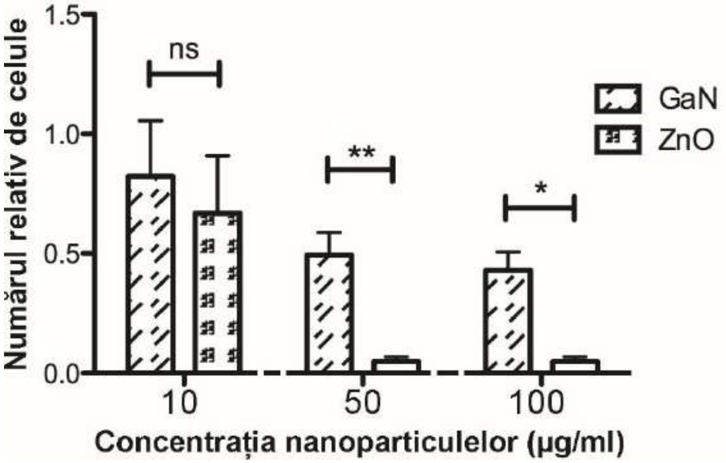
(a) - schematic representation of synthesis process of GaN/ZnO nanoparticles using ZnO and Fe_2O_4Zn sacrificial layer. SEM pictures presented in (c) and (d) show the morphology of the resulted nanoparticles, which does not differ form the initial ones depicted in (b)

T. Braniste *et al*, *Beilstein J. Nanotechnol. 7,* 1330–1337 (2016).

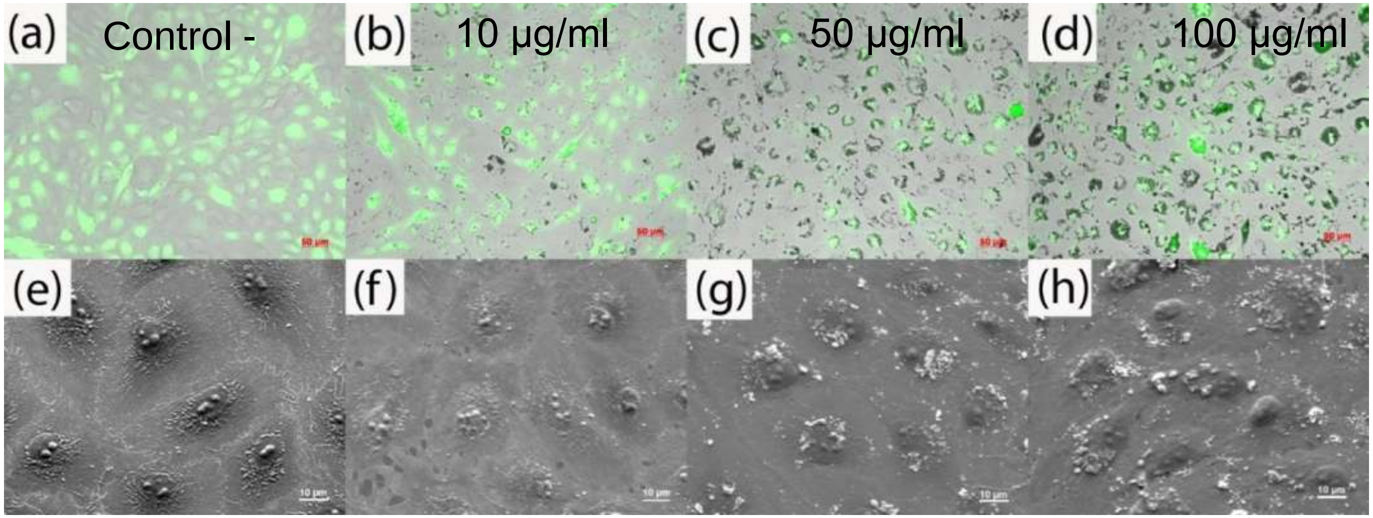
The interaction of free floating nanoparticles with living endothelial cells



Experimental concept



After 3 days of incubation of Endothelial Cells with NPs, we can observe that high concentrations of ZnO NPs are very toxic for cells, while by increasing the concentration of GaN NP cells are slowed down in the development and the nanoparticles are collected around cells.

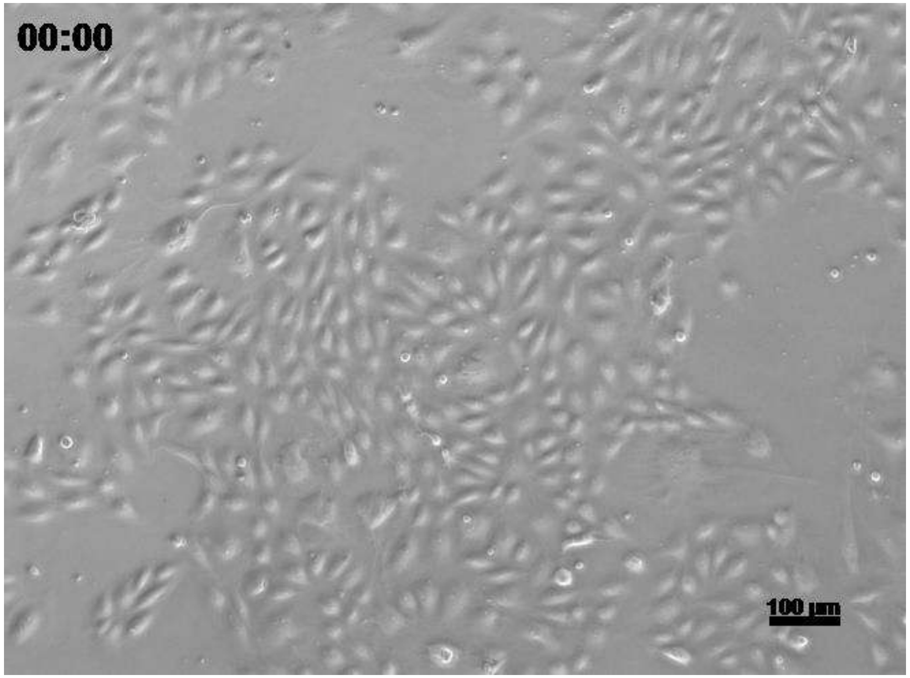


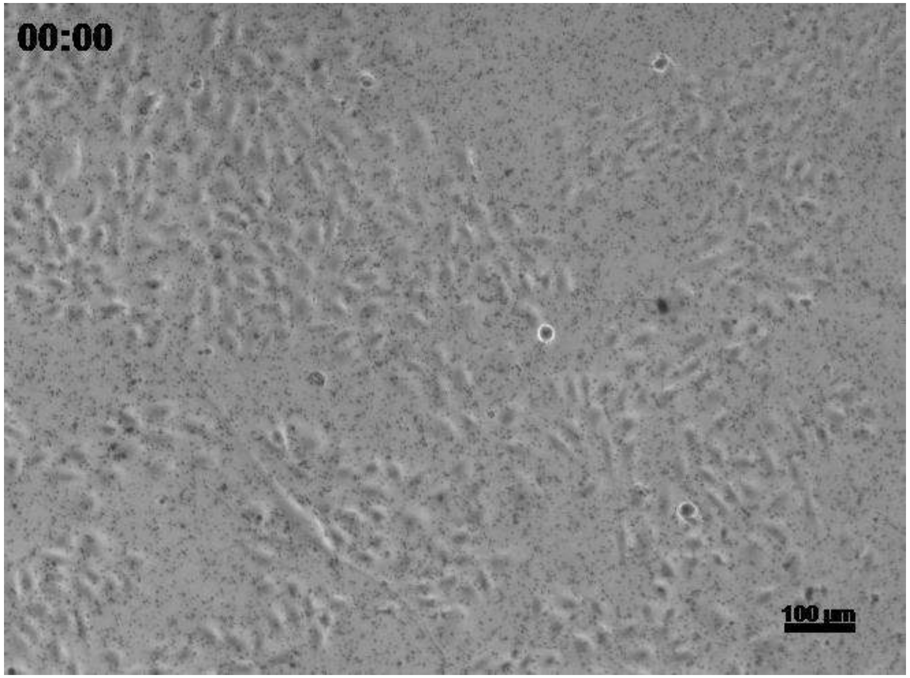
Nanoparticles distribution in endothelial cells culture after three days of cultivation of porcine aorta endothelial cells and GaN/ZnO NPs. Optical views are presented in pictures (a) – (d) and SEM images are in (e) – (h). The concentration of GaN/ nanoparticles is 10 µg/ml for (b) and (f), 50 µg/ml for (c) and (g), and 100 µg/ml for (d) and (h). Images (a) and (e) represent

Uptake of GaN nanoparticles by endothelial cells

Endothelial cells in the control group

Endothelial cells incubated with GaN nanoparticuels (50 µg/ml).



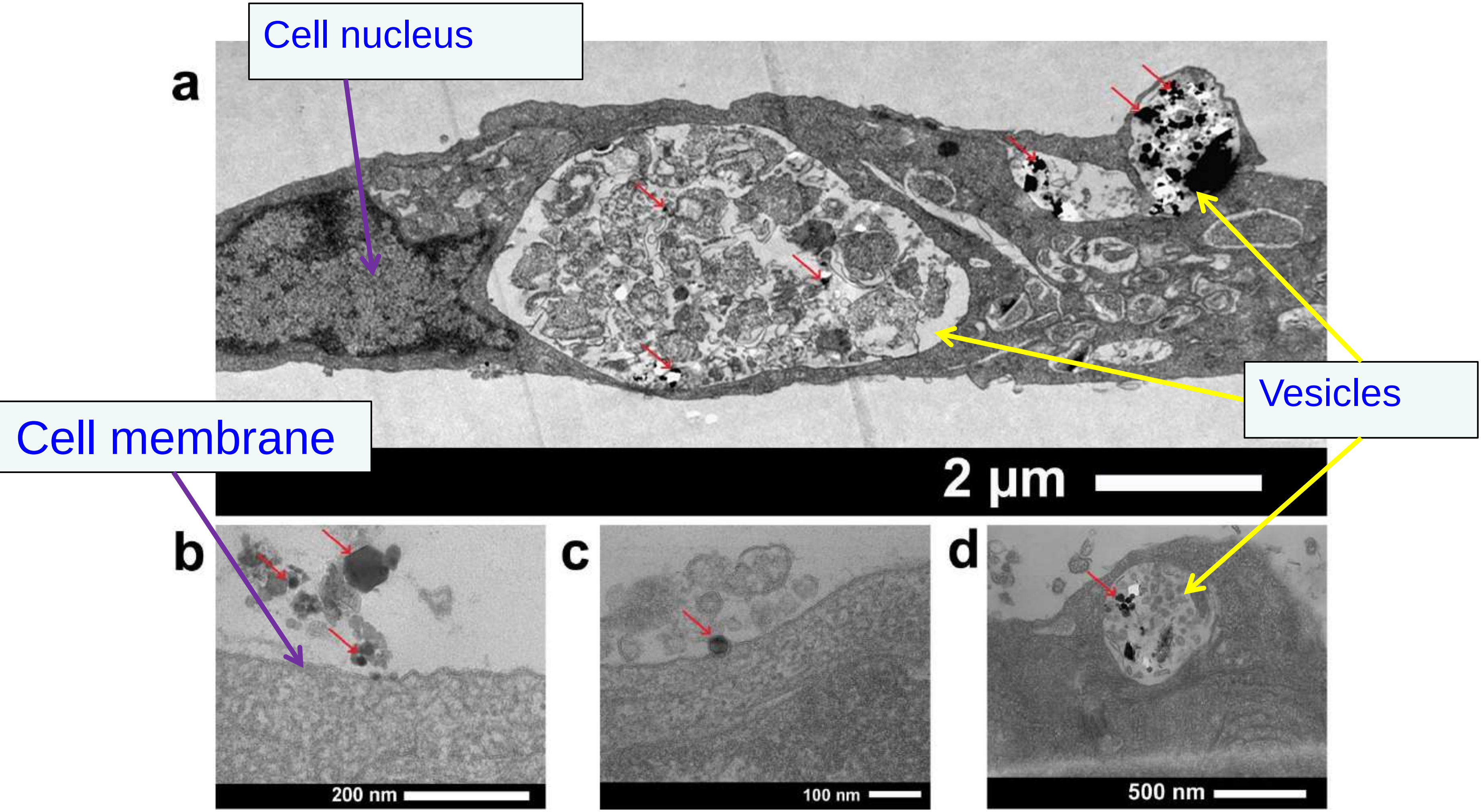


The cells were found to collect the nanoparticles surrounding them, nevertheless the mobility and the proliferation activity of endothelial cells are not affected by the presence of GaN/ZnO nanoparticles in the medium.

Note: The investigations were performed for 20 h, one picture being shot every 10 min.

T. Braniste *et al*, *Beilstein J. Nanotechnol. 7,* 1330–1337 (2016)

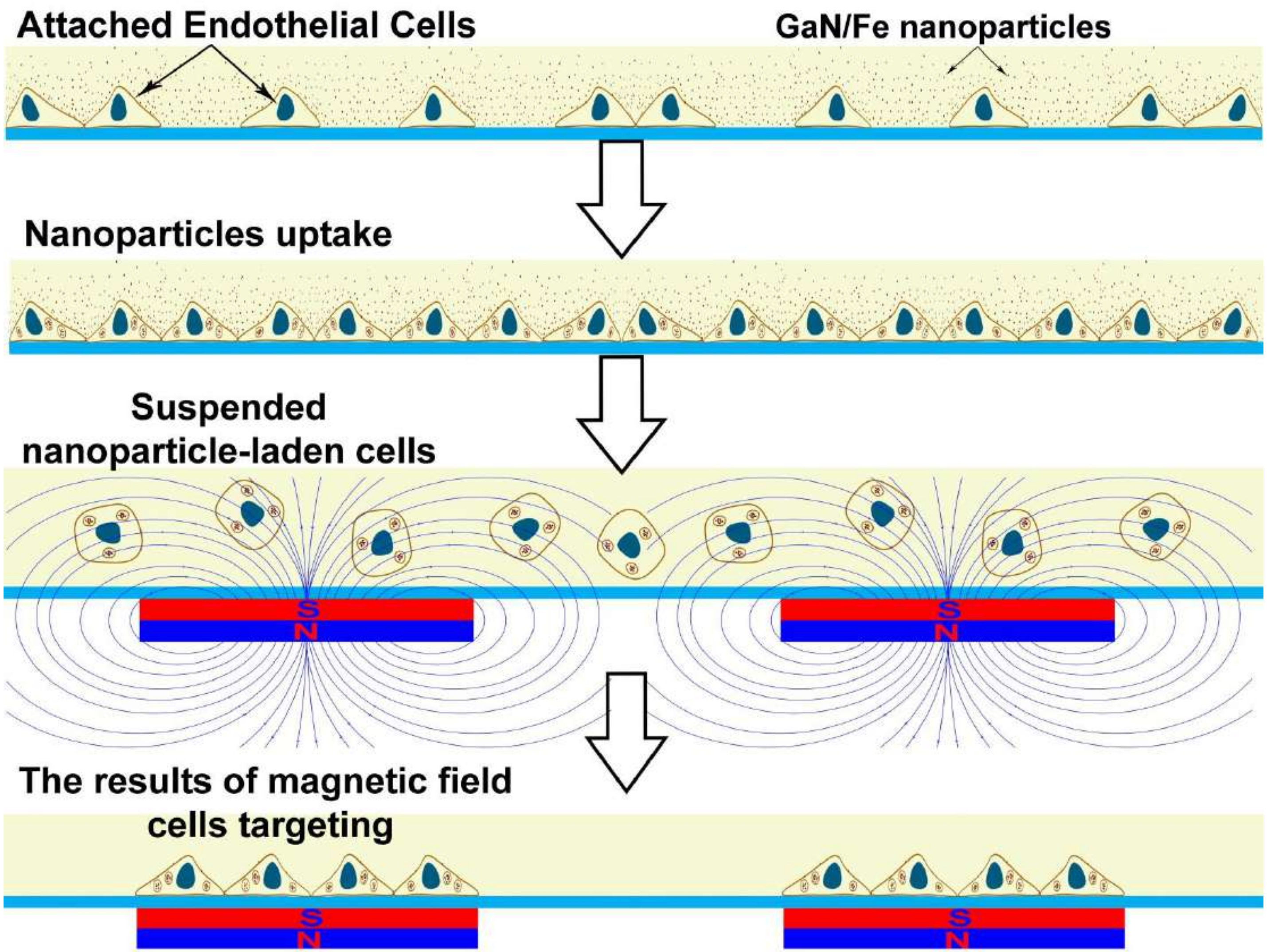
Uptake of nanoparticles by endothelial cells and localization in vesicles determined by TEM investigations



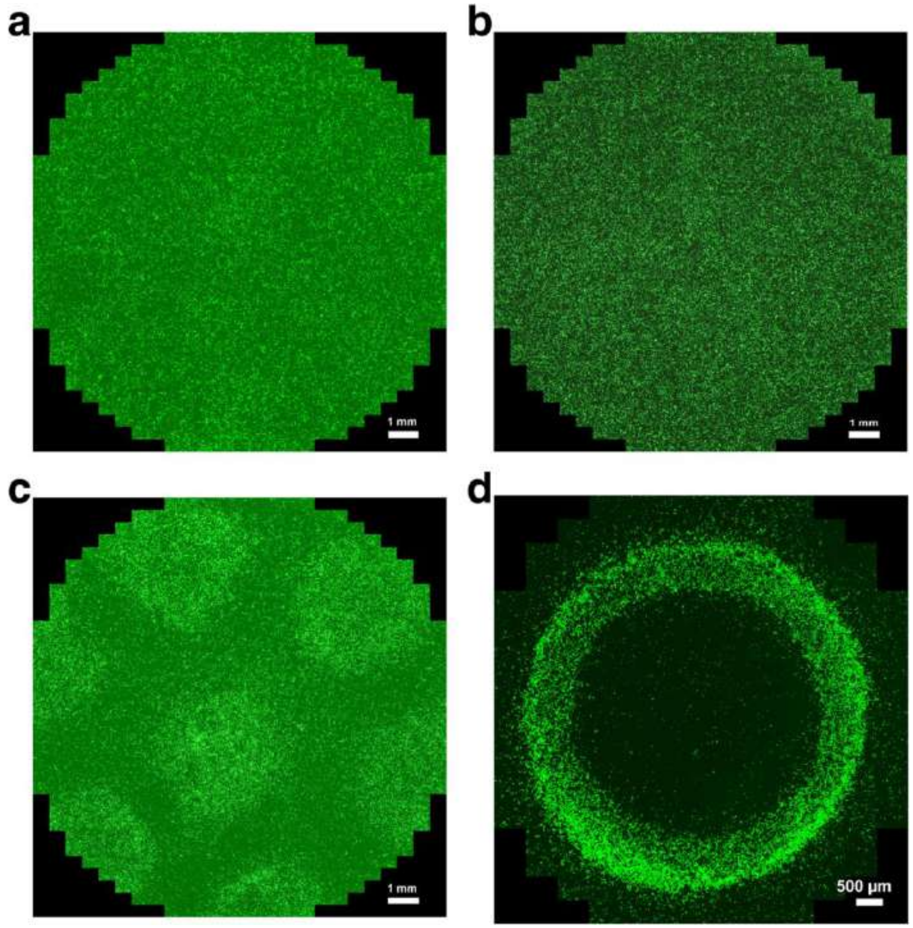
TEM pictures taken from a endothelial cell incubated with GaN/Fe nanoparticles.

T. Braniste *et al*, *Nanoscale Research Letters 12,* 486 (2017).

Magnetic guiding of endothelial cells targeted with nanoparticles



Magnetic guiding of endothelial cells targeted with nanoparticles

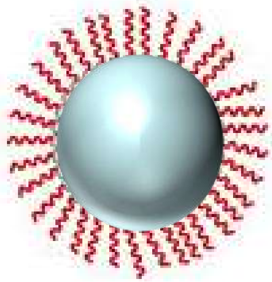


Fluorescence pictures of endothelial cells targeted with GaN/Fe nanoparticles and incubated in control groups (a,b) and in magnetic field gradients (c,d) and. After few hours of incubation a non-uniform distribution of cells exposed to magnetic field could be notified, while cells targeted with nanoparticles and incubated in normal conditions (without magnetic field) are distributed uniformly on the surface of the culture plate.

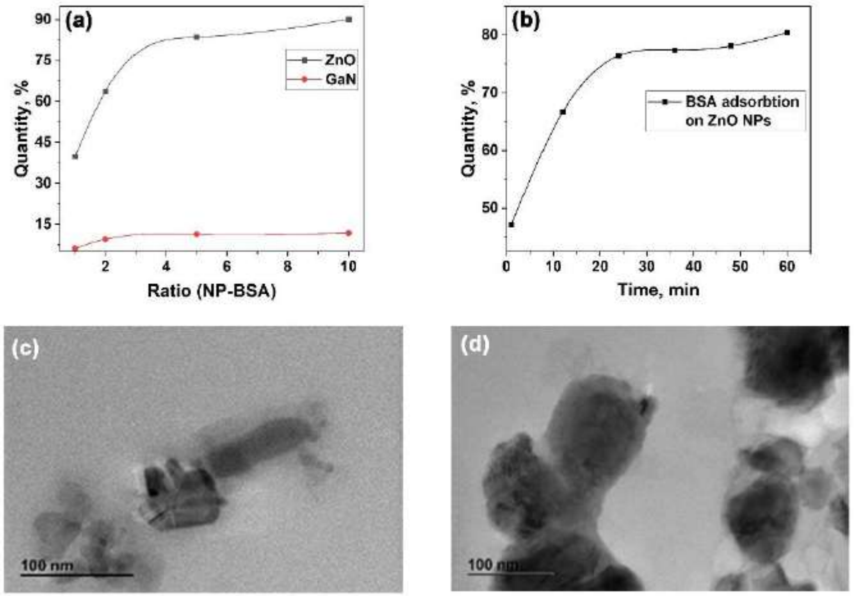
T. Braniste *et al*, *Nanoscale Research Letters 12,* 486 (2017).

Nanoparticles-proteins interaction (V.Ciobanu @JRC)

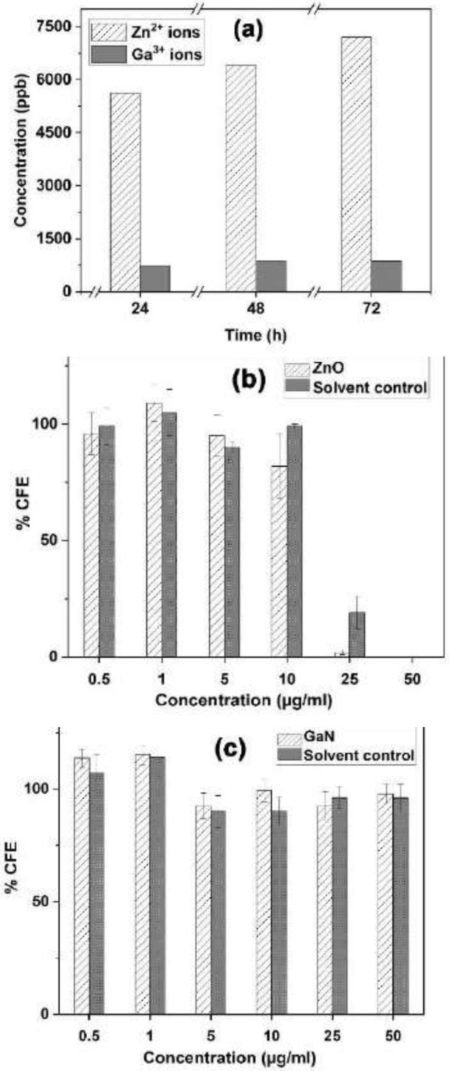
ZnO+albumin



GaN+Albumin



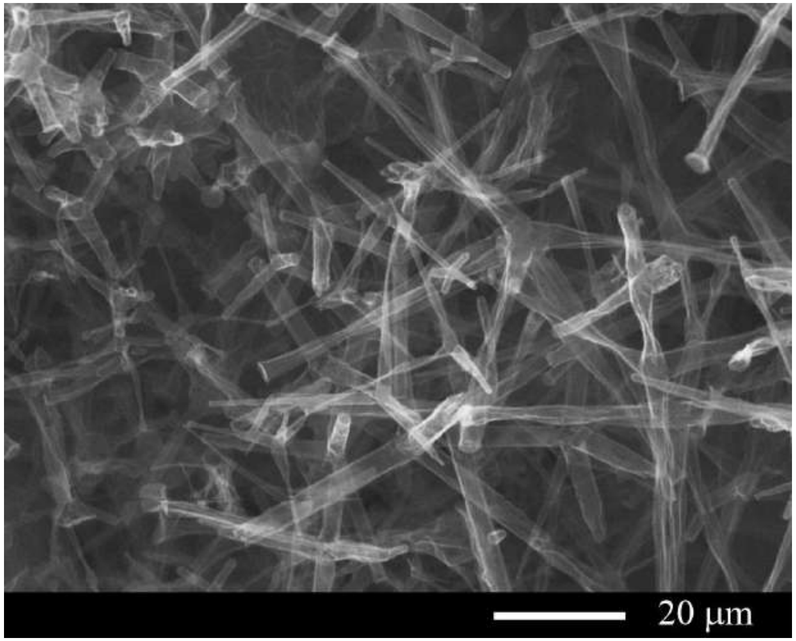
BSA adsorption on ZnO surface at different NPs-BSA ratios **(a)**. The dynamic of the association of the BSA on ZnO NP surface **(b)**. TEM images of protein corona on ZnO **(c)** and GaN **(d)** particles



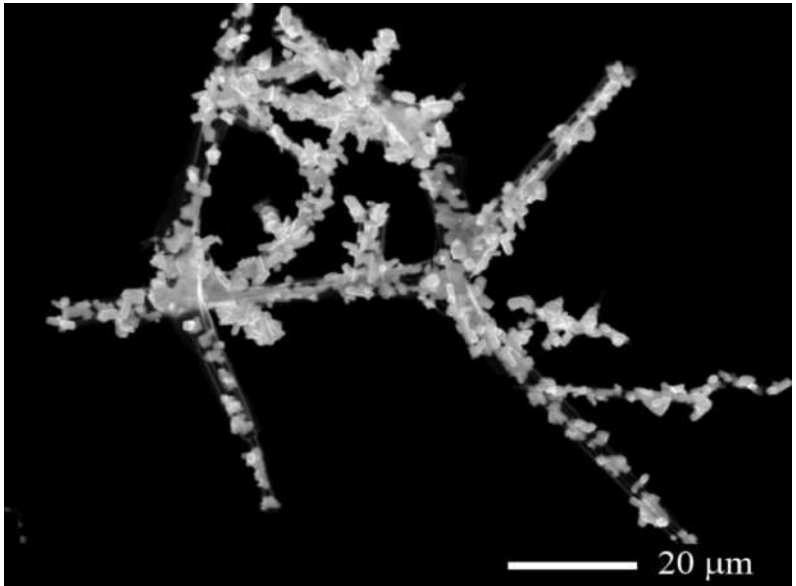
Zn^{2+} and Ga^{3+} ions concentration in DMEM measured by ICP-MS **(a)** and HaCaT cells viability after incubation with ZnO **(b)** and GaN **(c)** NPs for 48 h

Three-dimensional flexible hybrid architectures on GaN

Deposition of GaN crystallytes on Aerographite scaffold

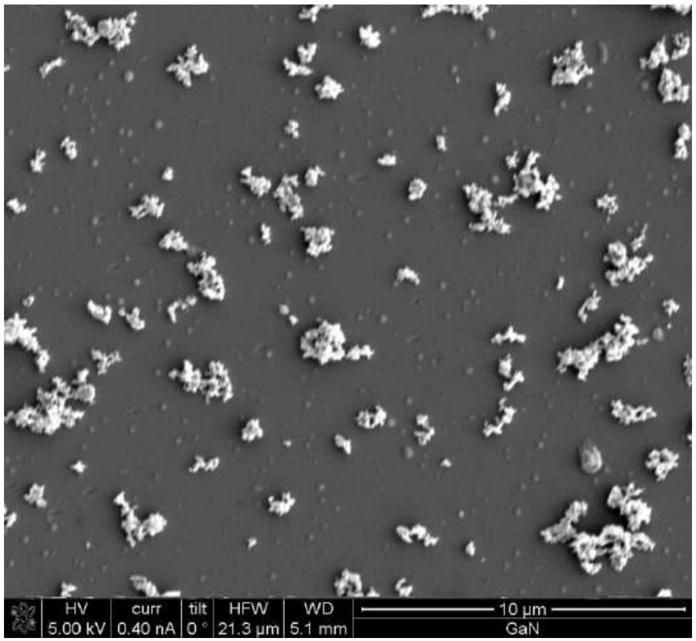


Aerographite
the world's lightest material



R. Adelung et al,
***Advanced Materials* 24 3486-3490 (2012)**

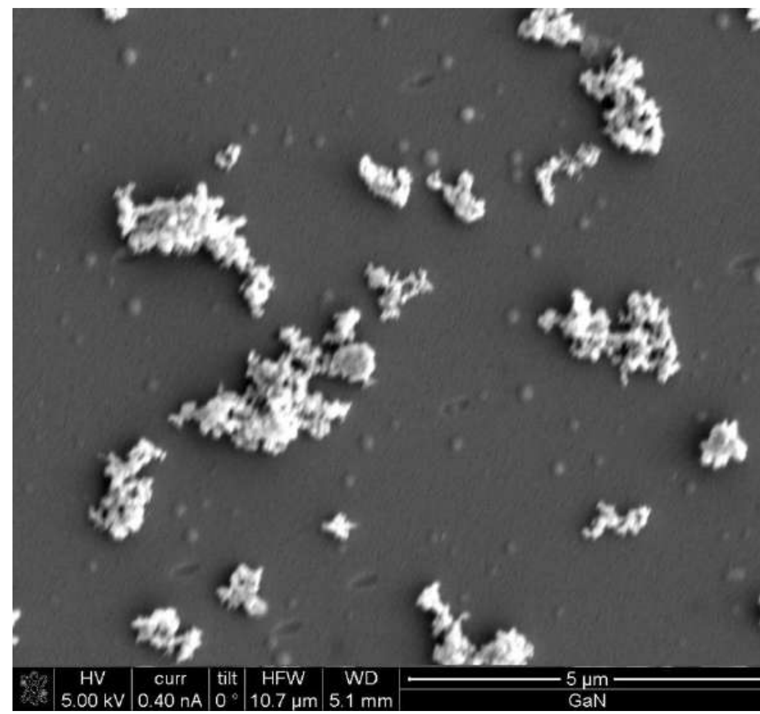
Agglomeration of nanoparticles



How to protect particles against agglomeration ?

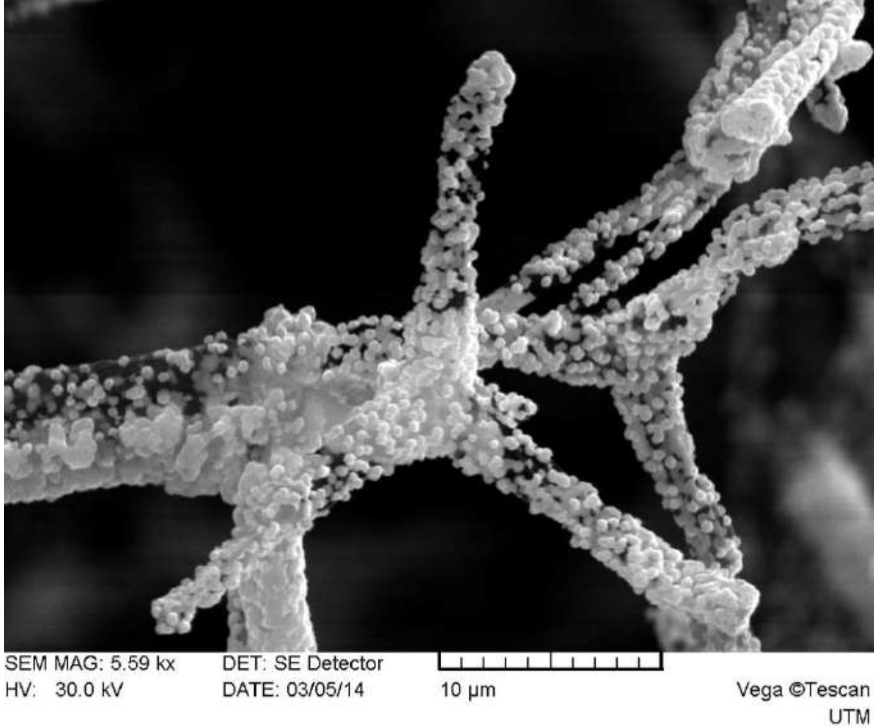
GaN nanoparticles

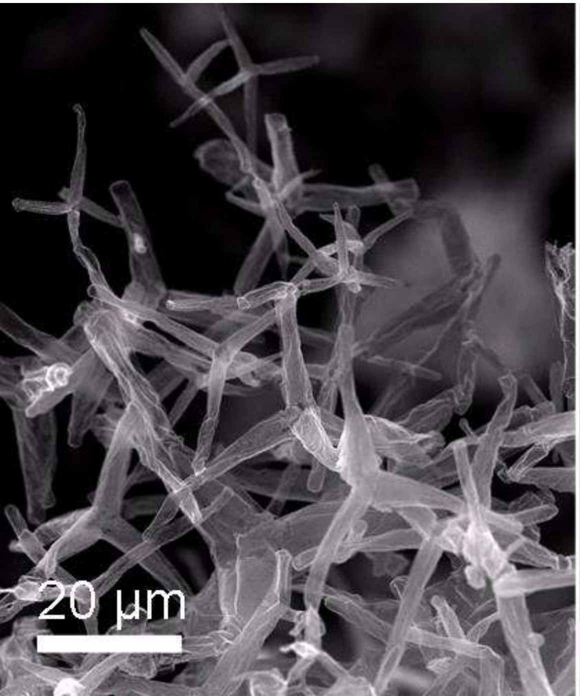
50 nm

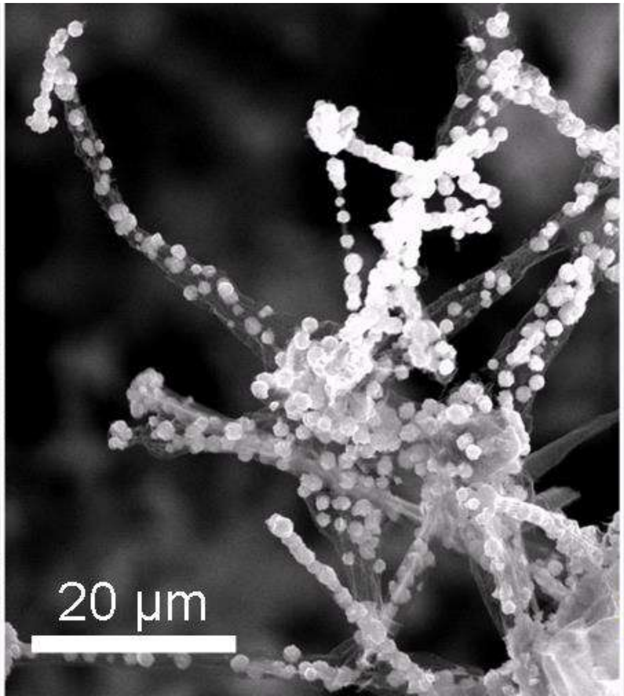


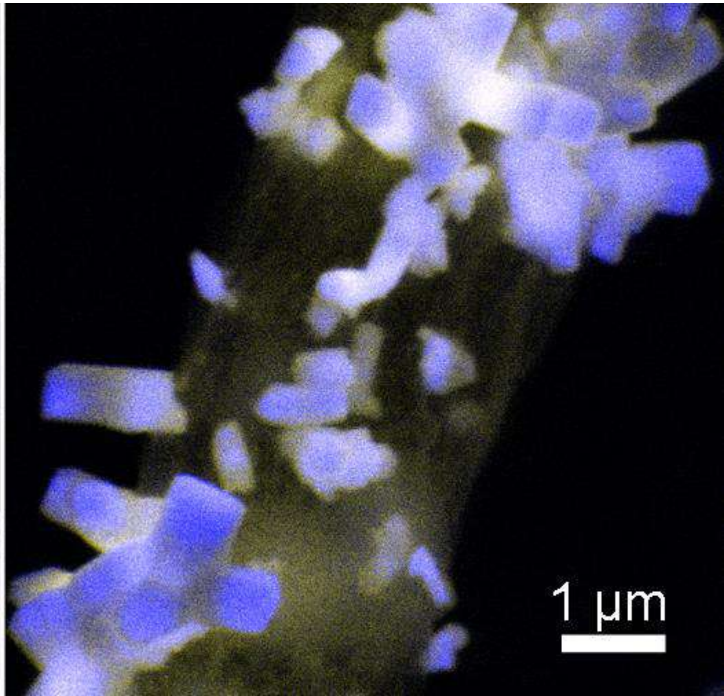
GaN particles deposited on graphite microtubular scaffold

A.Schuchardt *et al*,
Scientific Reports,
Vol. 5, 8839 (2015)

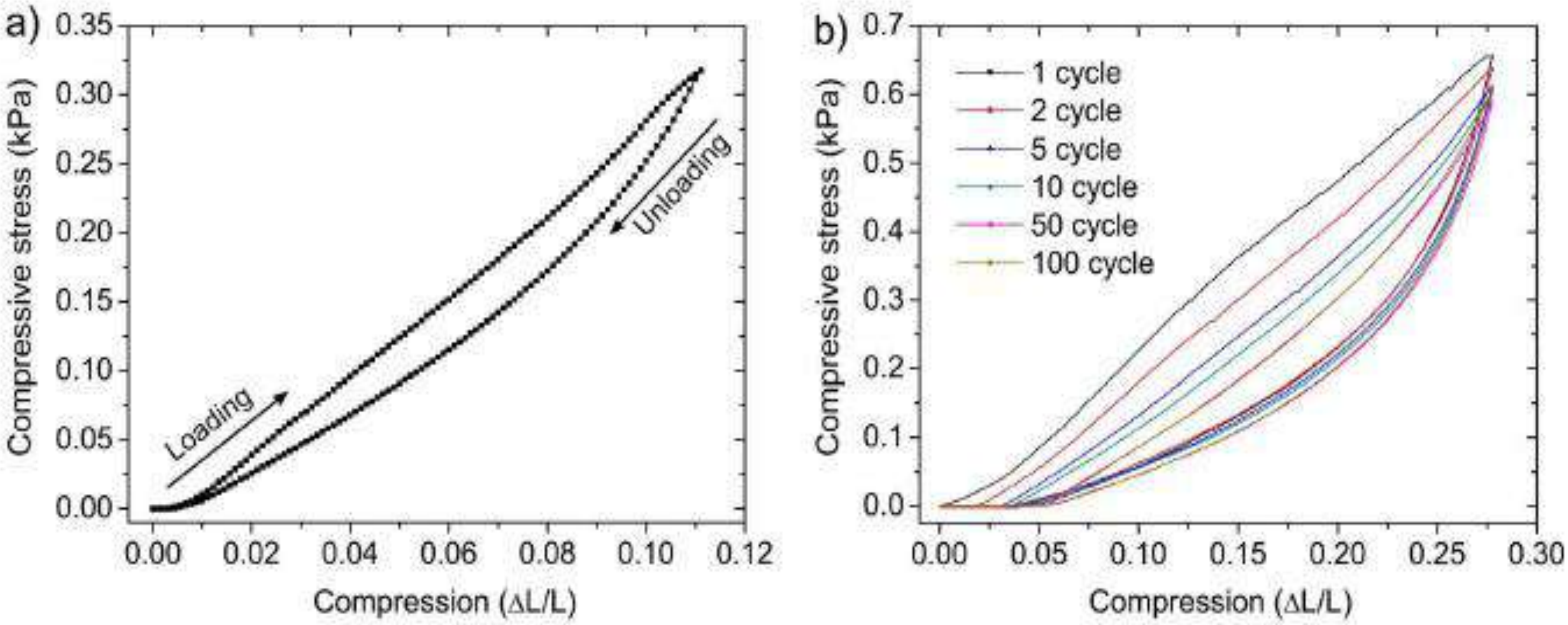








Cyclic loading-unloading response of the Aerographite-GaN network under compressive stress



Arnim Schuchardt, Tudor Braniste et al, Three-dimensional Aerographite-GaN hybrid networks: Single step fabrication of porous and mechanically flexible materials for multifunctional applications, *Scientific Reports*, Vol. 5, 8839 (2015).

LATEST NEWS ARTICLES

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- Nanopores detect individual proteins
- Electron pairing without superconductivity seen at long last
- Swirling light beams carve intricate patterns
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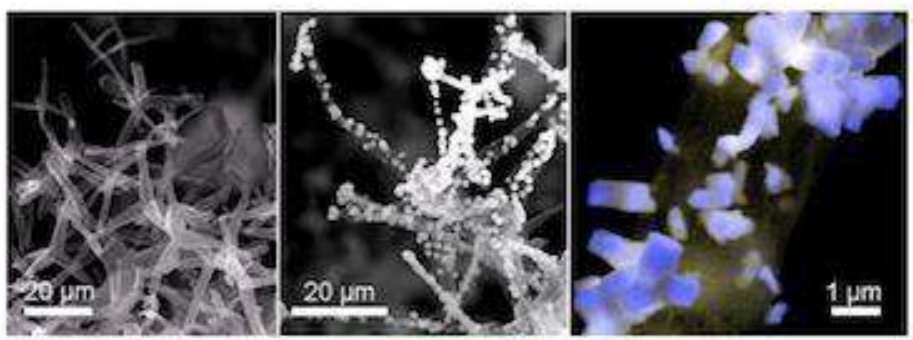
- "Hopping" electrodeposition makes gold nanodot plating (Feb 2015)
- Surface writing produces optical waveguides (Jan 2014)
- Cheap carbon foam makes good battery catalyst (Apr

TECHNOLOGY UPDATE

May 8, 2015

Aerographite makes multifunctional hybrid

Researchers in Germany, Moldova and Australia have developed a new way to build 3D architectures of semiconducting crystallites by growing gallium nitride (GaN) nano- and micro-buds on an aerographitic "tree". The technique might be used to create flexible composites as next-generation nanomaterials for electronic, photonic and sensor applications.

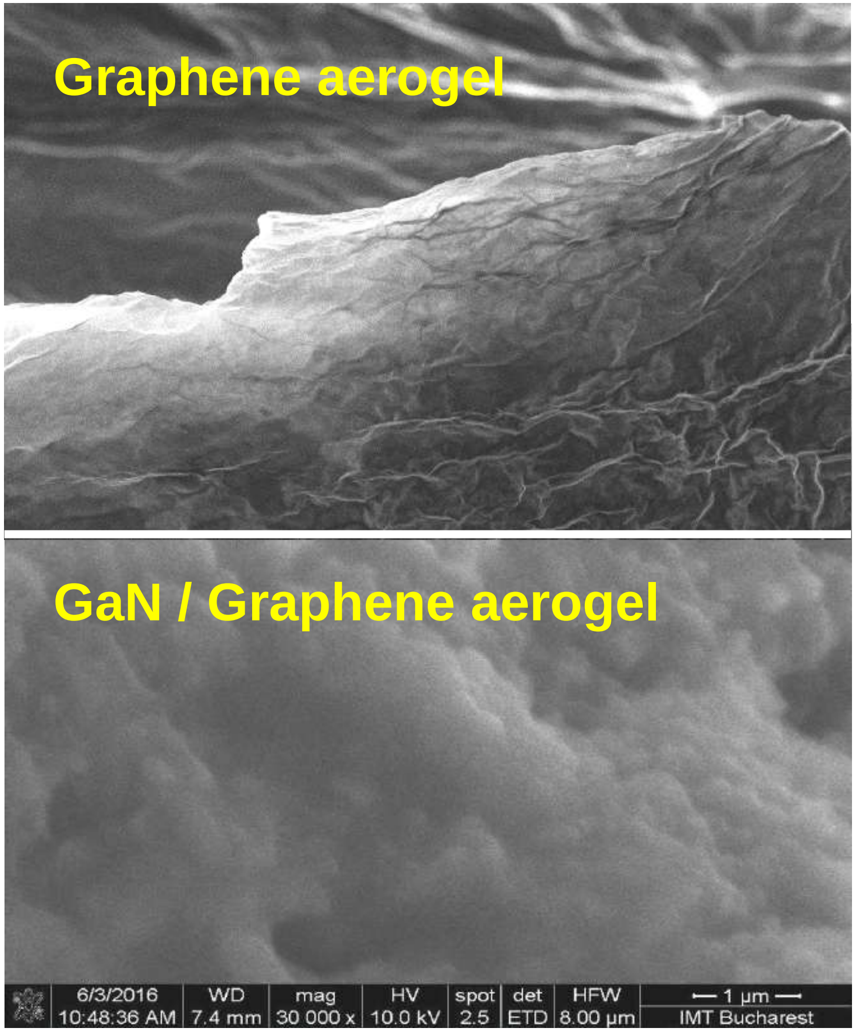


3D aerographite

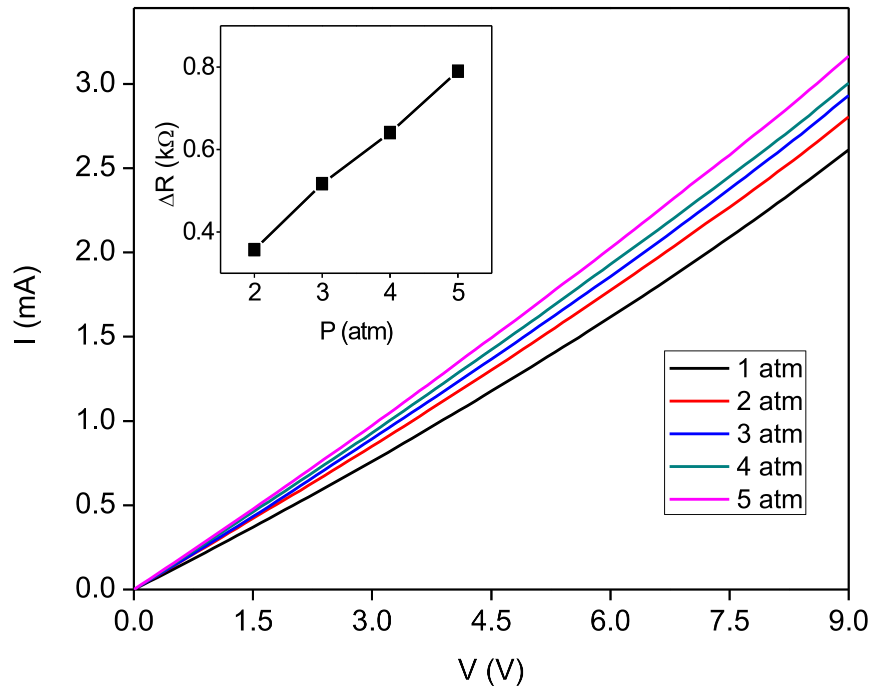
GaN is a wide-bandgap semiconductor compound routinely employed in high-temperature and high-power electronics as well as in optoelectronics for short wavelength light-emitting diodes and lasers. It is biocompatible, piezoelectric and

Pressure sensor on GaN - Graphene aerogel

Nanocrystalline GaN was deposited by RF magnetron sputtering



GaN / Graphene aerogel

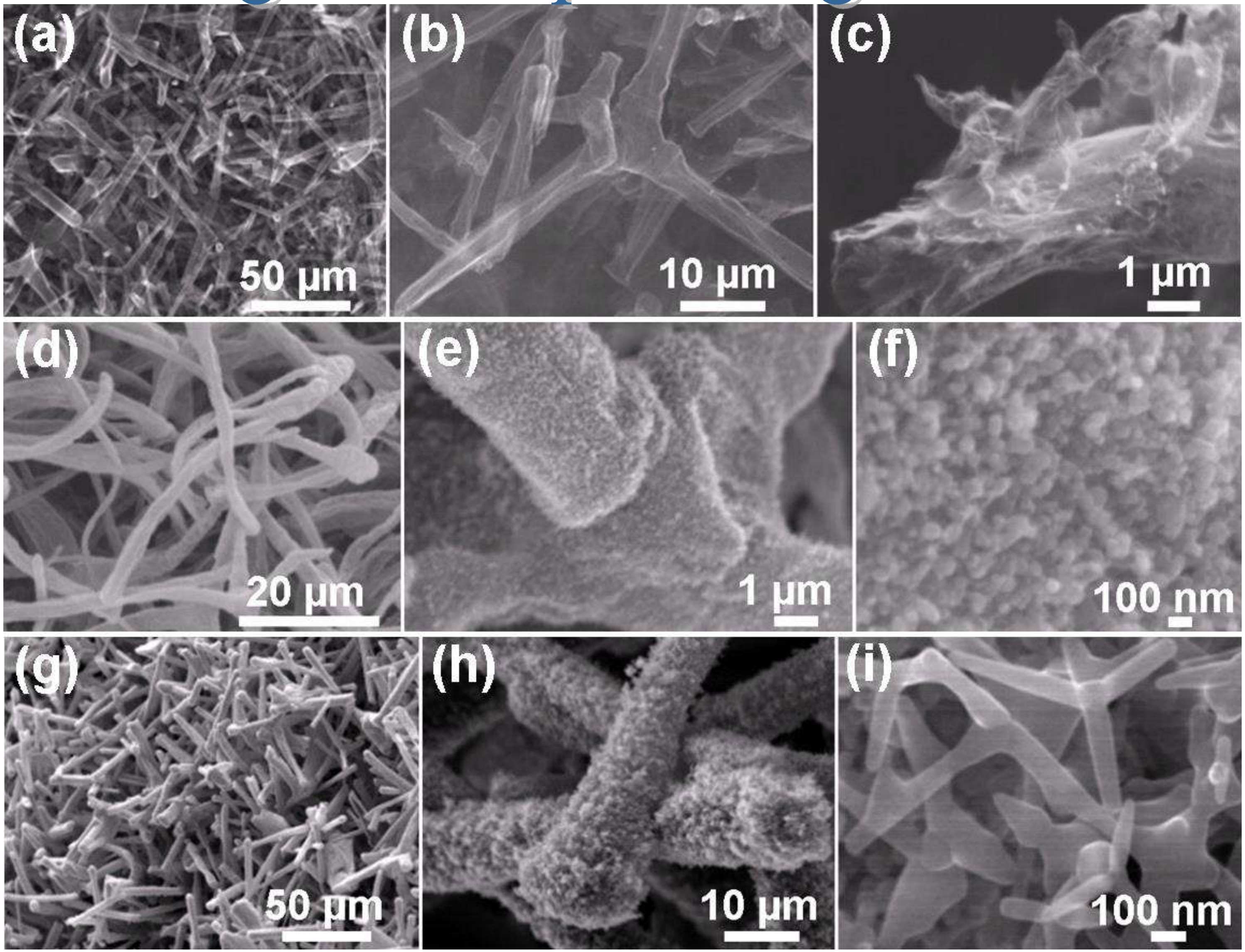


The sensitivity of the GaN – graphene aerogel nanocomposite equals 6.75×10^{-4} kPa^{-1}, which is 25 times higher than the sensitivity of the graphene suspended membranes.

M. Dragoman, L. Ghimpu *et al*, Ultra-lightweight pressure sensor based on graphene aerogel decorated with piezoelectric nanocrystalline films, *Nanotechnology,* Vol. 27, 475203 (2016).

Three-dimensional flexible hybrid architectures on ZnO

Magnetron sputtering of ZnO on AG



Isolated nano-crystallites

Continuous nano-crystalline layer

Sub-µm tetrapods

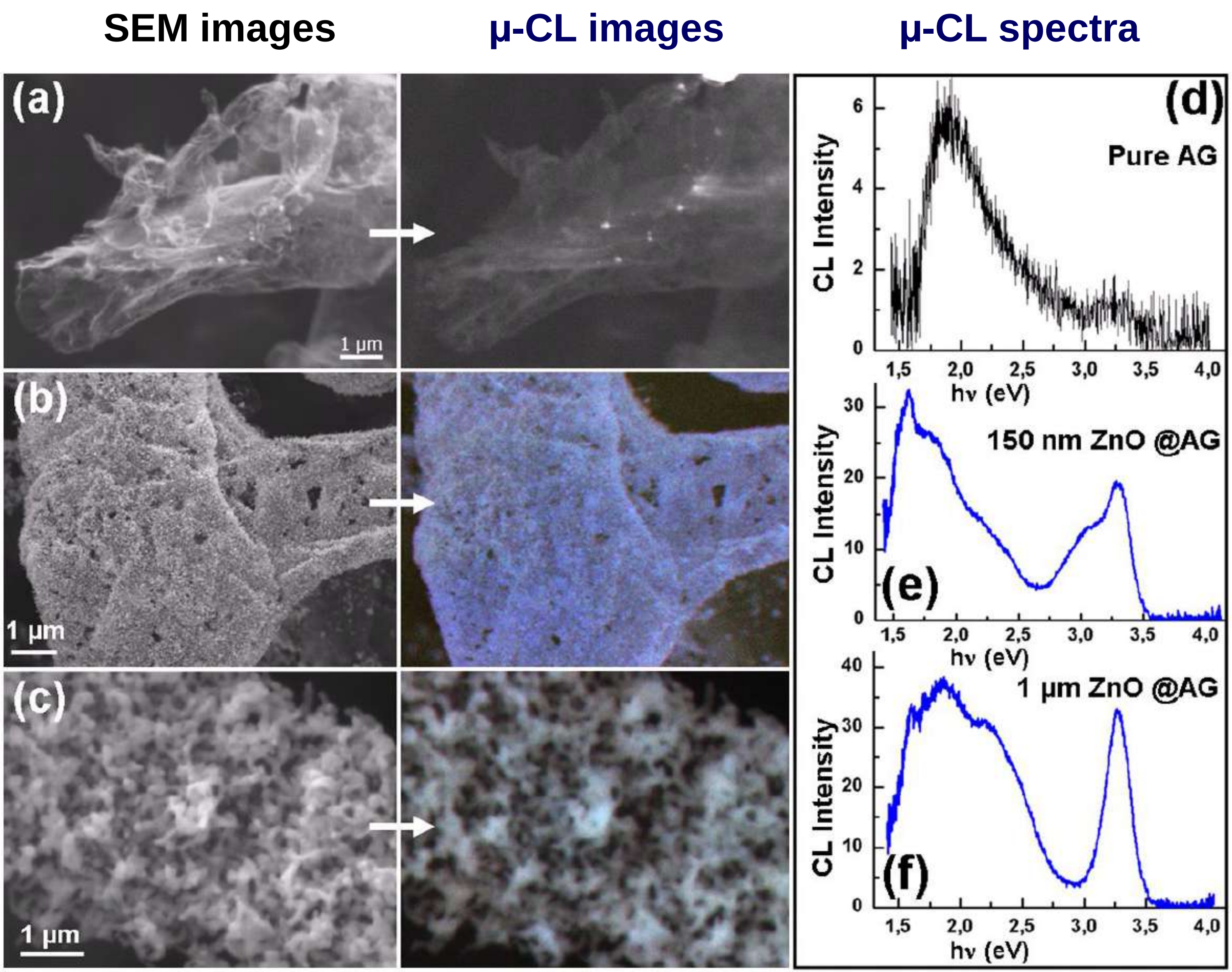
I.Tiginyanu et al, Scientific Reports, **Strong light scattering and broadband (UV to IR) photoabsorption in stretchable 3D hybrid architectures based on Aerographite decorated by ZnO nanocrystallites, Sci. Rep. 6, 32913 (2016).**

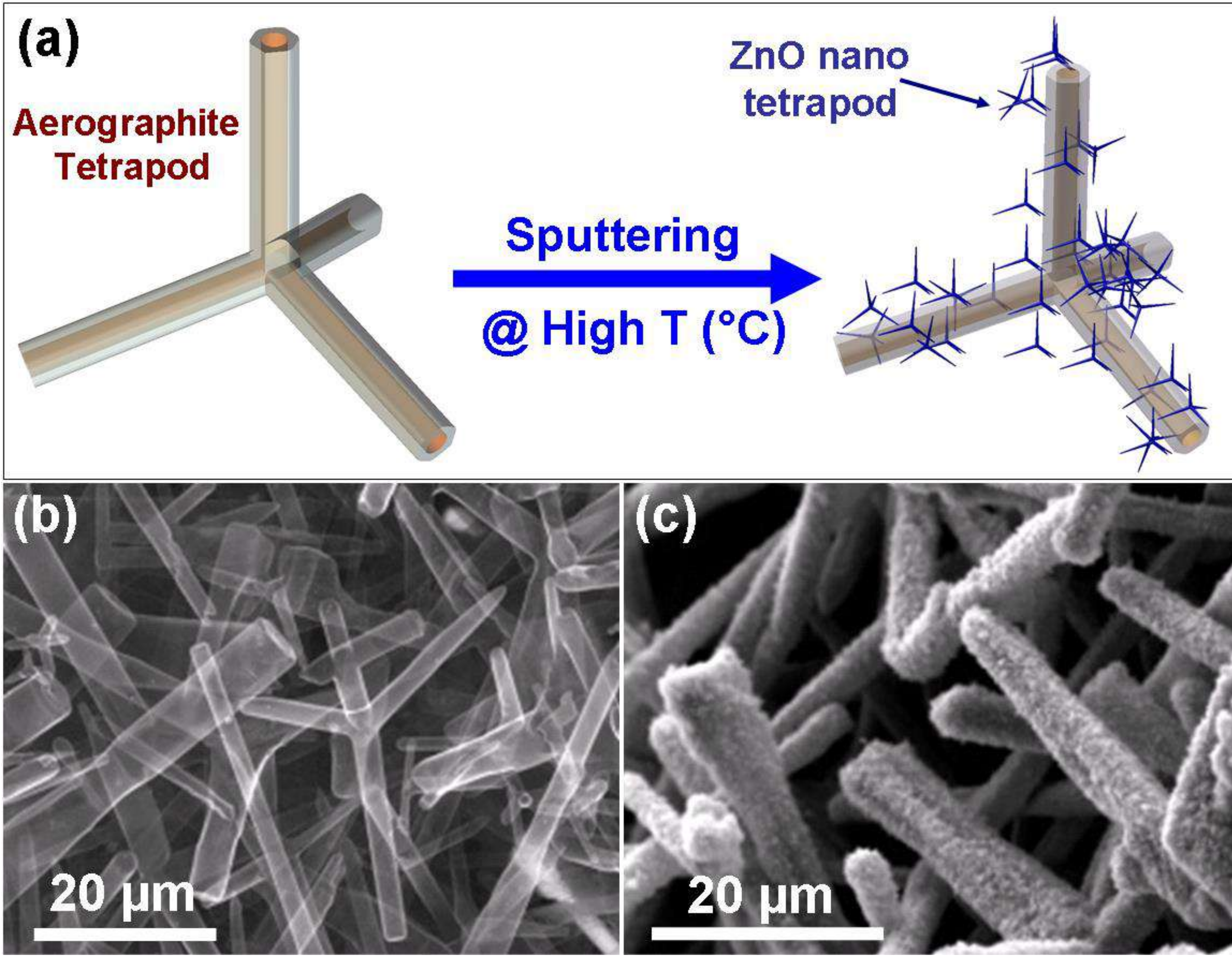
Cathodoluminescence characterization

Isolated nano-crystals

Continuous nano-crystalline layer

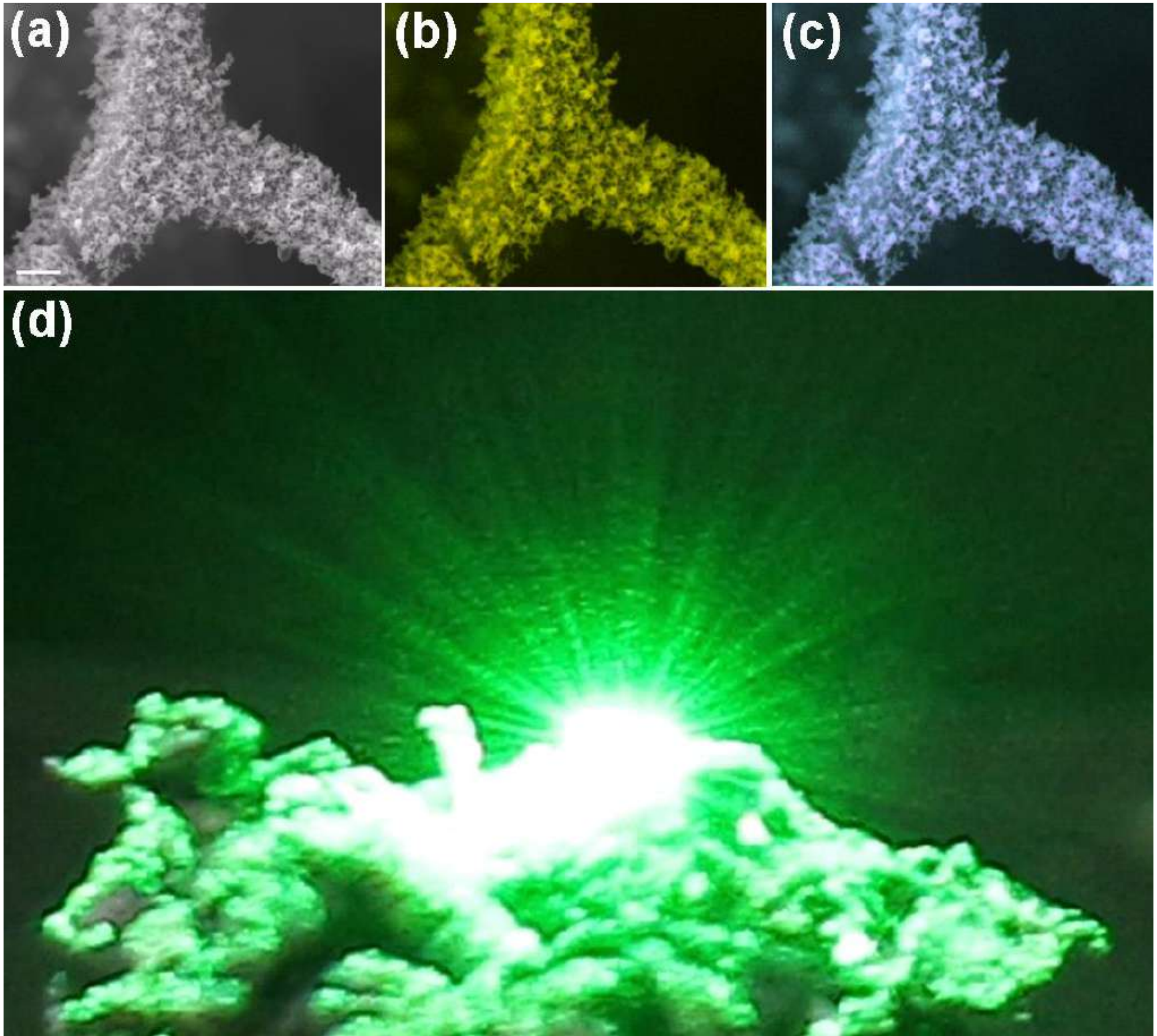
Sub-µm tetrapods



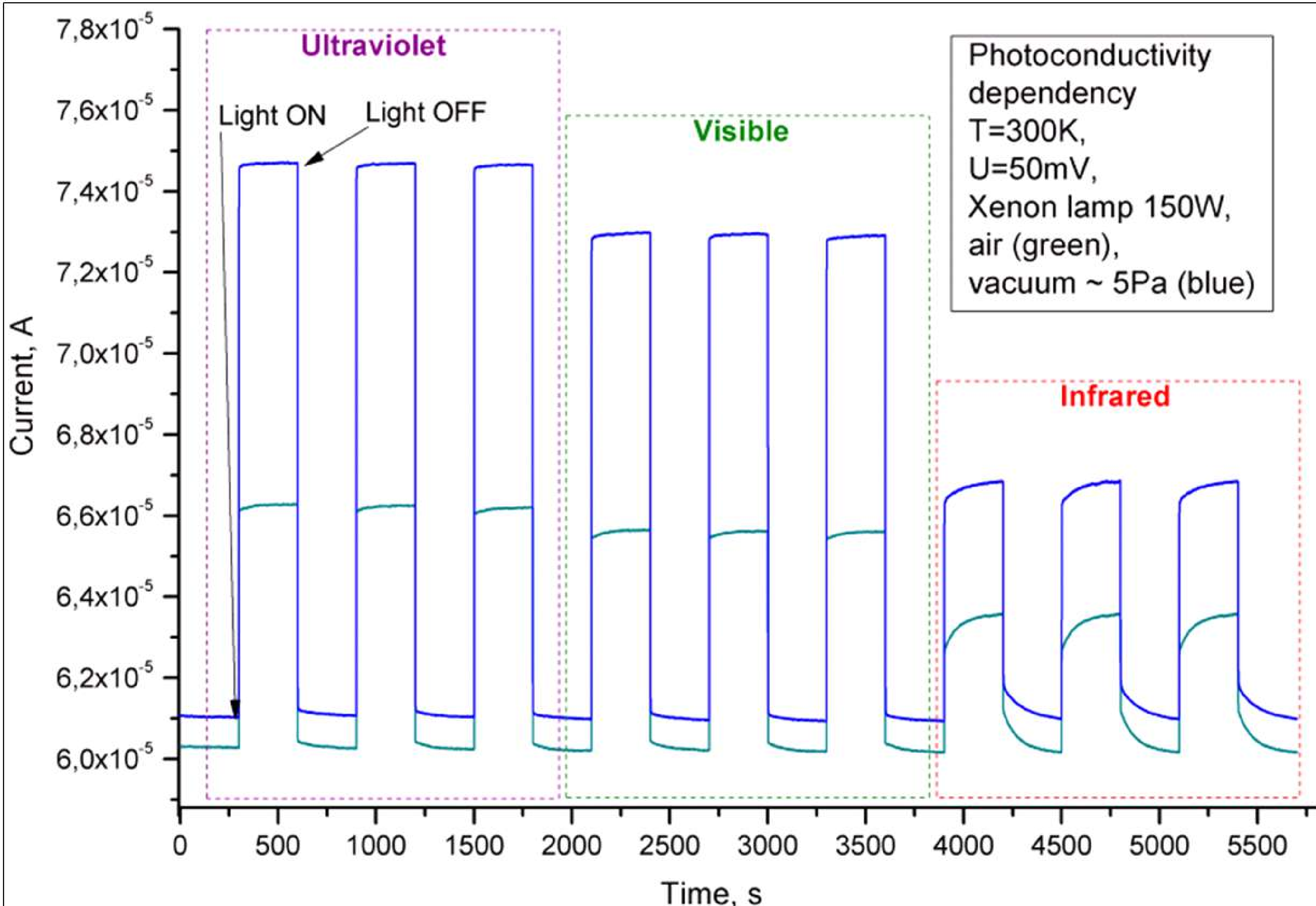

(a)
Aerographite
Tetrapod
Sputtering
@ High T (°C)
ZnO nano
tetrapod
(b)
20 µm
(c)
20 µm

Strong Light Scattering

SEM **CL (525 + 675) nm** **(360 + 400 + 525) nm**



Broadband Photoabsorption



GaN/ZnO

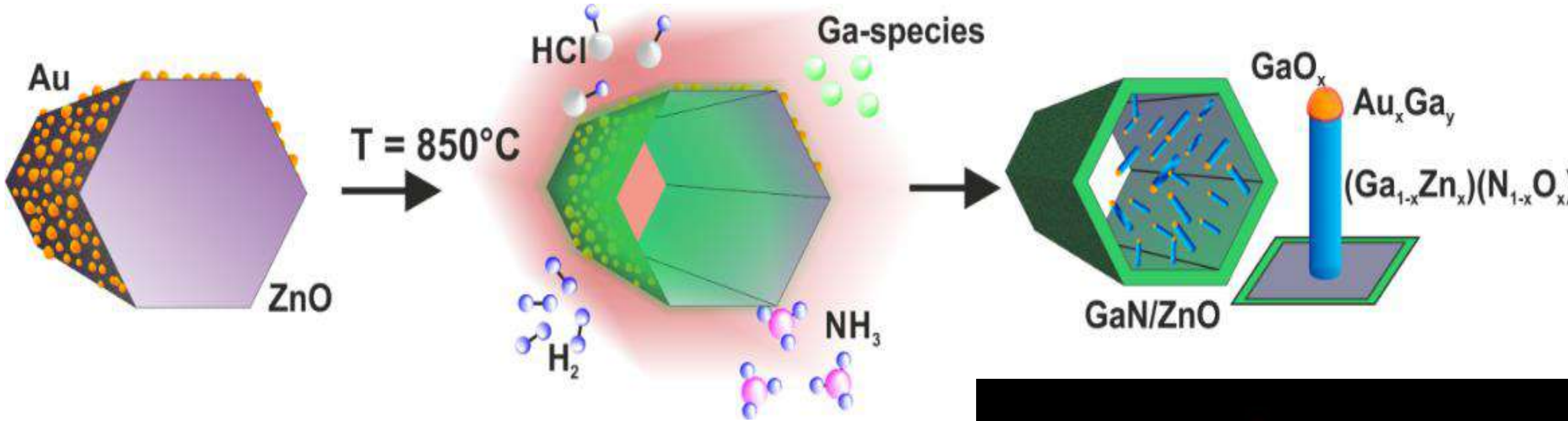
light-driven, fluorescent micro-nano-engines

In collaboration with the Institute for Integrative Nanosciences, Leibniz IFW Dresden; Institute for Materials Science, Kiel University; Max Planck Institute for Solid State Research, Stuttgart; Material Systems for Nanoelectronics, Chemnitz University of Technology; State University of Moldova.

GaN/ZnO micro-nano-tubes

exhibiting a gradient in diameter

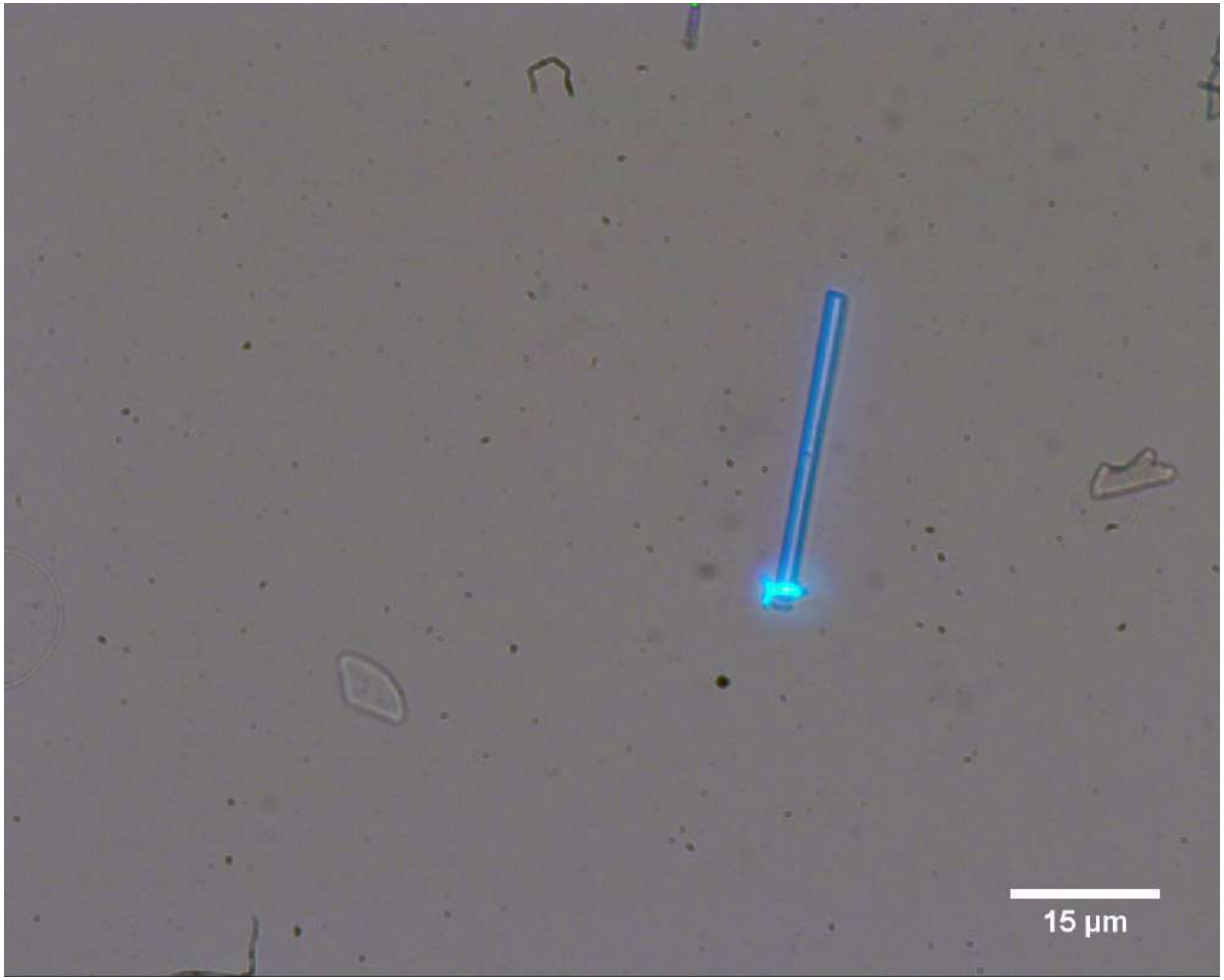
are promising for the development of micro-nano-engines



The high density of nanowires grown inside the hollow microstructures was visualized by a three-dimensional volume reconstruction computed from STEM tomography experiments

***Small*, 1905141 (2020)**

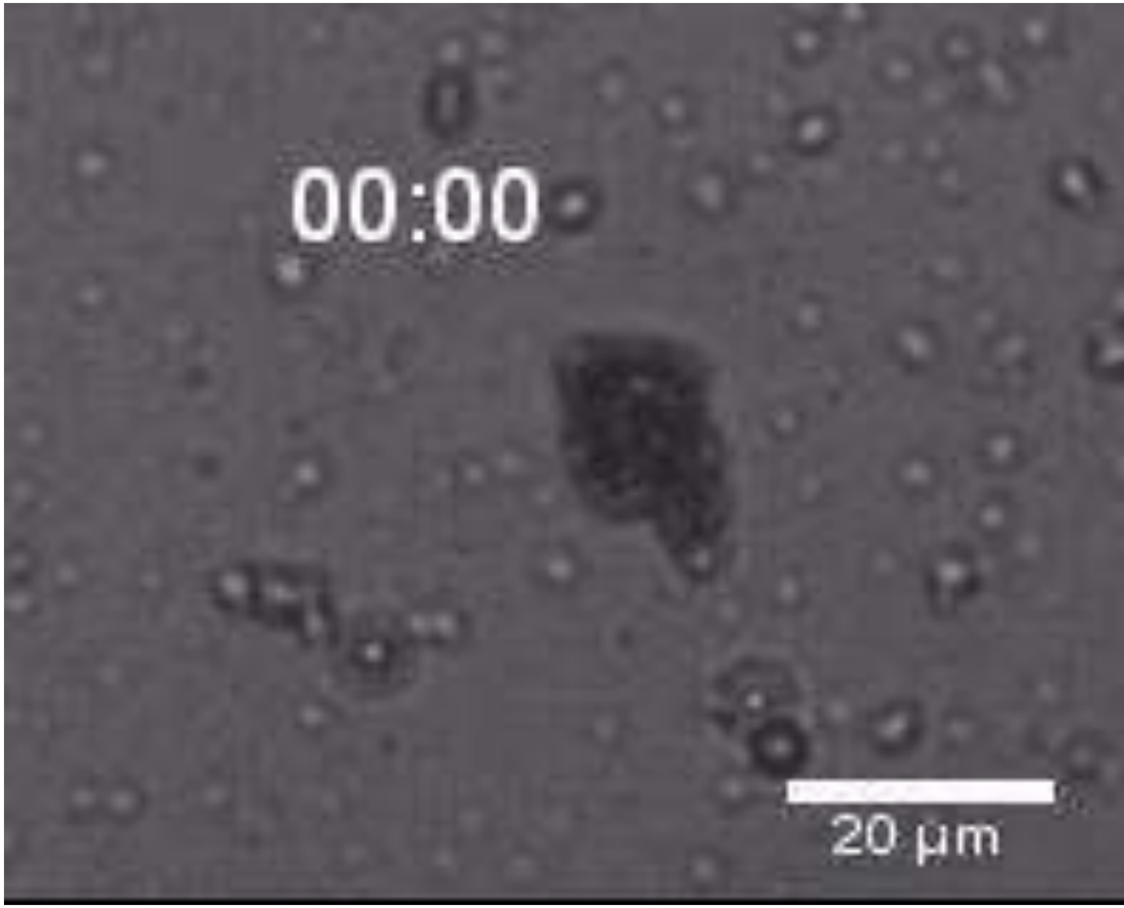
Fluorescent microengines



Niklas Wolff, Vladimir Ciobanu, Mihail Enachi, Marius Kamp, Tudor Braniste, Viola Duppel, Sindu Shree, Simion Raevschi, Mariana Medina-Sánchez, Rainer Adelung, Oliver Schmidt, Lorenz Kienle, Ion Tiginyanu, **Advanced hybrid GaN/ZnO nano-architectured microtubes for fluorescent micromotors driven by UV-light, *Small*, 1905141 (2020).**

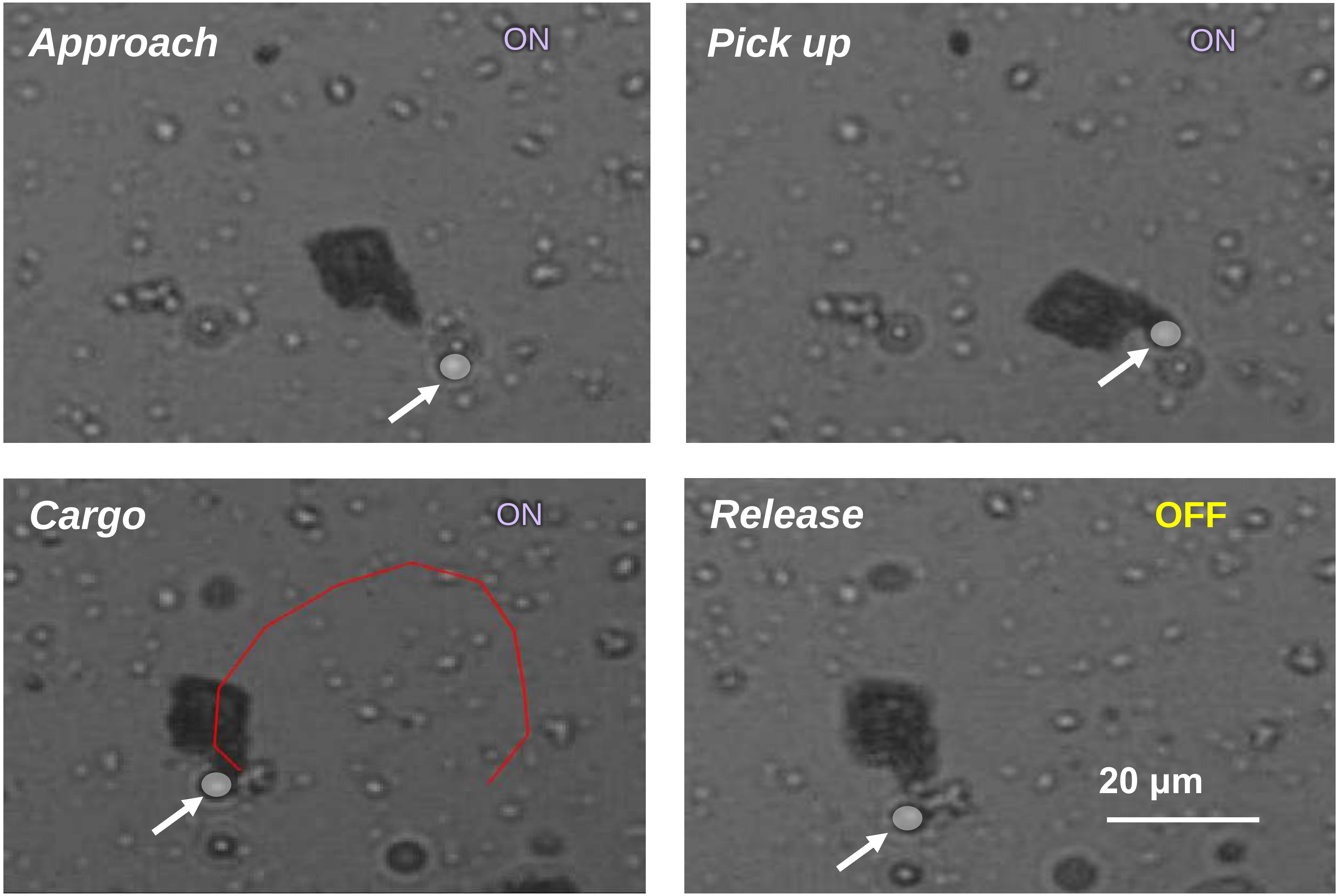
Light-driven microengines with cargo capabilities

Microsubmarines based on microarrays of TiO_2 nanotubes



Mihail Enachi, Maria Guix, Vitalie Postolache, Vladimir Ciobanu, Vladimir M. Fomin, Oliver G. Schmidt, Ion Tiginyanu. Light-induced motion of microengines based on microarrays of TiO_2 nanotubes. ***Small,*** Vol. 12, no 39, pp. 5497-5505 **(**2016).

Pick up, transport and release of microparticle



M. Enachi *et al*, Light induced motion of microengines based on microarrays of TiO2 nanotubes, *Small* 12, 5497–5505 (2016)

GaN/ZnO
three-dimensional micro-nano-architectures

In collaboration with the Institute for Materials Science, Kiel University; Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy; University of New South Wales, Sydney, Australia; State University of Moldova.

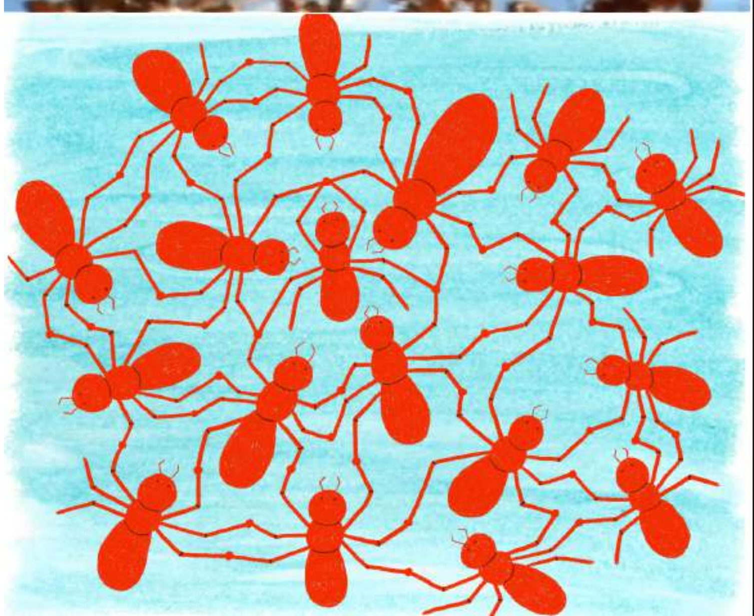
Aerogalnite

Aero-GaN

the first artificial material with dual hydrophilic/hydrophobic properties

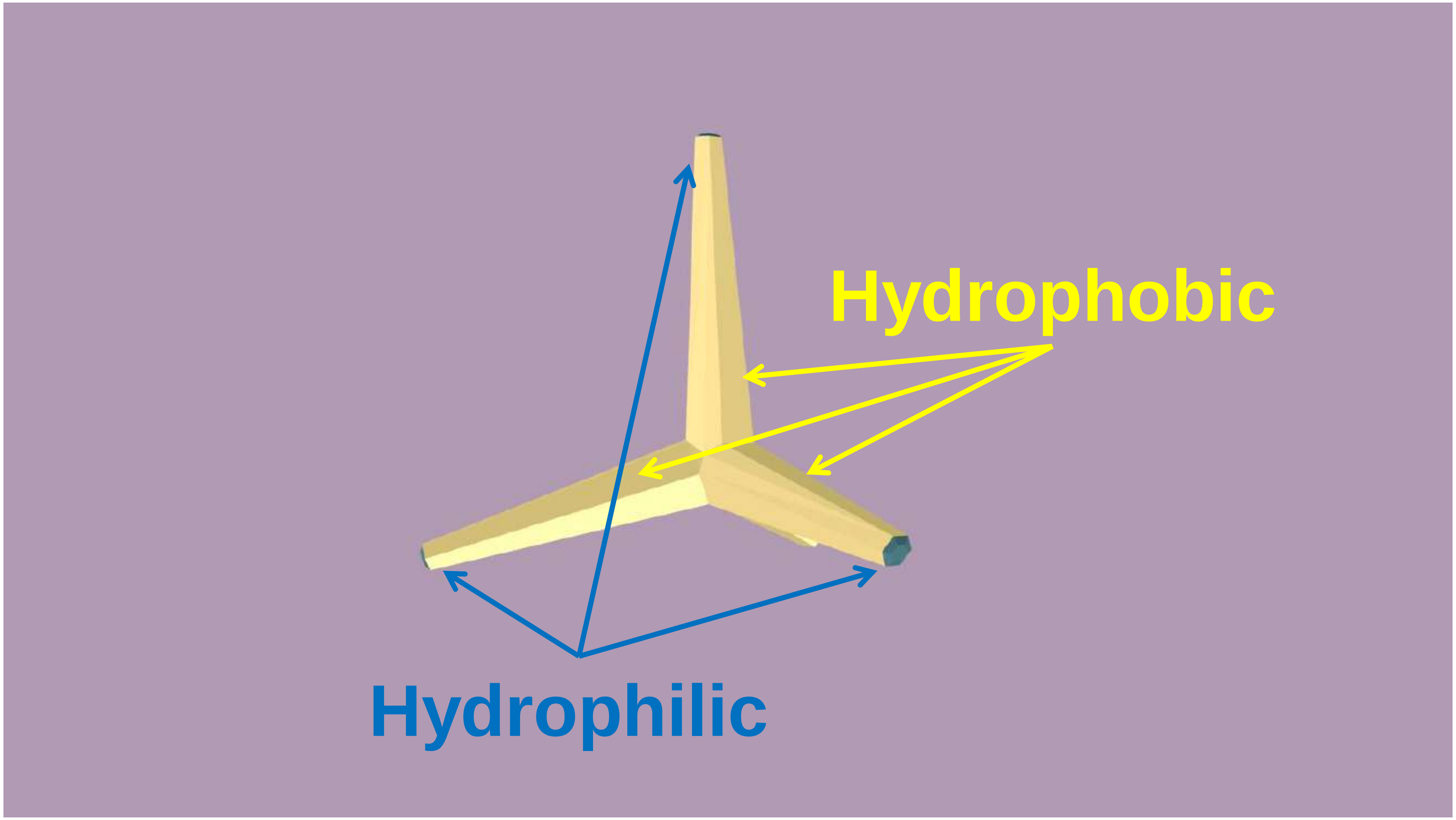
Interaction

between fire ants

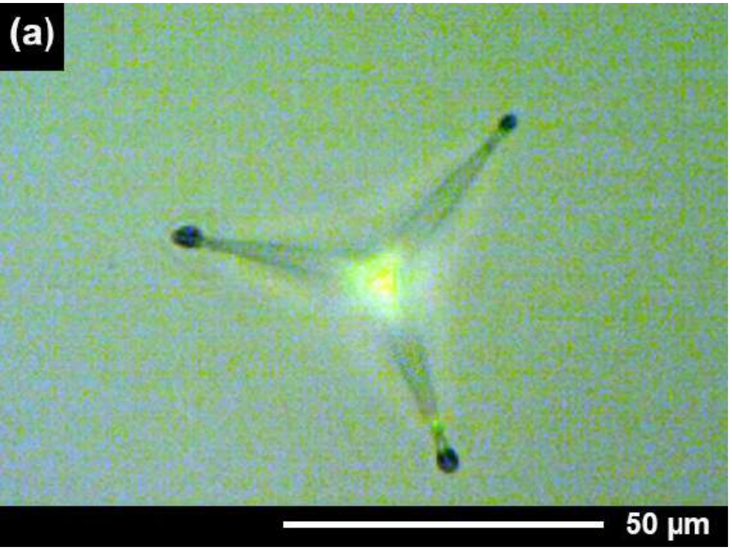


between artificial insects

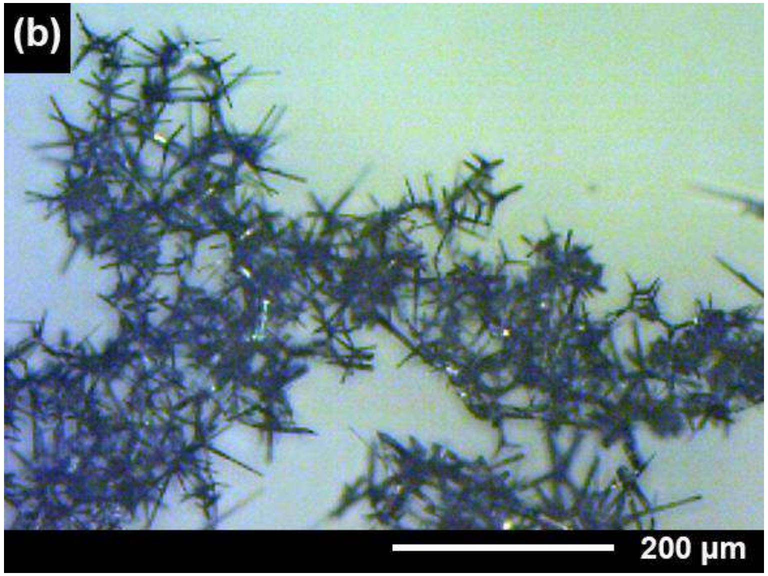
Dual hydrophilic-hydrophobic behavior



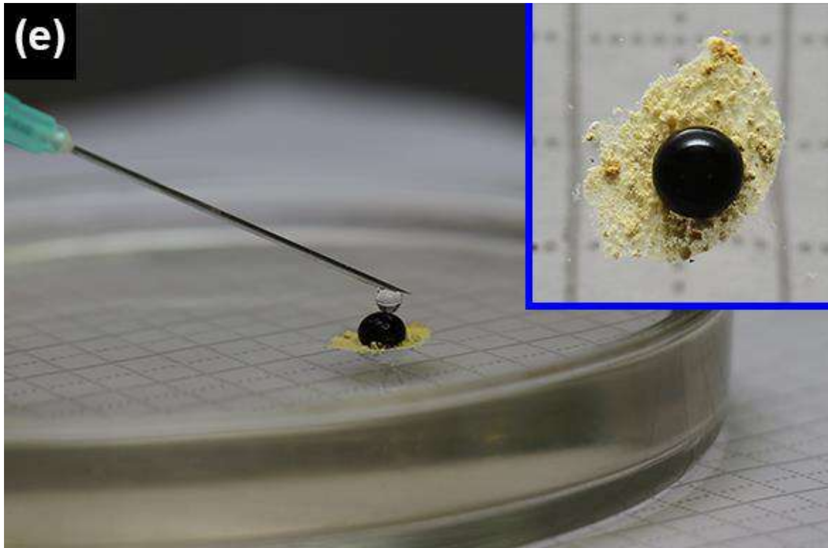
Weaving GaN/ZnO floating carpets



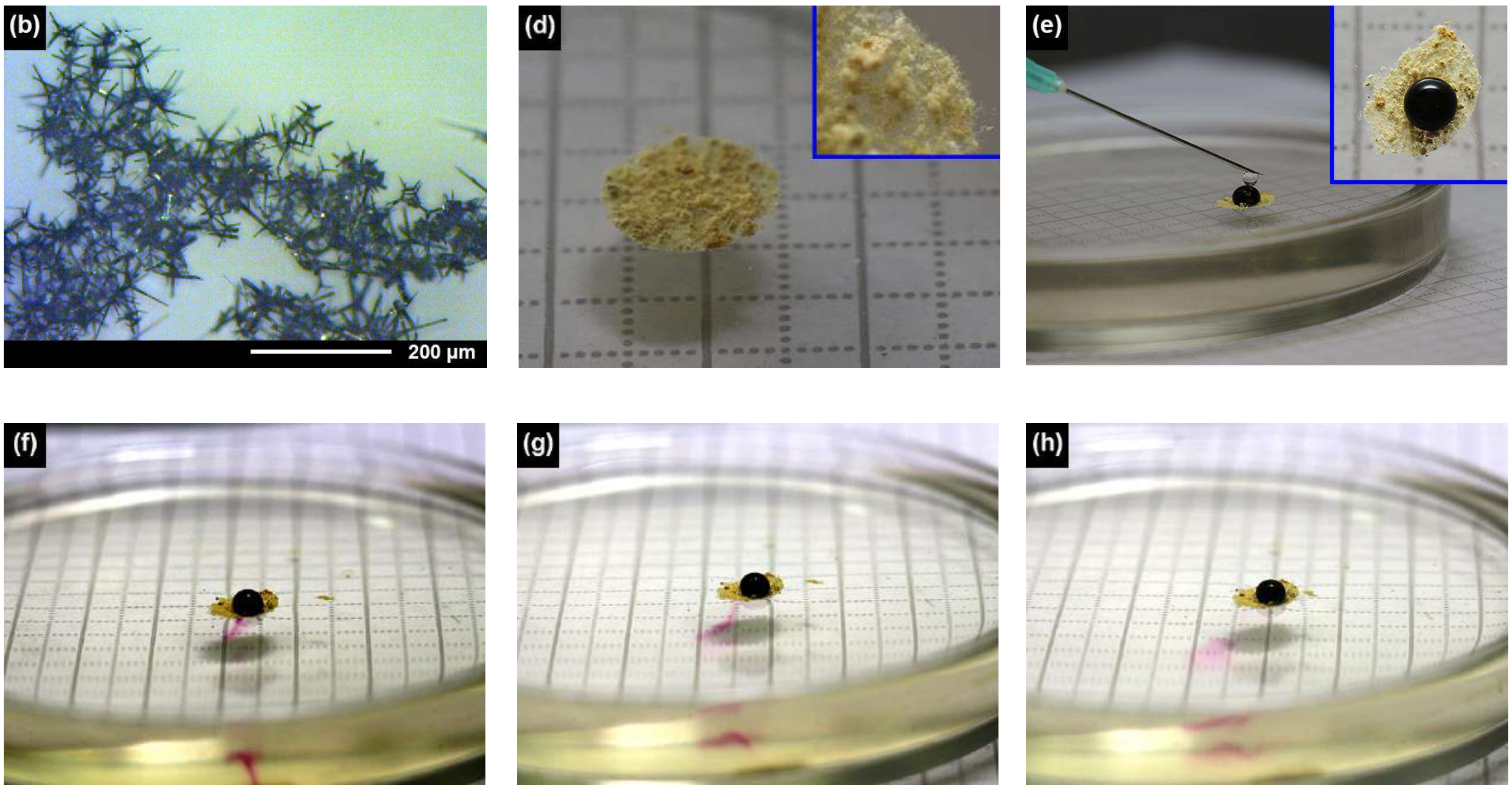
single GaN/ZnO hollow tetrapod on water surface



Interaction between many GaN/ZnO hollow tetrapods on water surface

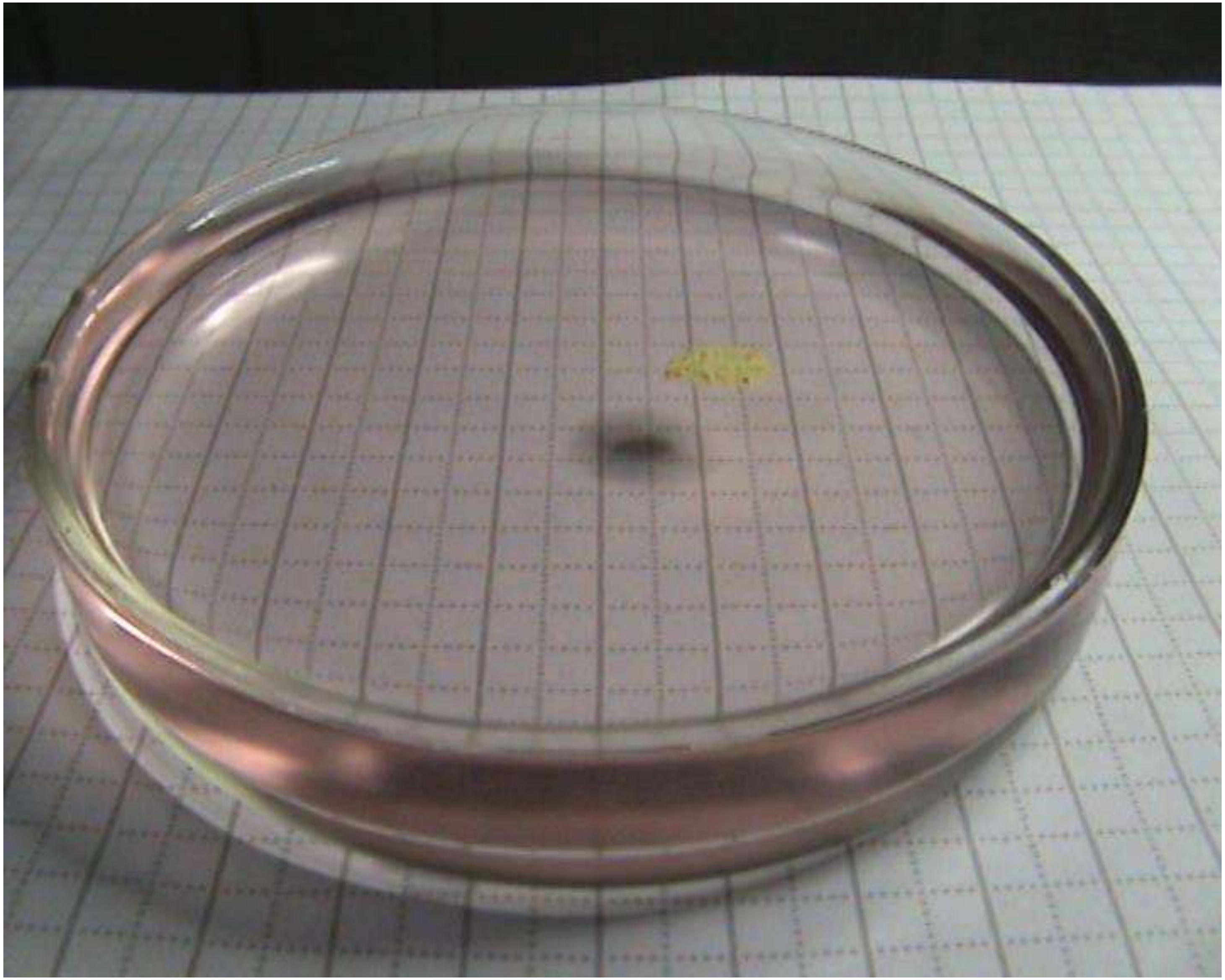


Weaving GaN floating carpets and their use as self-healing rafts

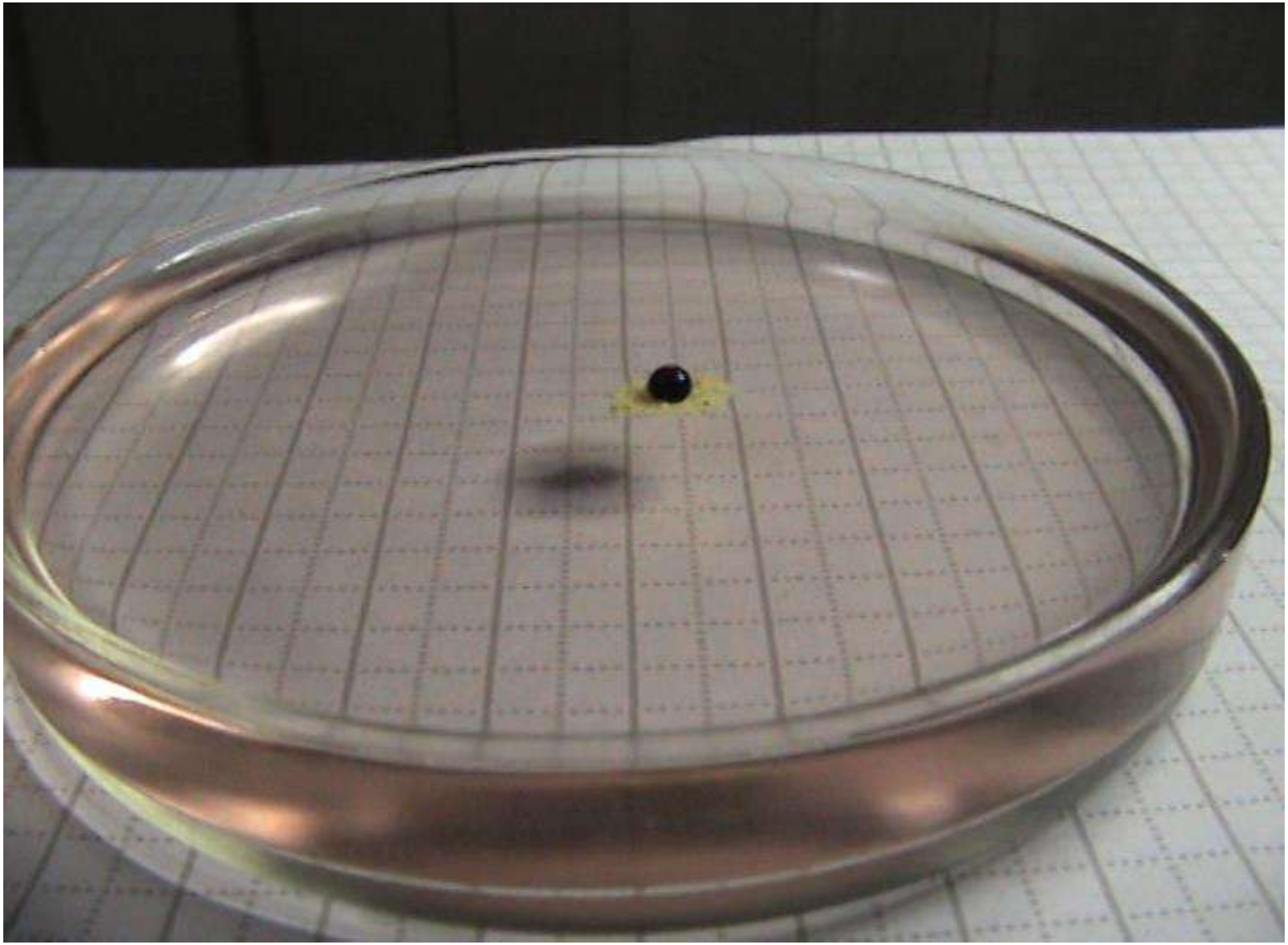


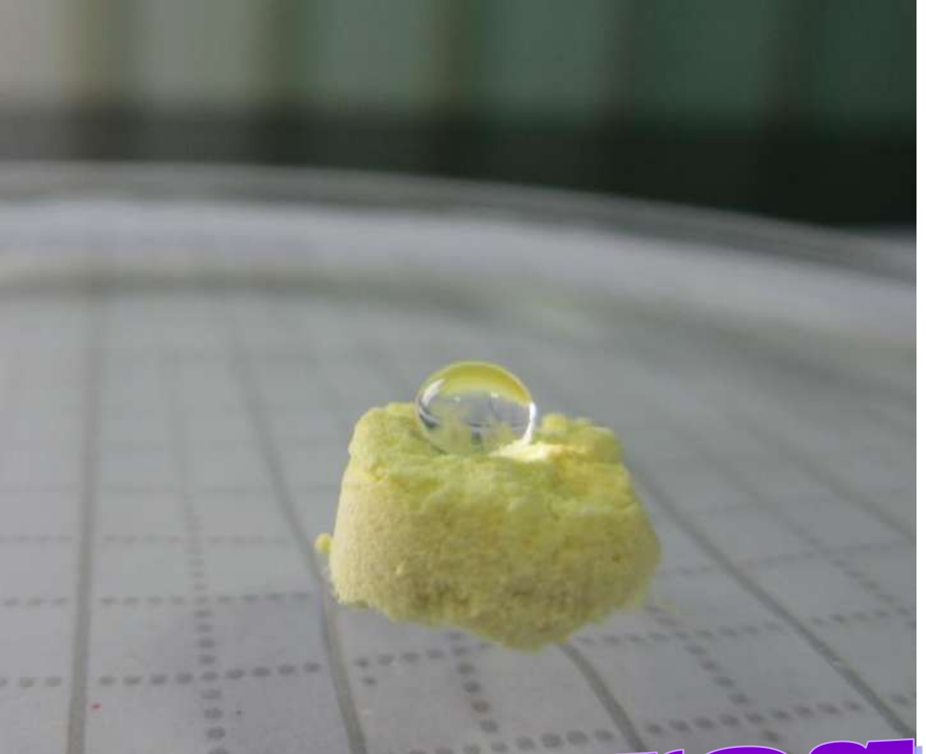
I. Tiginyanu, T. Braniste *et al*, Nano Energy, Vol. 56, pp. 759-769 (2019)

Dielectrophoretic actuation of a floating raft



Dielectrophoretic actuation of a floating raft

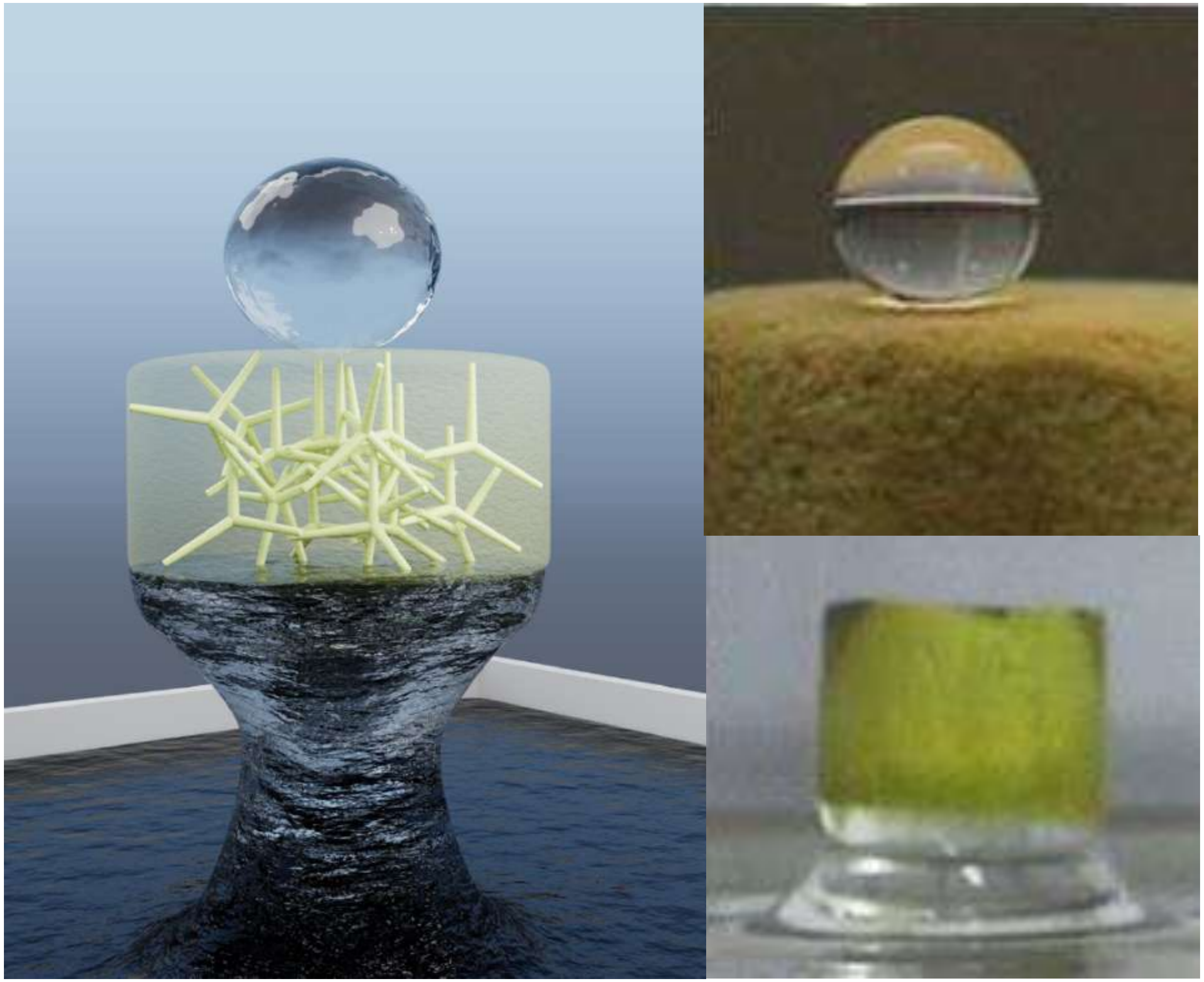




aerogalnite

Physics World

https://physicsworld.com/a/hydrophobic-or-hydrophilic-aero-gallium-nitride-is-both/

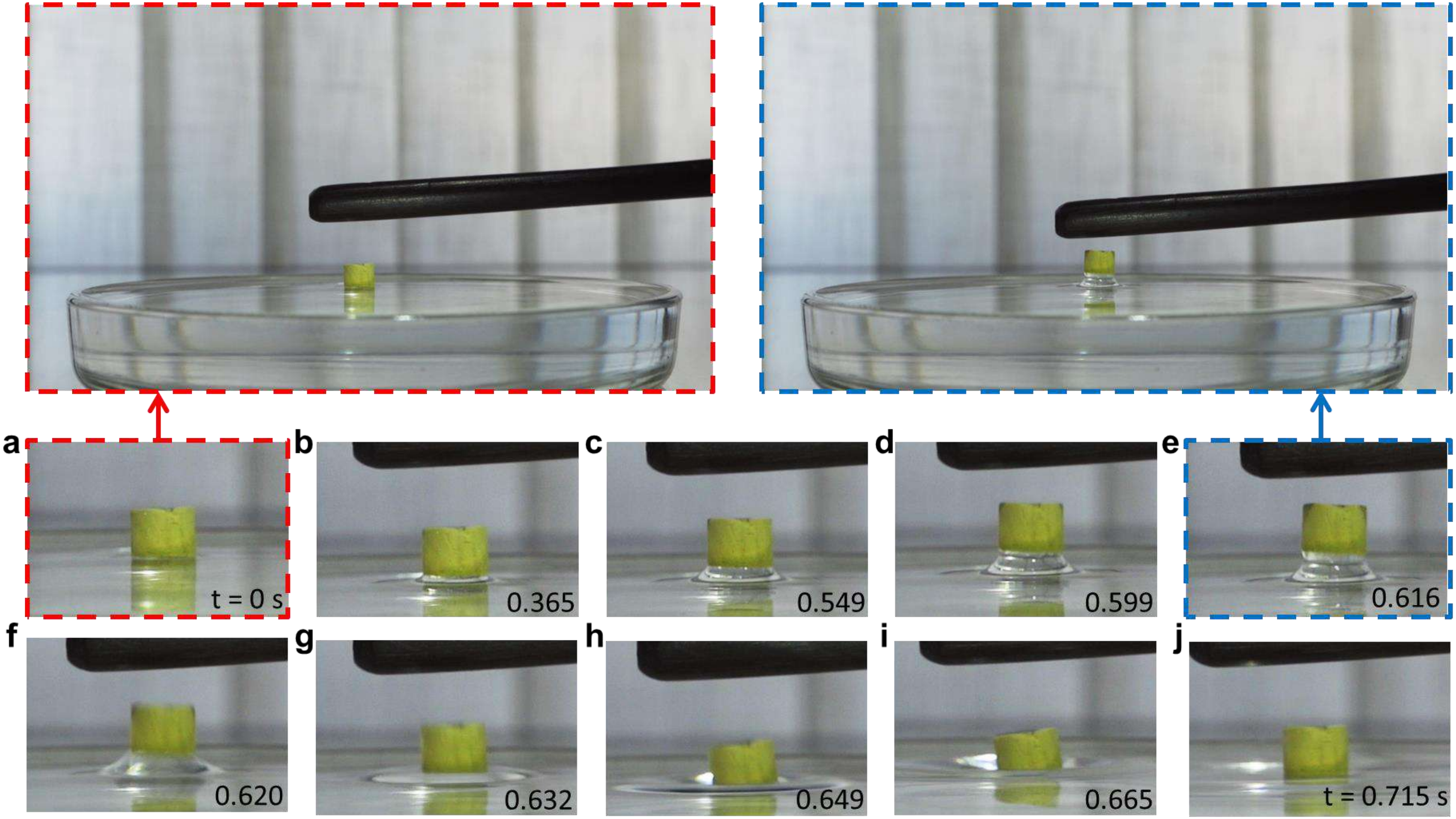


Hydrophobic wetting

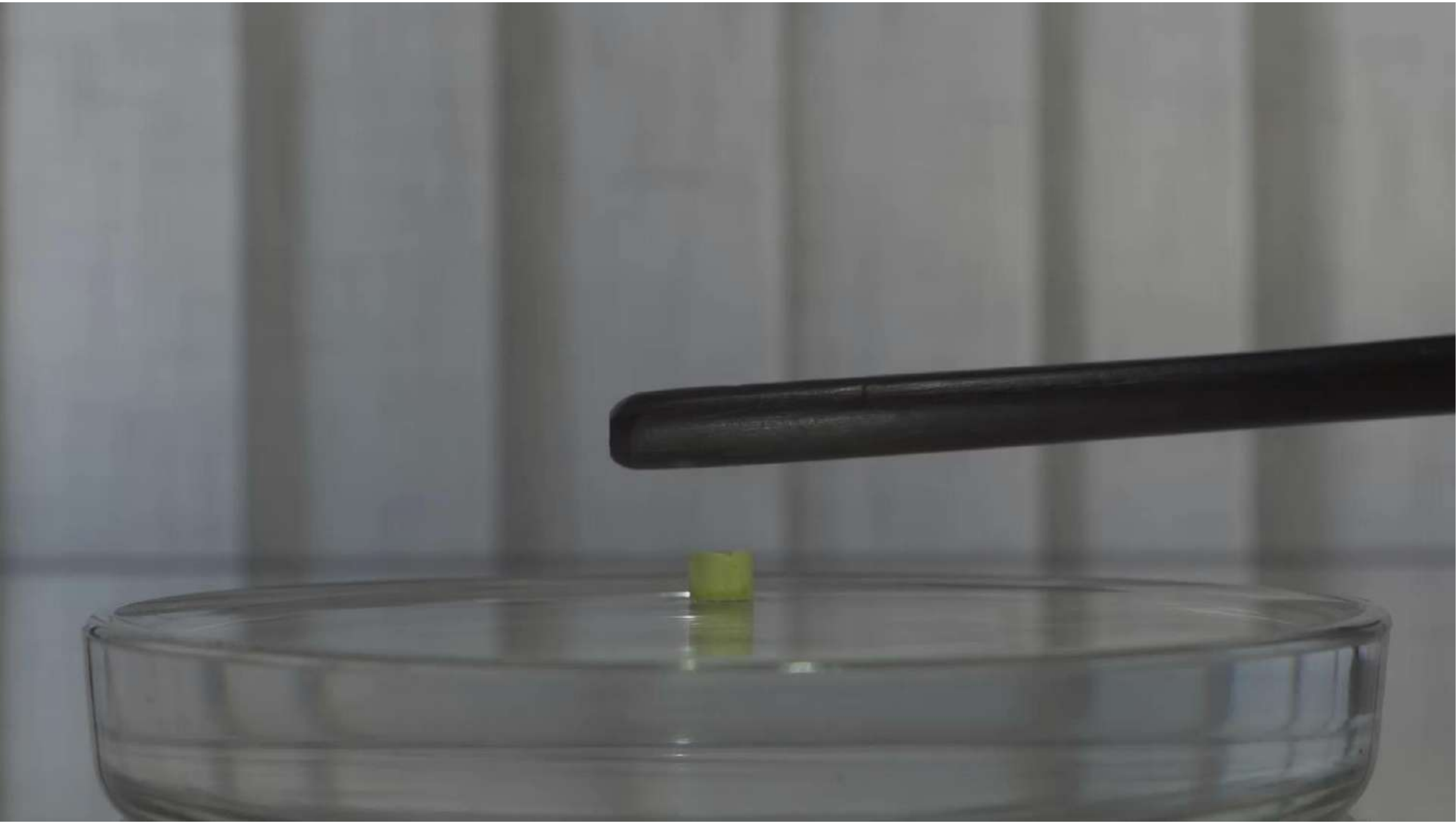
Hydrophilic dewetting

Ion Tiginyanu, Tudor Braniste, Daria Smazna, Mao Deng, Fabian Schütt, Arnim Schuchardt, Marion A. Stevens-Kalceff, Simion Raevschi, Lorenz Kienle, Nicola Puglo, Yogendra K. Mishra, Rainer Adelung, Self-organized and self-propelled aero-GaN with dual hydrophilic-hydrophobic behaviour, Nano Energy 56, 759-769 (2019).

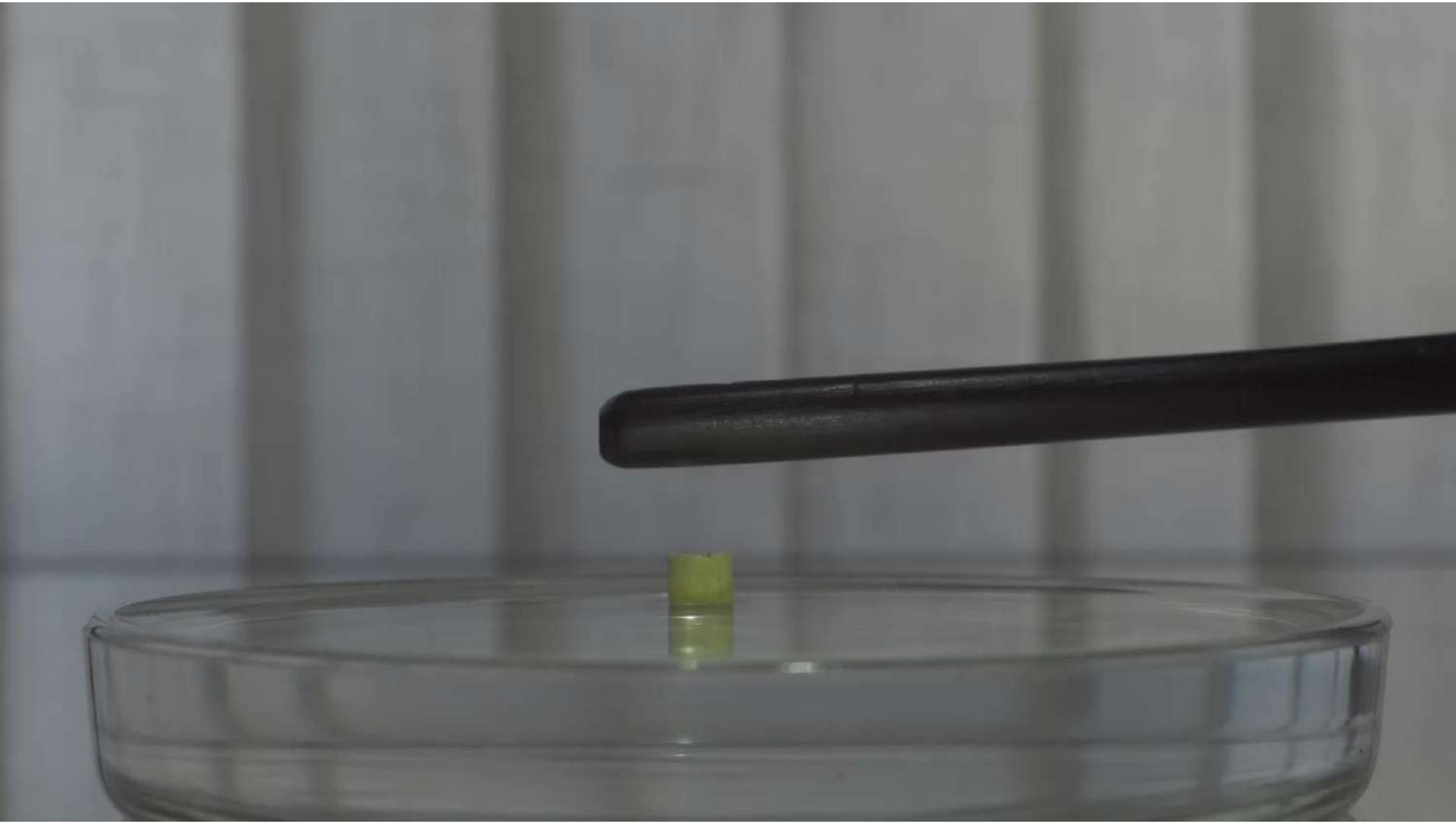
Demonstration of hydrophilic dewetting



Demonstration of hydrophilic dewetting

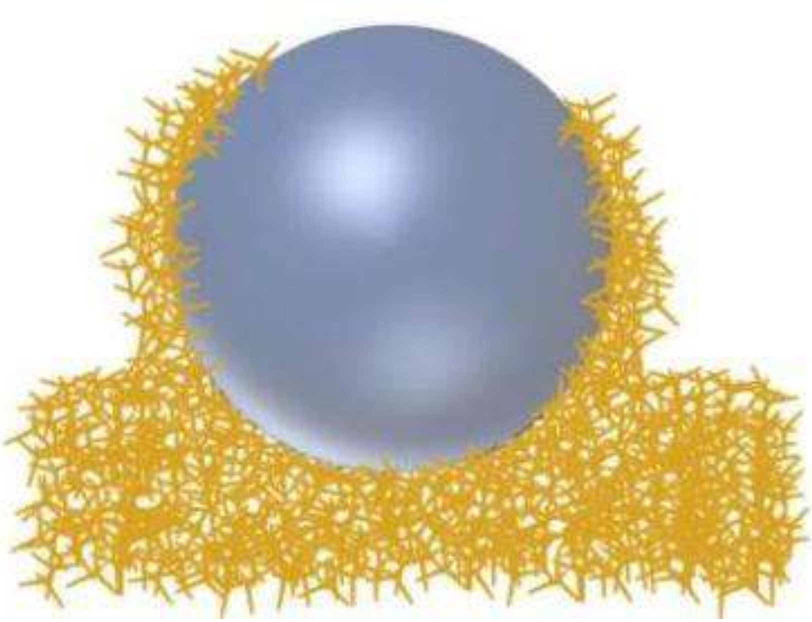


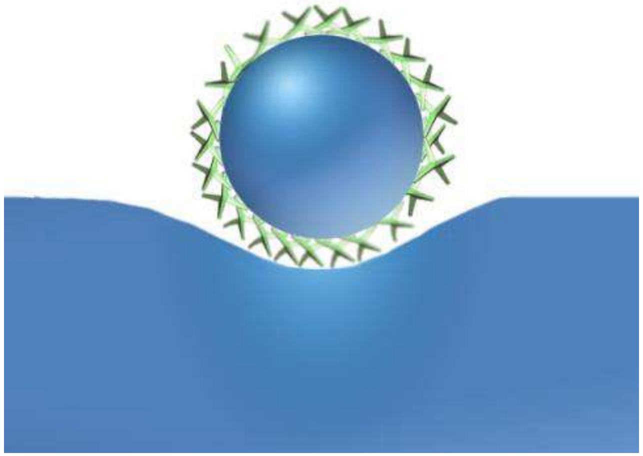
15 times slower



Self-propelled liquid marbles based on aero-GaN

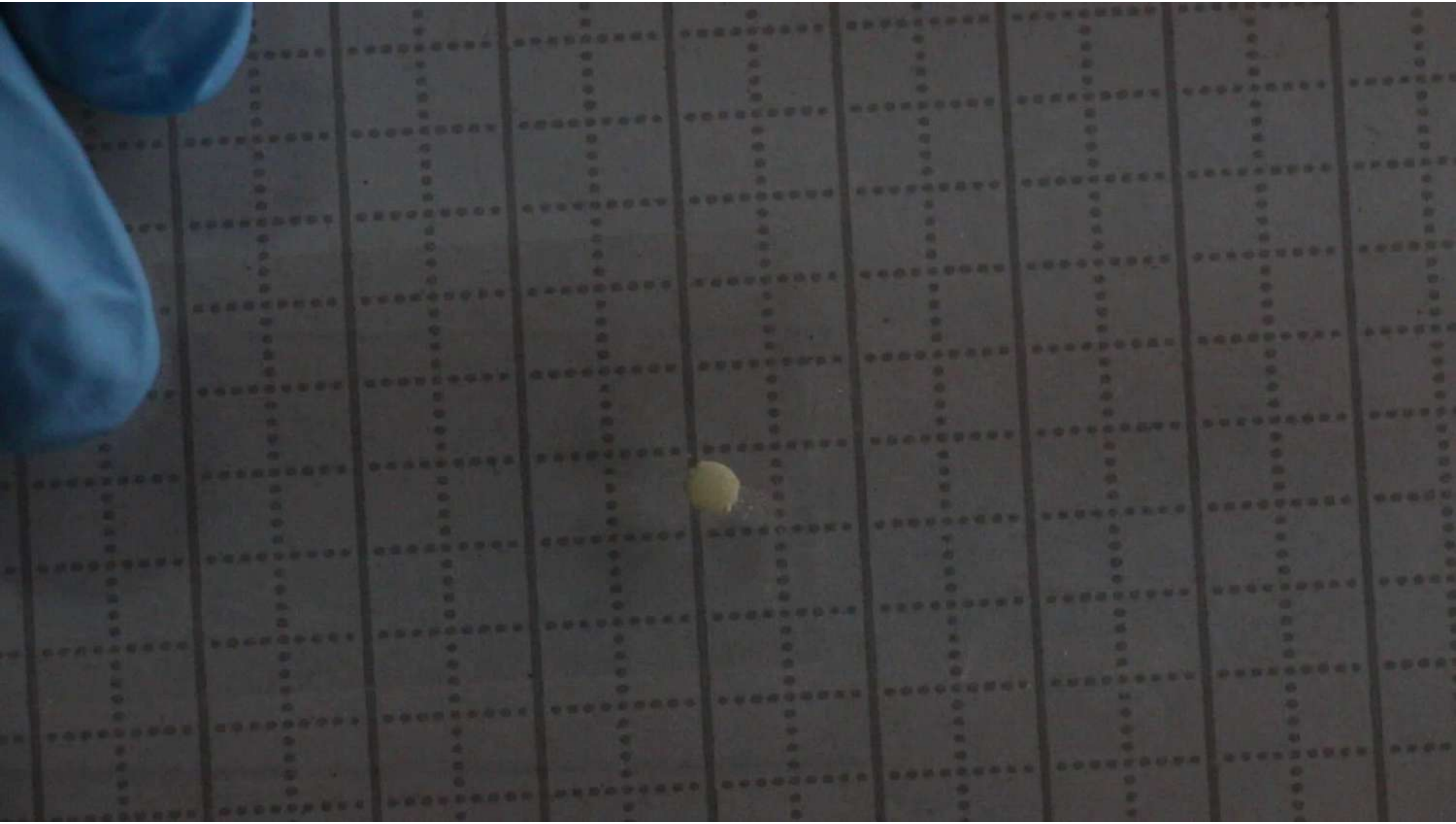
Aerogalnite liquid marbles





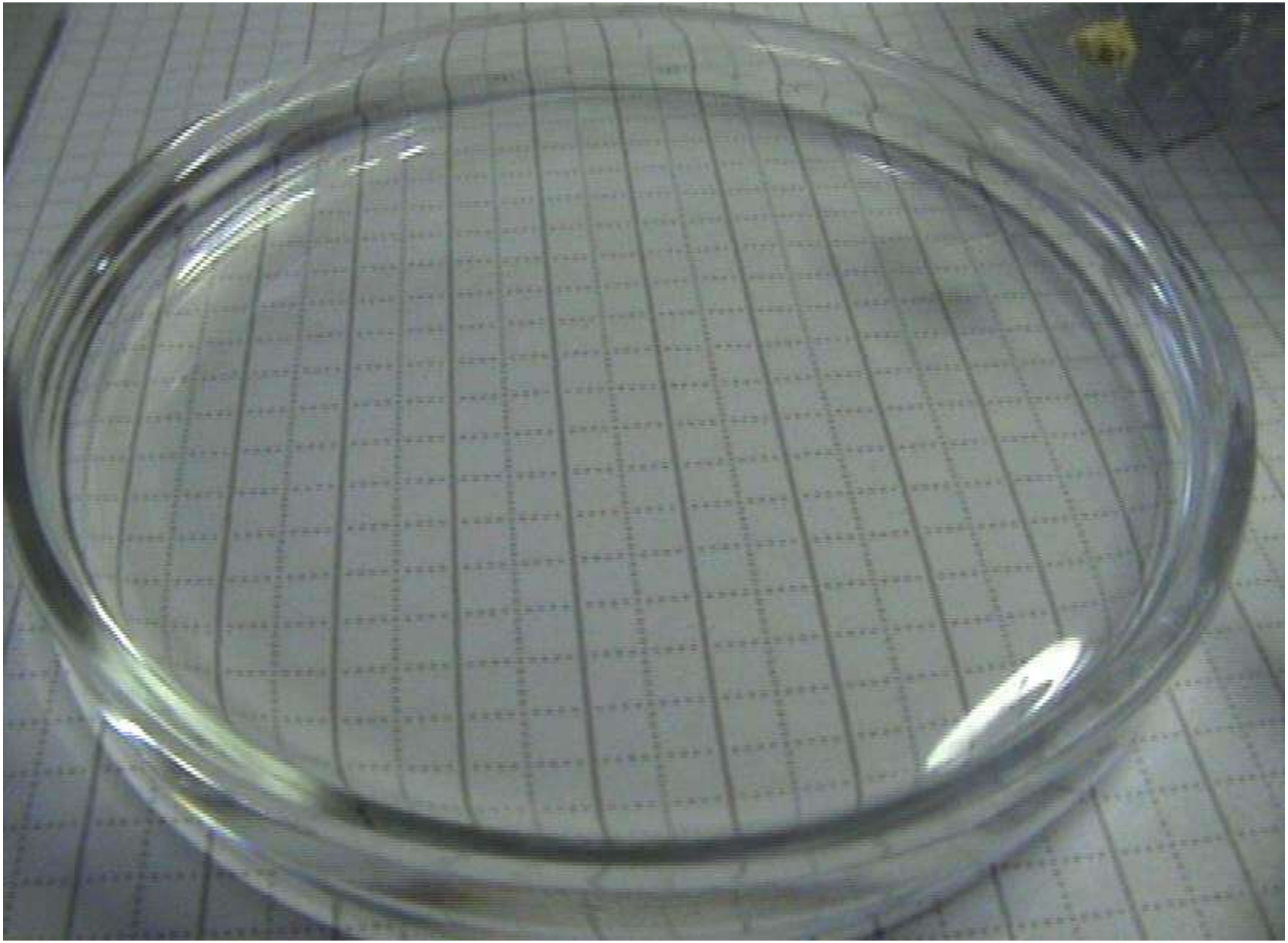
Ion Tiginyanu, Tudor Braniste, Daria Smazna, Mao Deng, Fabian Schütt, Arnim Schuchardt, Marion A. Stevens-Kalceff, Simion Raevschi, Lorenz Kienle, Nicola Puglo, Yogendra K. Mishra, Rainer Adelung, Self-organized and self-propelled aero-GaN with dual hydrophilic-hydrophobic behaviour, Nano Energy 56, 759-769 (2019).

Mechanical stability of consolidated liquid marble

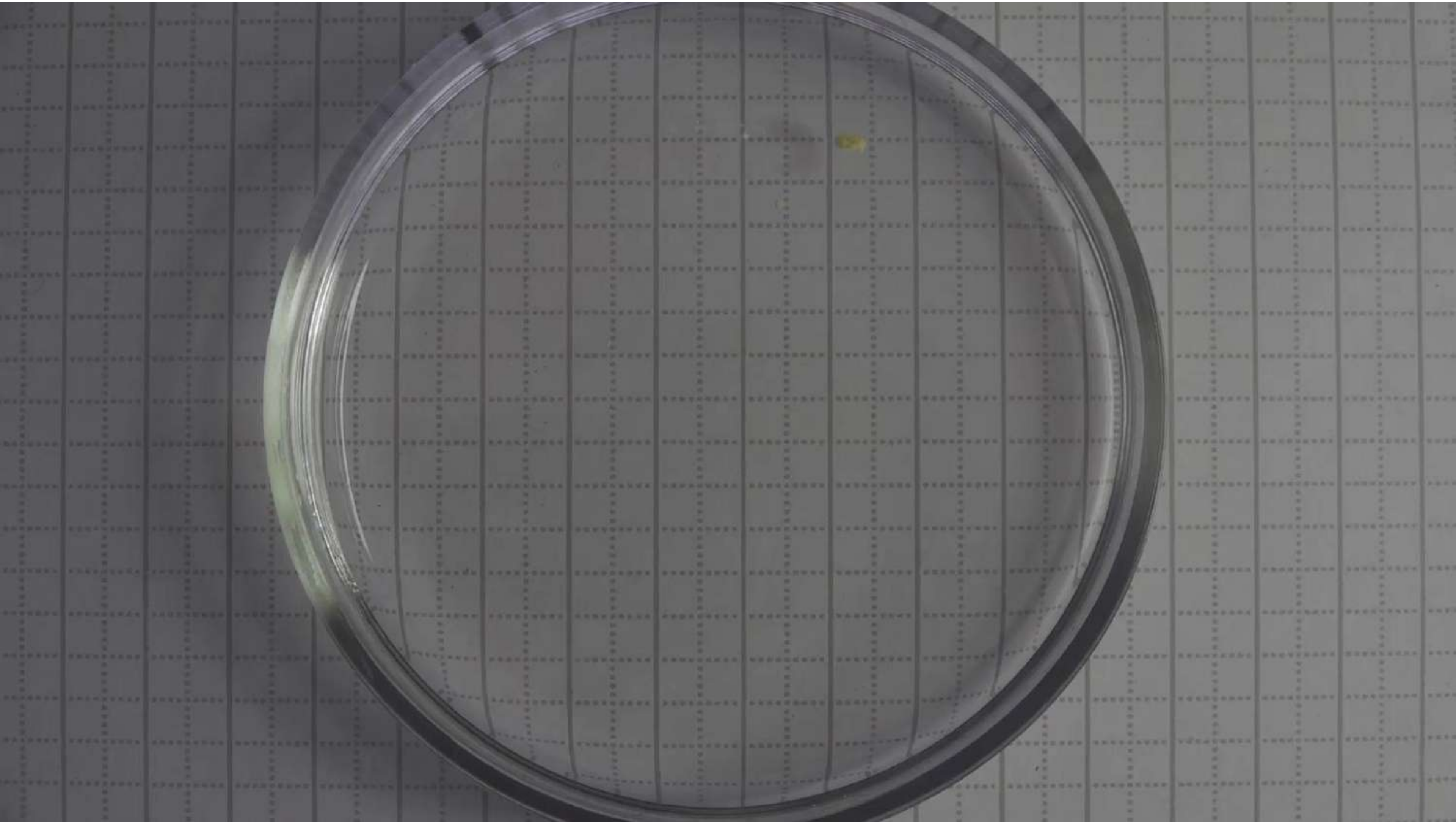


They survive e.g. on the surface of water subjected to intense ultrasonic treatment.

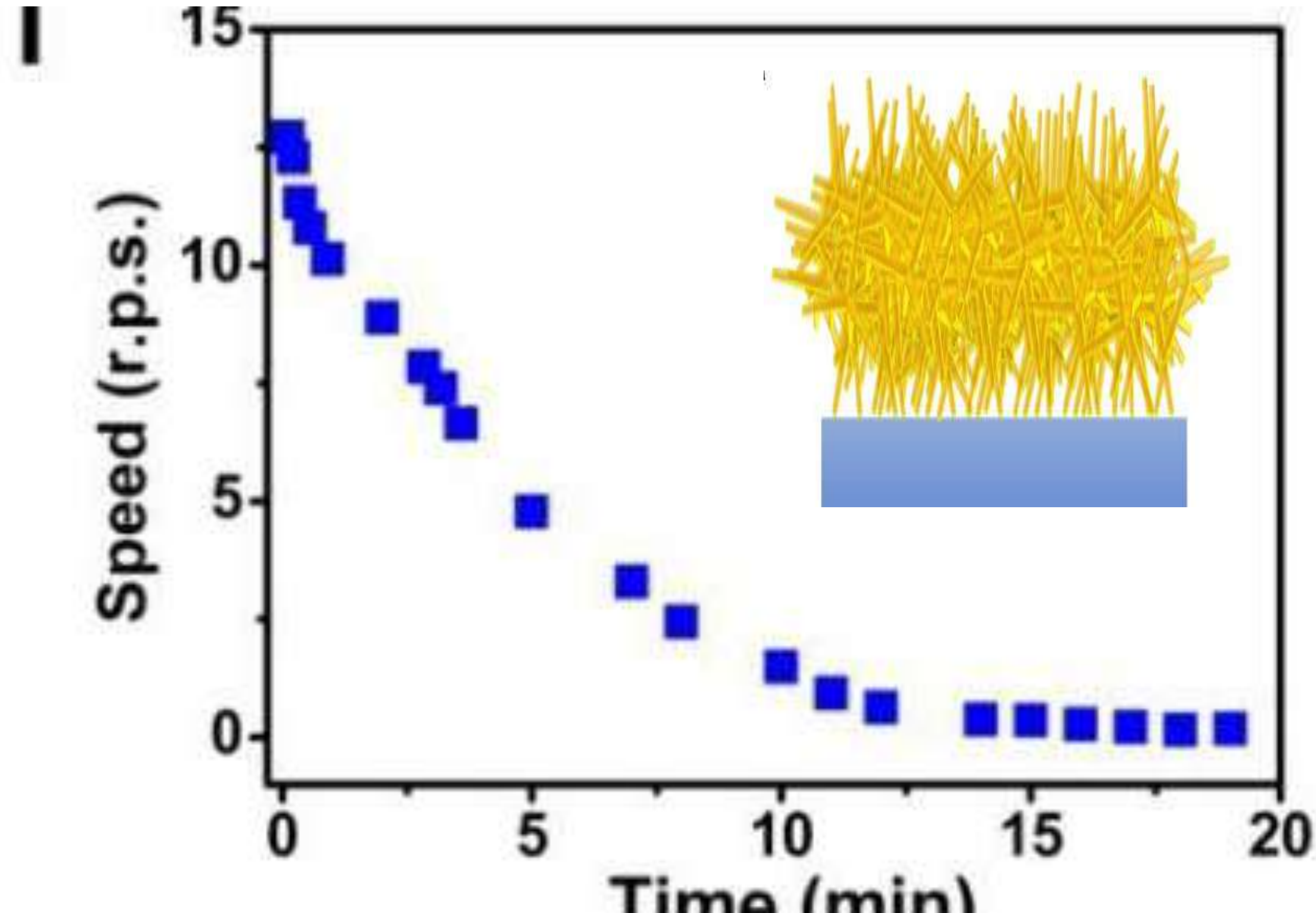
Rectilinear movement of liquid marble



Rotating liquid marble
(stationary rotation)



Rotation of liquid marbles

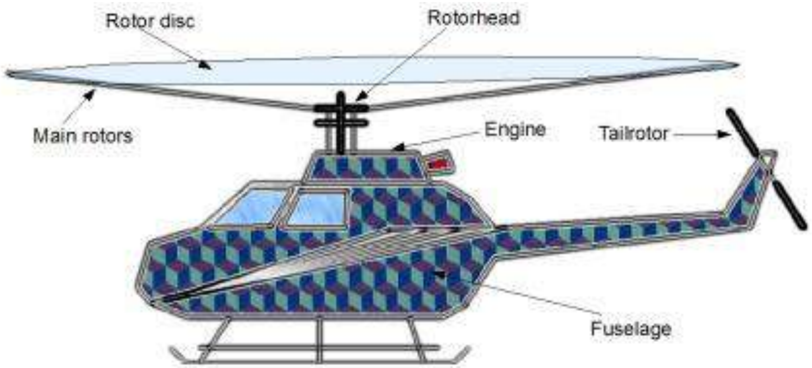


Flying water lily beetle

tethered to the water by four hydrophilic claws

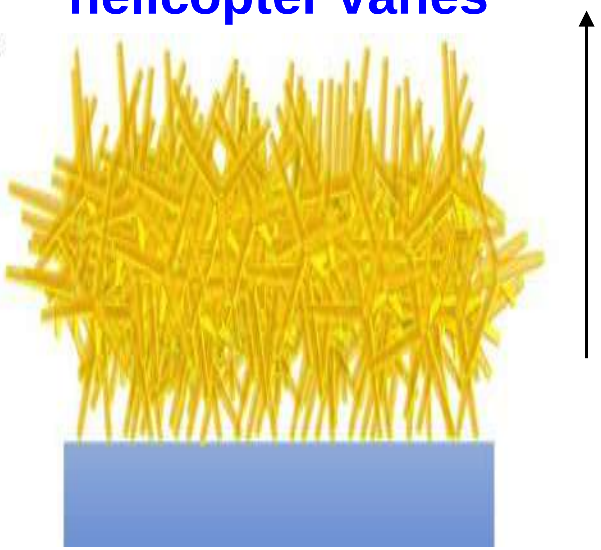
Science, 2014

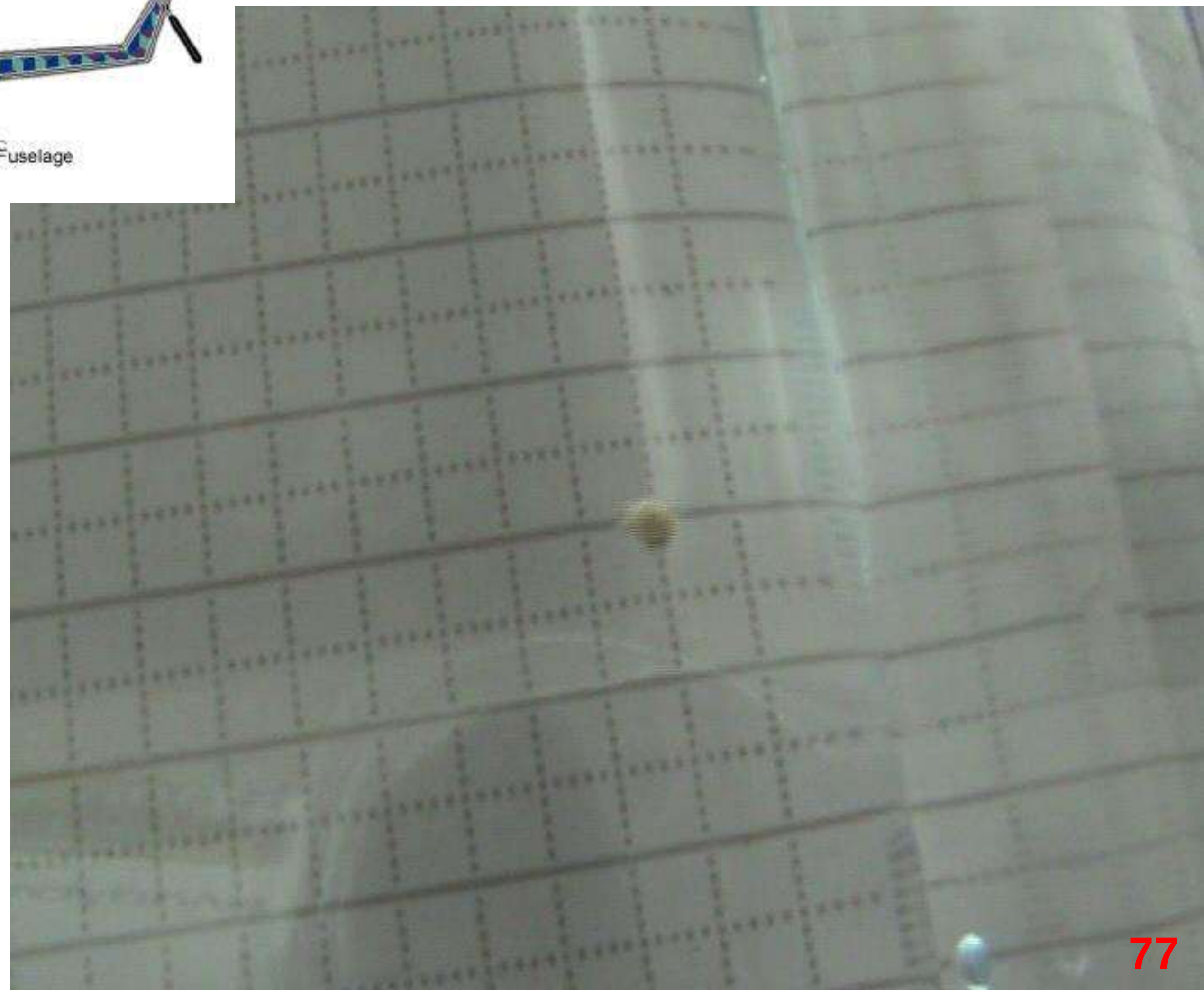
Liquid marble rotating in pulses



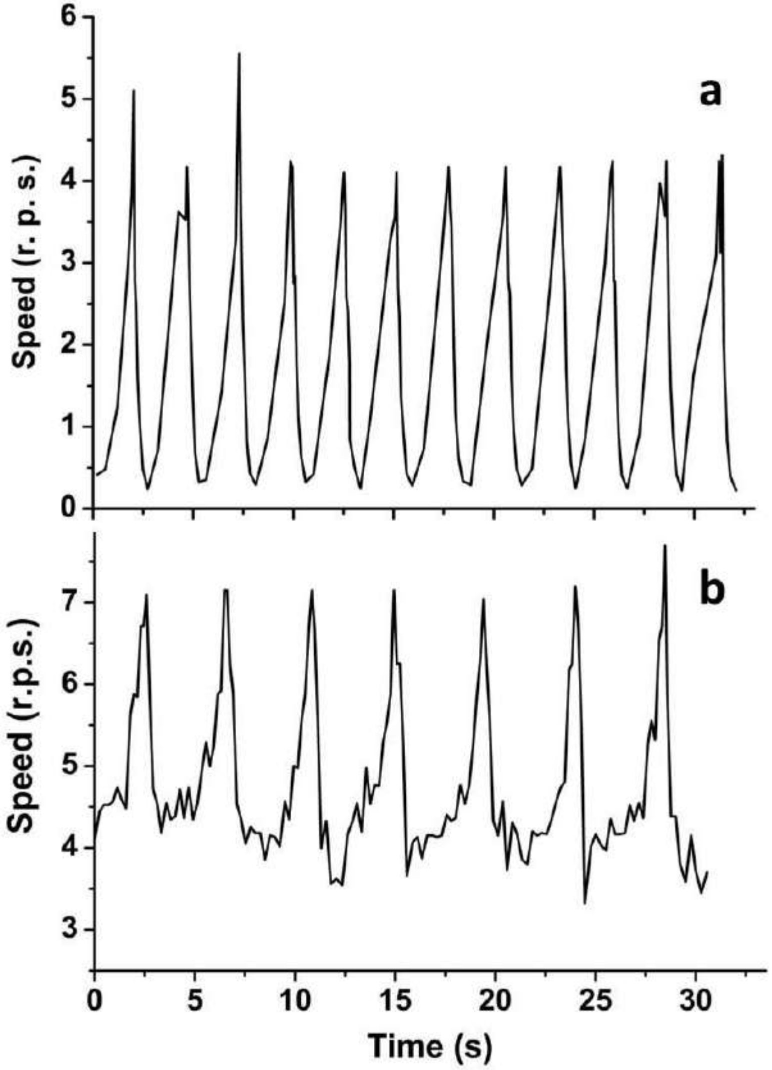
Helicopter effect

Some arms of tetrapods play the role of helicopter vanes





Time dependence of the speed of pulsed rotation for liquid marbles with different weights



6.5 mg

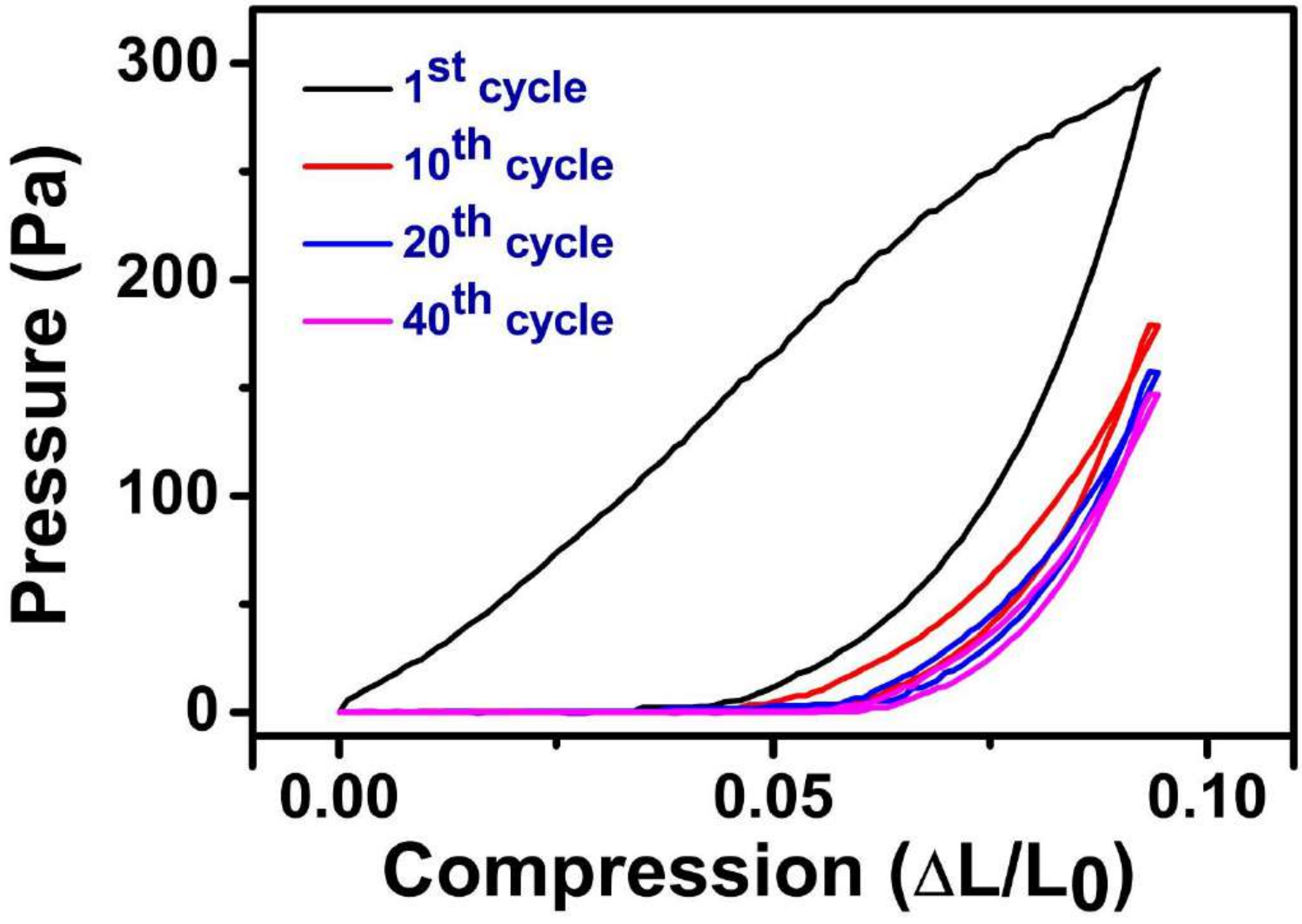
14.5 mg

T. Braniste et al, Self-propelled aero-GaN based liquid marbles exhibiting pulsed rotation on the water surface, *Materials*, Vol. 14, no 7, 5086 (2021).

Applications of Aero-GaN

In collaboration with the Institute of Microtechnologies, Bucharest, Romania; Moscow Institute of Physics and Technology, Russia; Institute for Materials Science, Kiel University, Germany; State University of Moldova; University of Bucharest, Romania.

Elastic behavior of aerogalnite after many loading-unloading cycles

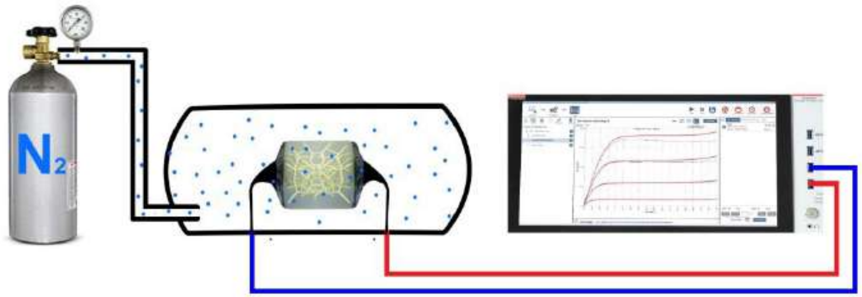


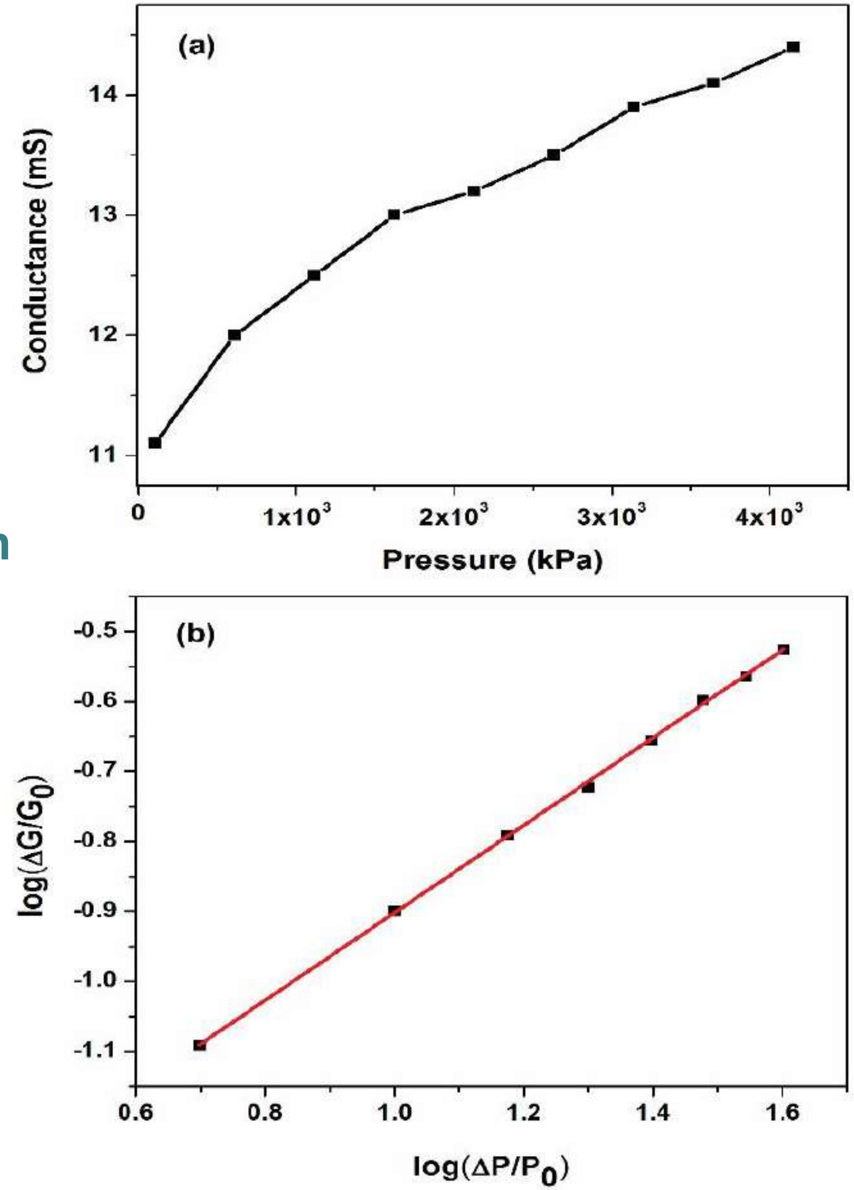
Compressive stress – strain response of the Aerogalnite architecture under cyclic loading and unloading

Dielectrophoretic actuation of aerogalnite

Pressure sensors based on Aero-GaN

Pressure sensor up to 40 atm based on Aerogalnite





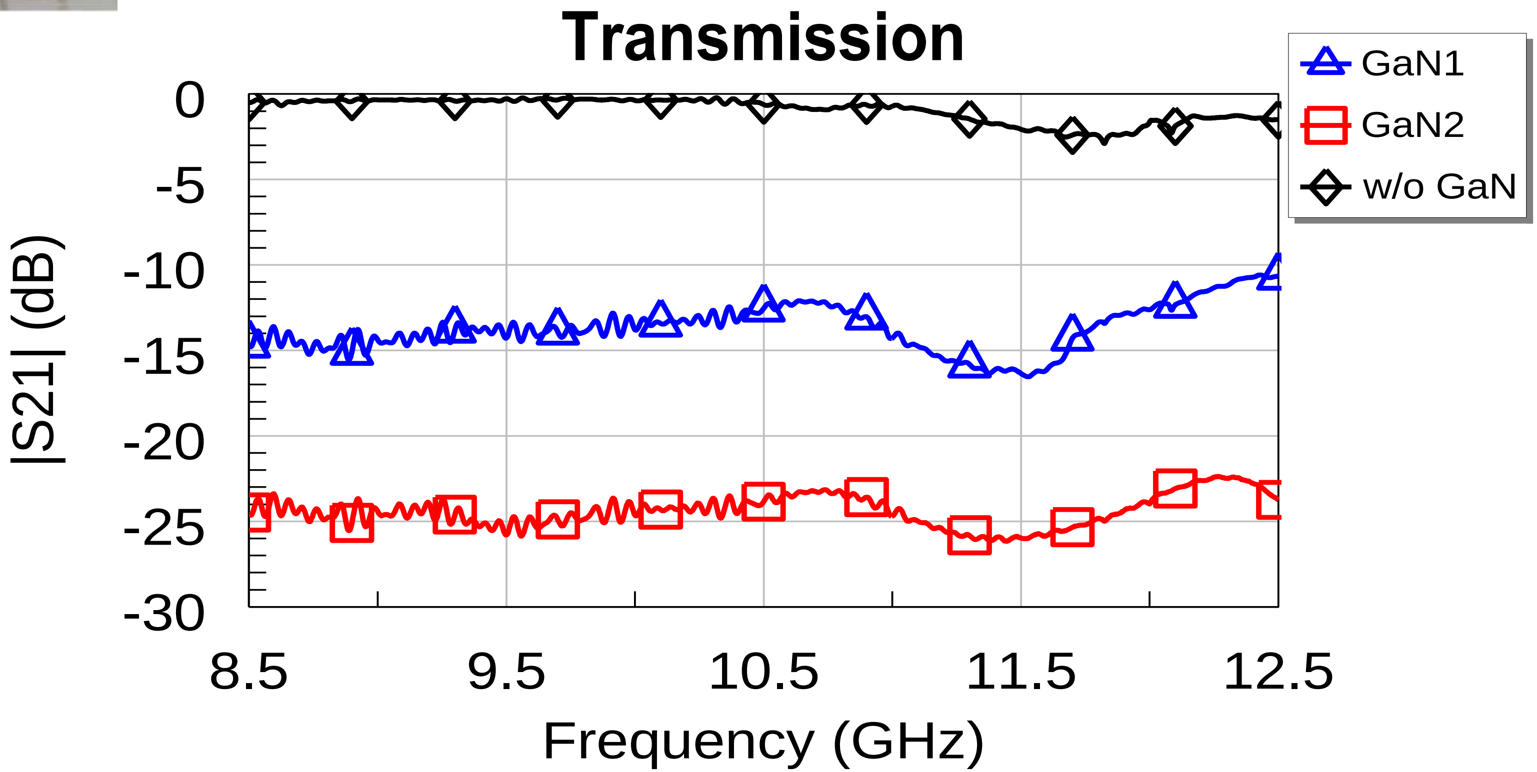
High sensitivity (16.2×10^{-3} at 5 atm and 7.4×10^{-3} at 40 atm) in conjunction with high currents of tens of milliamperes makes GaN aeromaterial feasible for exploitation in portable electrical equipment.

M. Dragoman, V. Ciobanu, S. Shree, D. Dragoman, Tudor Braniste, Simion Raevschi, Adrian Dinescu, Andrei Sarua, Yogendra K. Mishra, Nicola Pugno, Rainer Adelung, Ion Tiginyanu. Sensing up to 40 atm using pressure-sensitive aero-GaN.
***Physica Status Solidi – Rapid Research Letters*, V. 13, no 6, 1900012 (2019).**

Shielding in X-band (8-12 GHz) with Aero-GaN

Shielding in X-band with aero-GaN

X-band is important since most of radars work in this band and it is also allocated for terrestrial and space communications

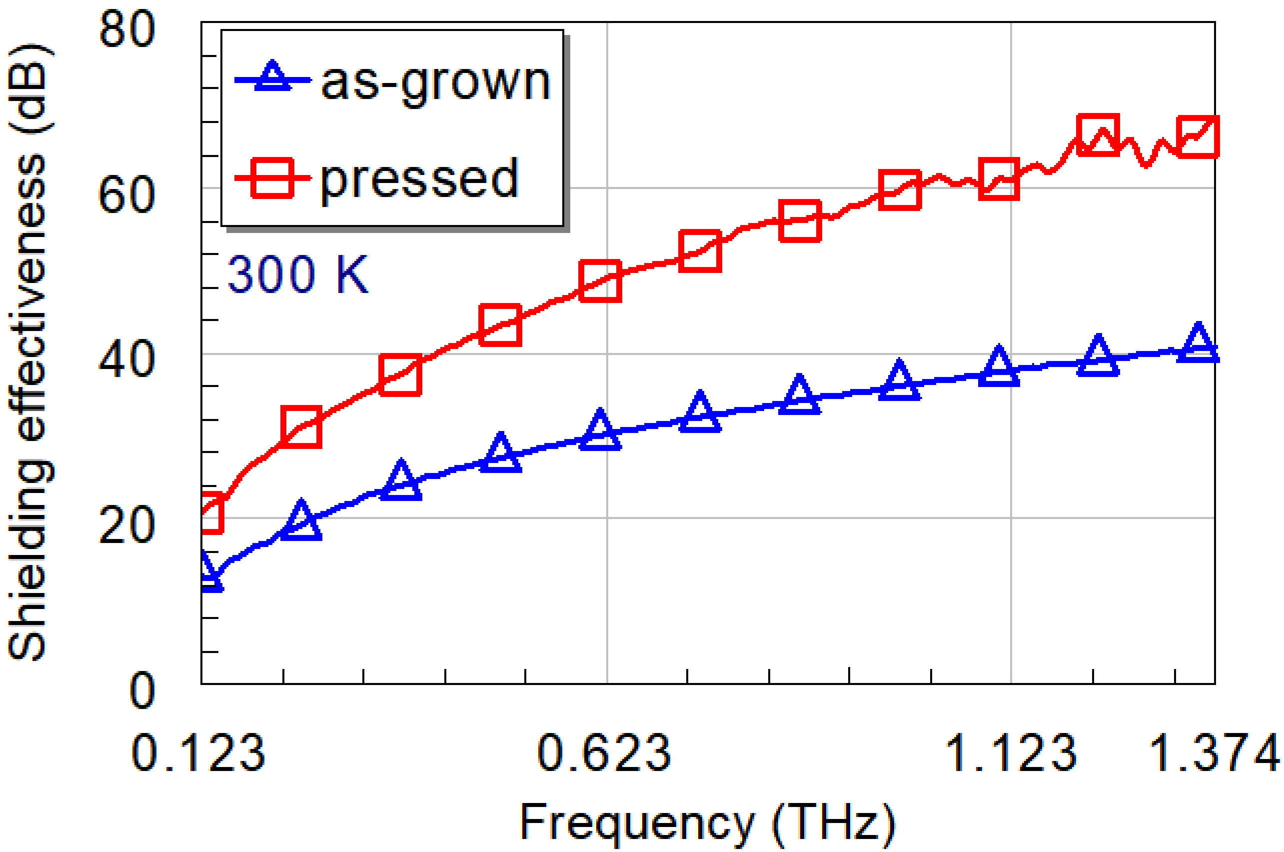


Two samples GaN1 and GaN2: Dimensions 24x12x2 mm^3, porosities 97 and 98.5 %, densities 0.185 g/cm^3 and 0.089 g/cm^3

M. Dragoman, T. Braniste, S. Iordanescu, M. Aldrigo, S. Raevschi, S. Shree, R. Adelung, I. Tiginyanu, Electromagnetic interference shielding in X-band with aero-GaN. Nanotechnology, Vol. 30, 34LT01 (2019).

GaN for Terahertz technology

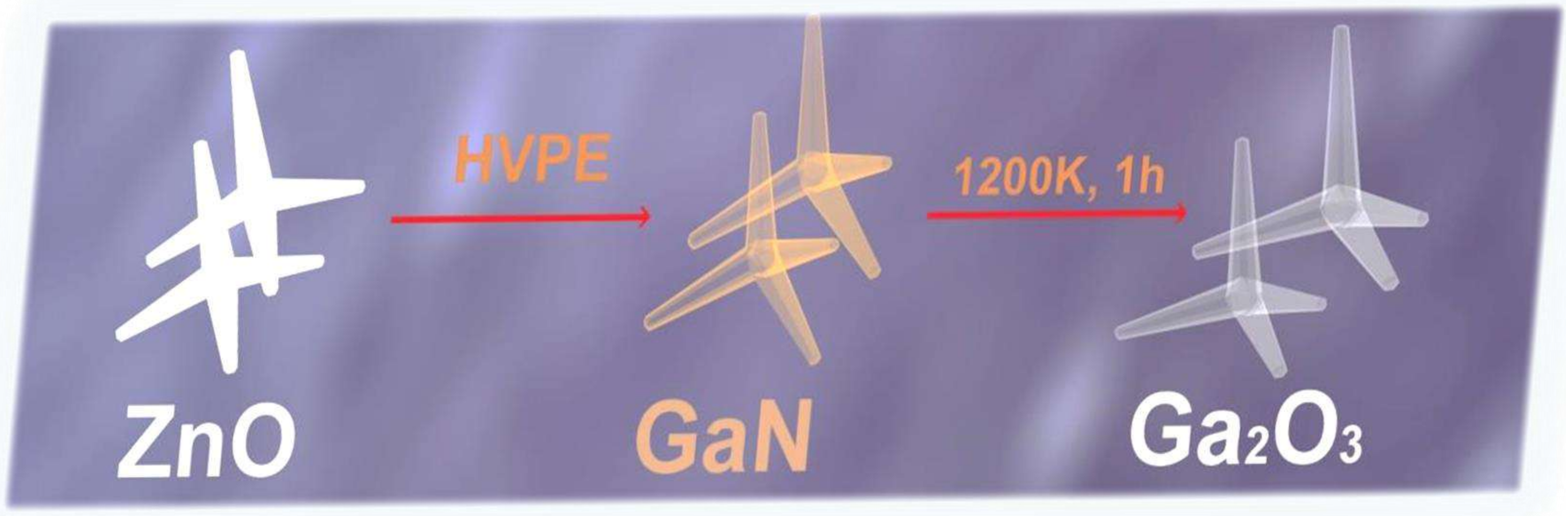
Terahertz shielding properties of aero-GaN



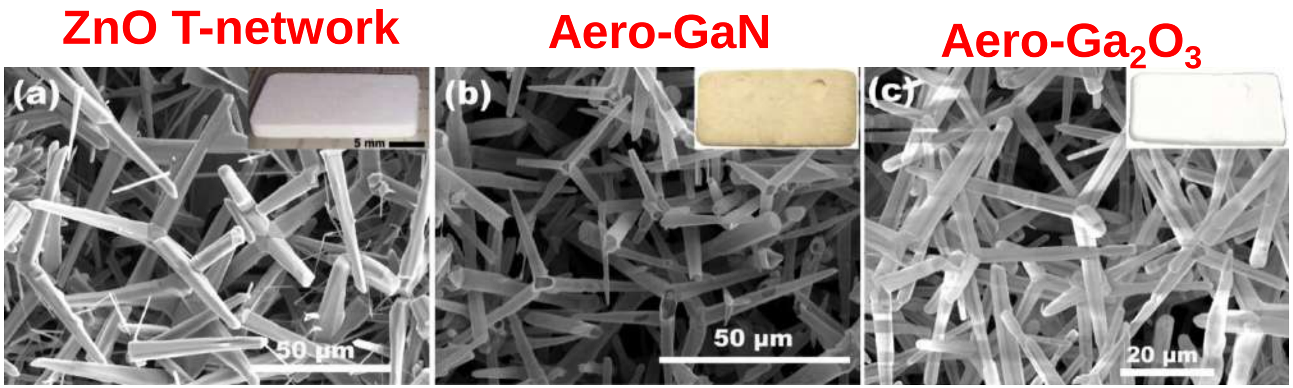
Shielding effectiveness of pressed aero-GaN exceeds 40 dB in the range 0.25-1.37 THz being among the best THz shields known today. The value of 40 dB is required for industrial applications and is fulfilled in the frequency bandwidth of 1.12 THz.

Tudor Braniste , Sergey Zhukov, Mircea Dragoman, Liudmila Alyabyeva, Vladimir Ciobanu, Martino Aldrigo, Daniela Dragoman, Sergiu Iordanescu, Sindu Shree, Simion Raevschi, Rainer Adelung, Boris Gorshunov, Ion Tiginyanu. **Terahertz shielding properties of aero-GaN**, **Semiconductor Science and Technology 34, 12LT02 (2019).**

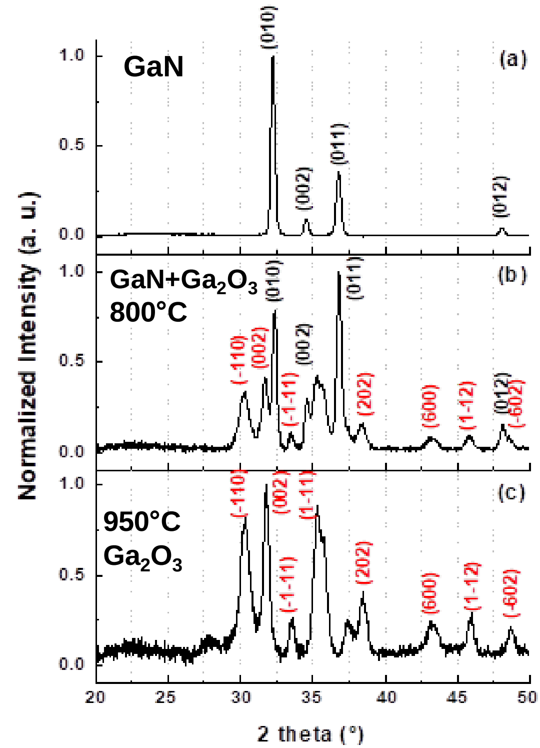
Aero-Ga_2O_3 (Aerogallox)



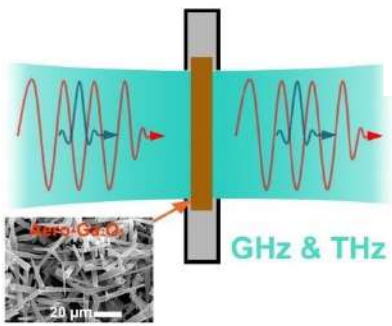
Aerogallox (Aero-Ga_2O_3) – Nanomaterial Electromagnetically Transparent from Microwaves to Terahertz

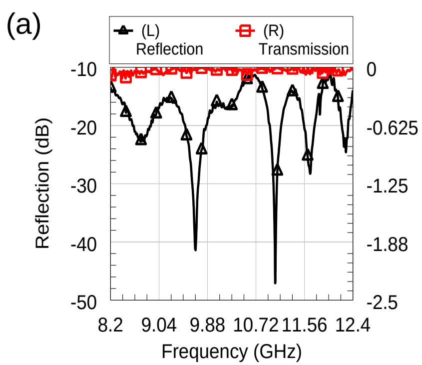


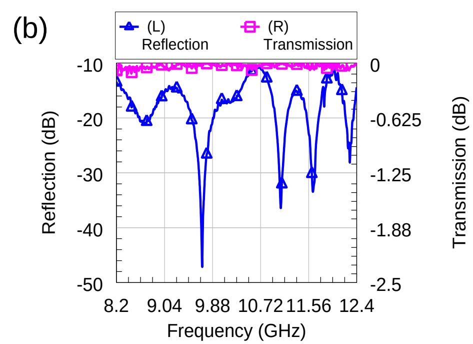
SEM images of (**a**) initial ZnO template, (**b**) intermediate aero-GaN, and (**c**) resulted aero-Ga2O3 nanomaterial. The inset pictures represent the photographs of the pellet samples of ZnO, GaN, and Ga2O3 respectively



XRD spectra of aero-GaN (**a**), mixture of GaN and Ga_2O_3 phases (**b**) and aero-Ga_2O_3 (**c**).



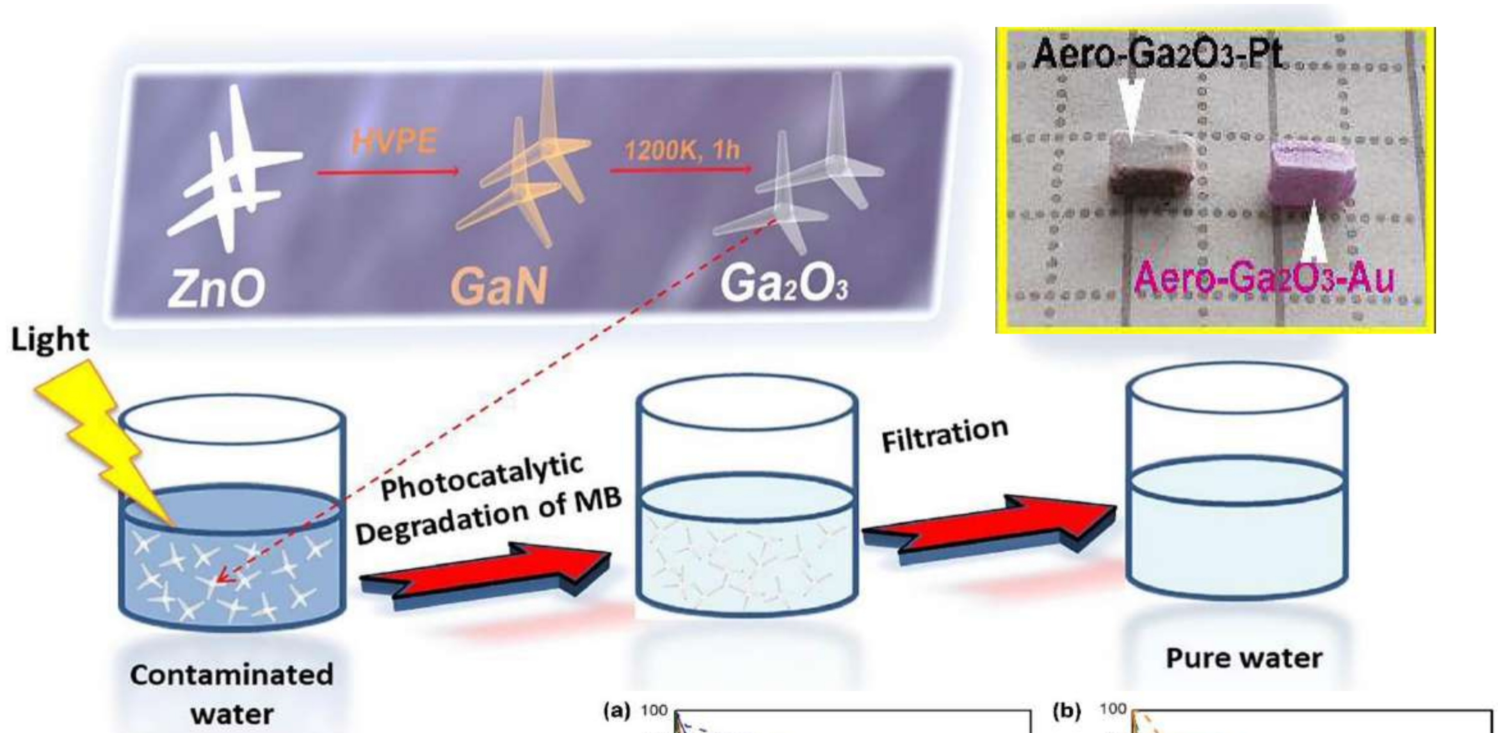


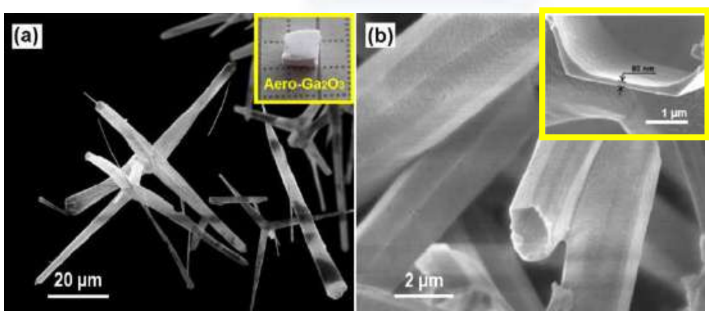


Microwave measurements in X-band for the two cases: (**a**) without the aero-Ga_2O_3 pellet and (**b**) with the aero-Ga_2O_3 pellet, in terms of reflection (left vertical axis, solid black and blue curves) and transmission (right vertical axis, solid red and pink curves).

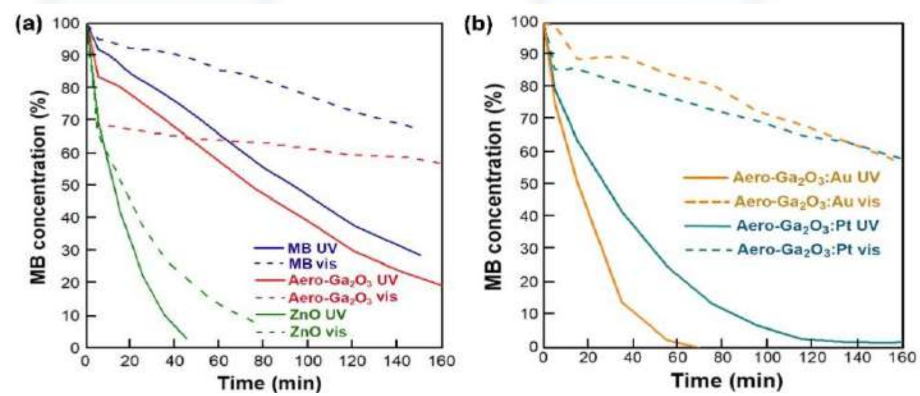
Nanomaterials **2020**, *10*, 1047.

Enhanced photocatalytic activity of Aero-Ga_2O_3 functionalized with noble metal nanoparticles





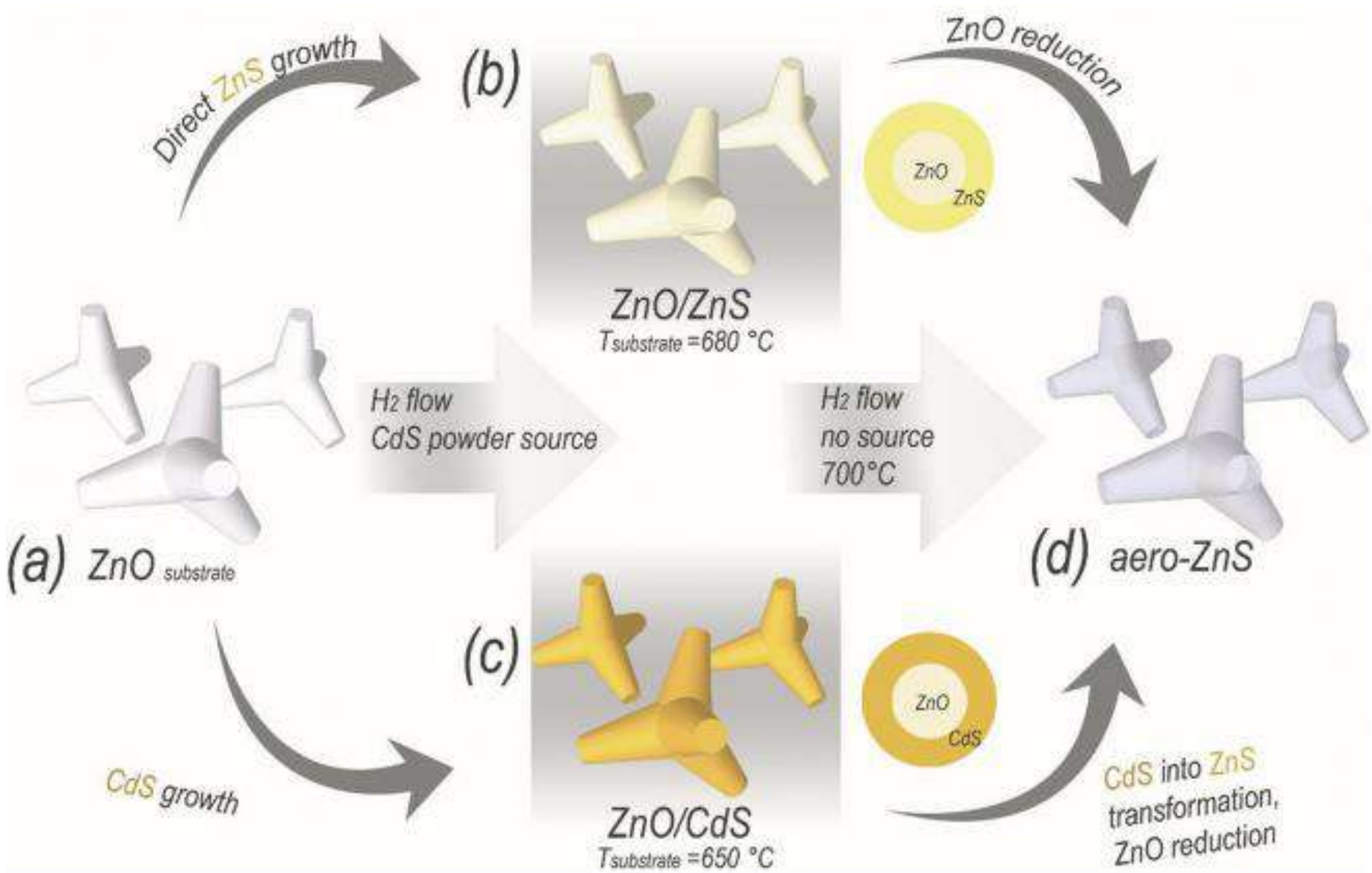
(a) SEM micrograph of aero-Ga2O3 microtetrapods, (b) Magnified micrograph revealing the surface features of the microtetrapod surface. The inset in (a) shows a photograph of Aero- Ga2O3.



Comparison of photocatalytic activities under UV and visible light illumination of the prepared aero-Ga2O3 material and the initial ZnO template (a), and of aero-Ga2O3-Au and aero- Ga2O3-Pt photocatalysts (b)

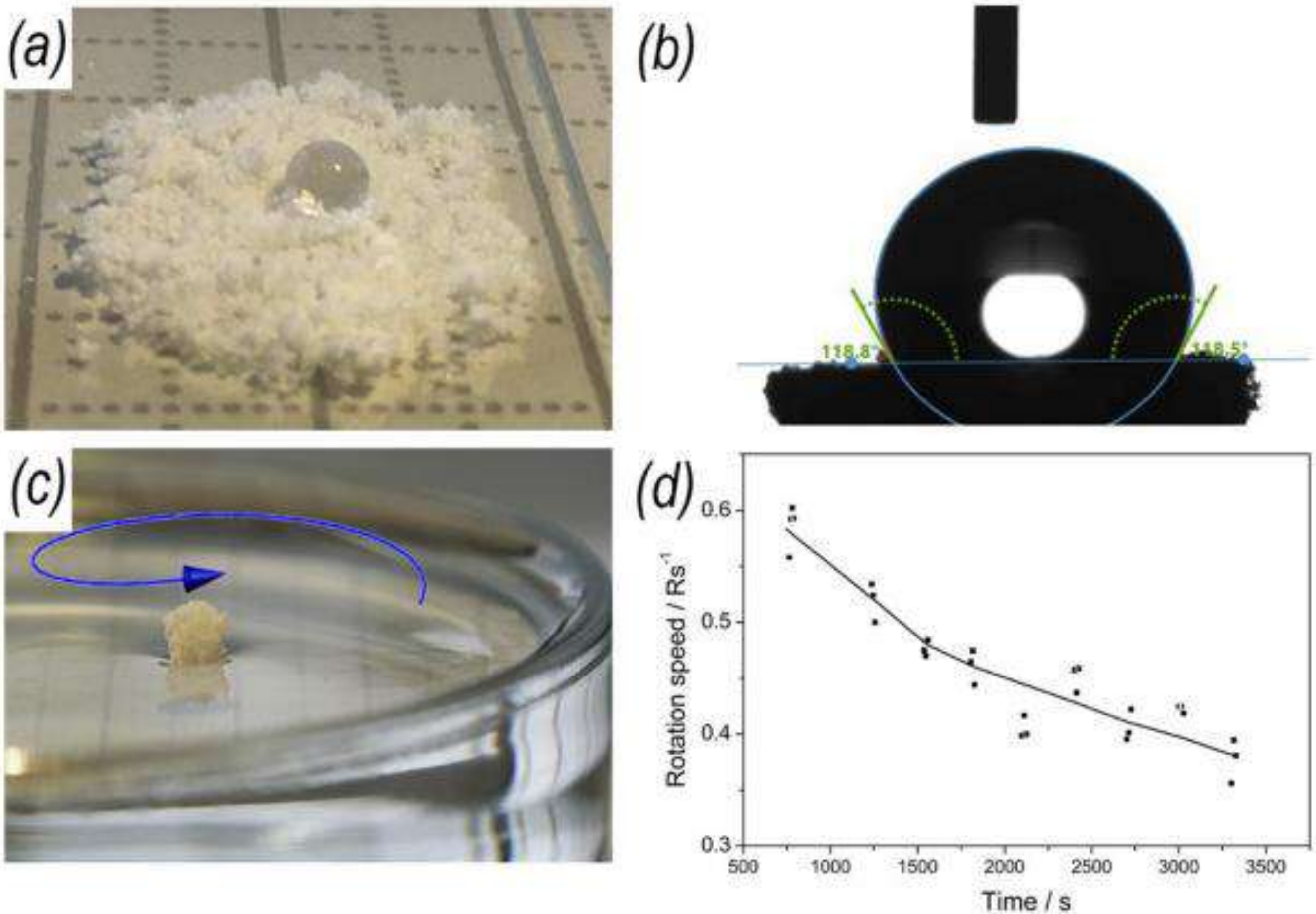
Materials **2021**, *14*, 1985

Aero-ZnS



(a) ZnO substrate for the HVPE process, (b) formation of the ZnS epitaxial layer on ZnO, (c) formation of the CdS epitaxial layer on ZnO, and (d) the final aero-ZnS material.

Aero-ZnS architectures with dual hydrophilic–hydrophobic properties for microfluidic applications



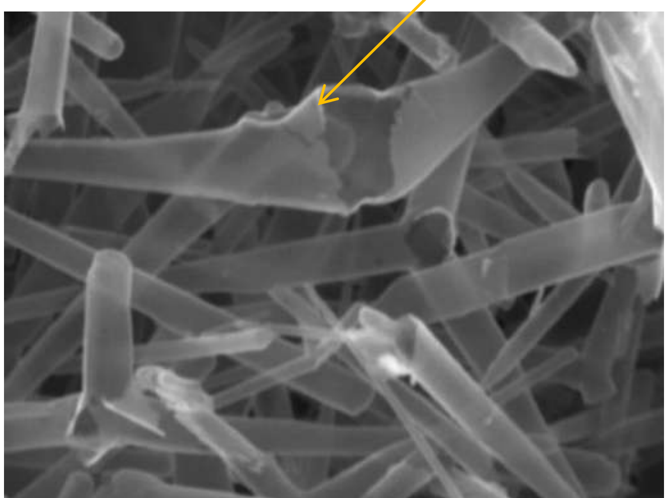
(a) A water droplet rolling onto an aero-ZnS tetrapod bed, (b) contact angle measurement between a water drop and aero-ZnS surface, (c) a liquid droplet encapsulated by an aero ZnS network on the water surface, and (d) time dependency of speed of rotational motions of the self-propelled aero-ZnS liquid marbles.

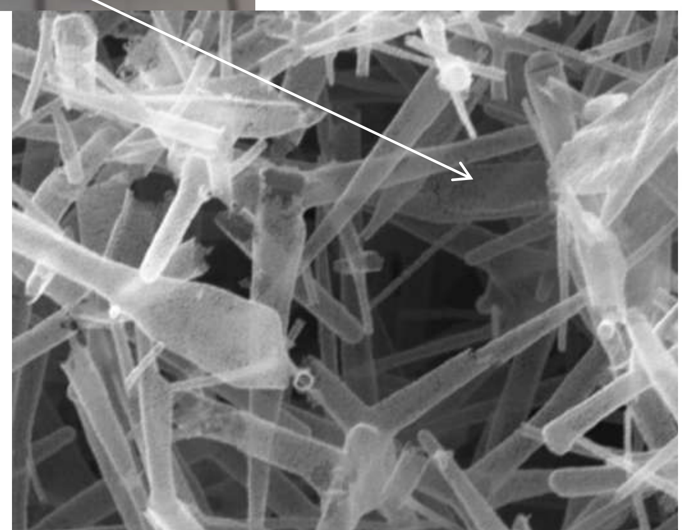
Coming soon:

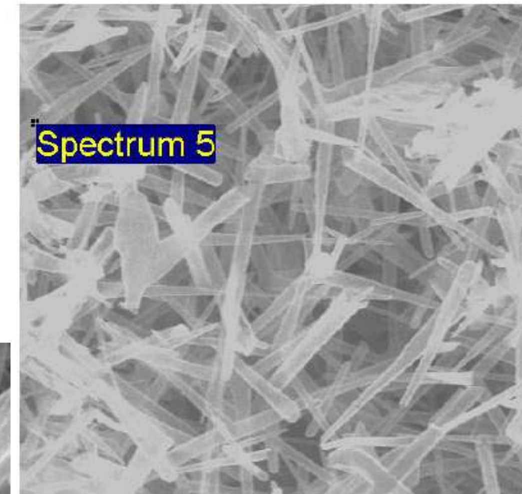
- Aero-TiO_2
- Aero-ZnO

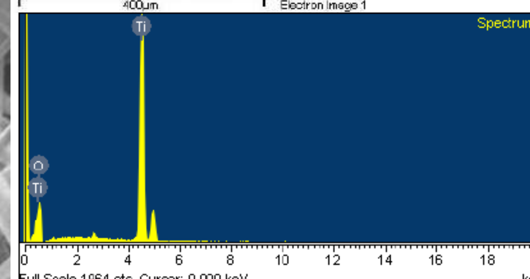
First results on obtaining Aero-TiO_2

ZnO->TiO2 H2+HCl dry etch





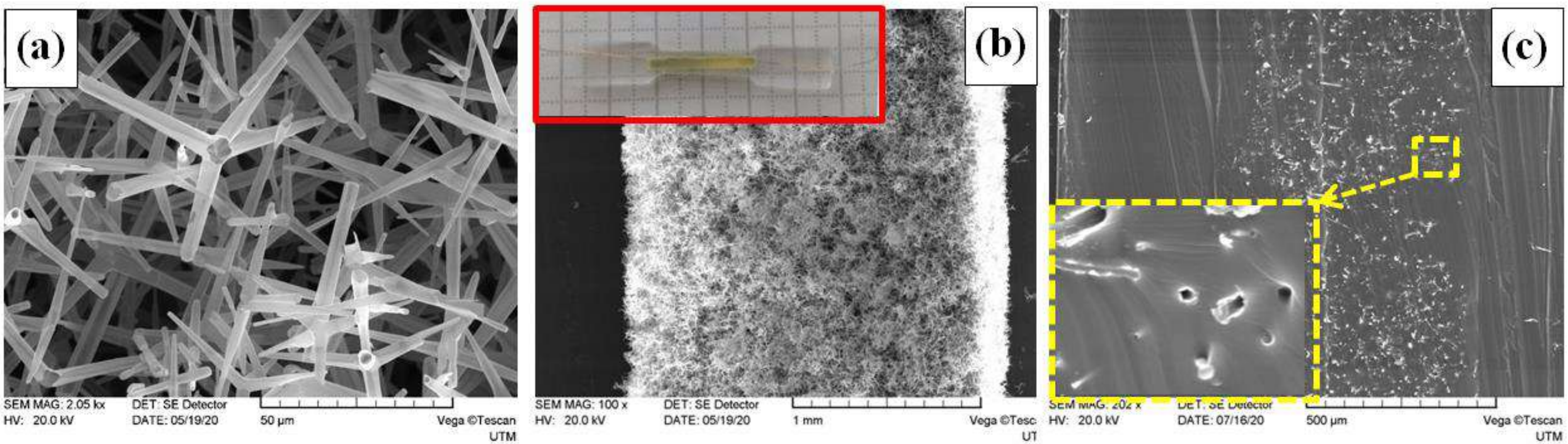




Element	Weight%	Atomic%
O K	39.78	66.42
Ti K	60.22	33.58
Totals	100.00	

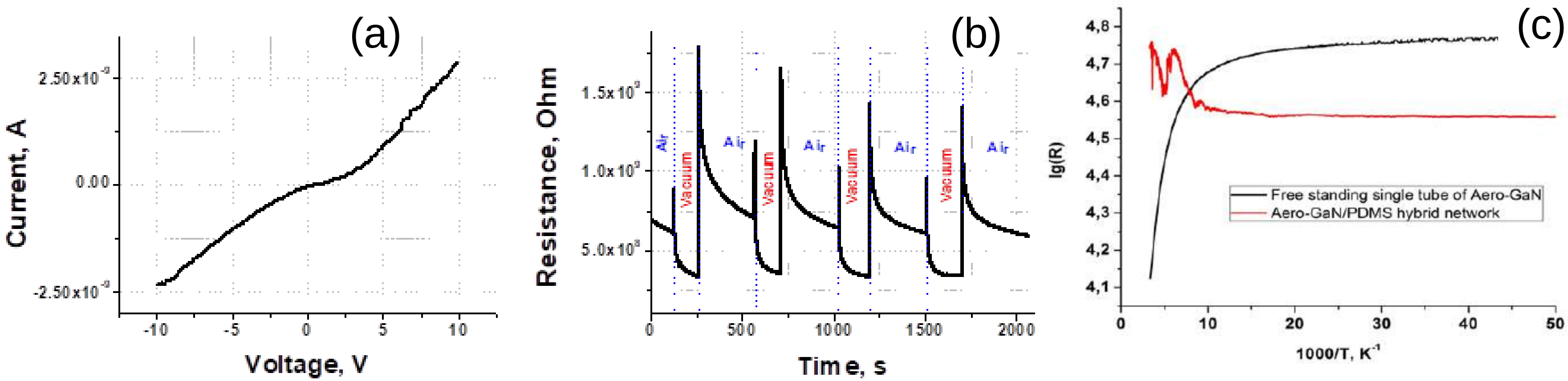
Aerogalnite-polymer composite material

Aero-GaN network filled with Sylgard 184 silicone elastomer



SEM pictures of initial Aero-GaN sample (a, b). The inset in (b) shows the picture of a wired sample of Aero-GaN completely embedded in PDMS. Picture (c) represents the cross section SEM image of a PDMS/Aero-GaN. The inset shows a higher magnification where one can distinguish the open ends of the GaN sectioned microtubes surrounded by PDMS

Electrical characteristics of Aero-GaN/PDMS composite

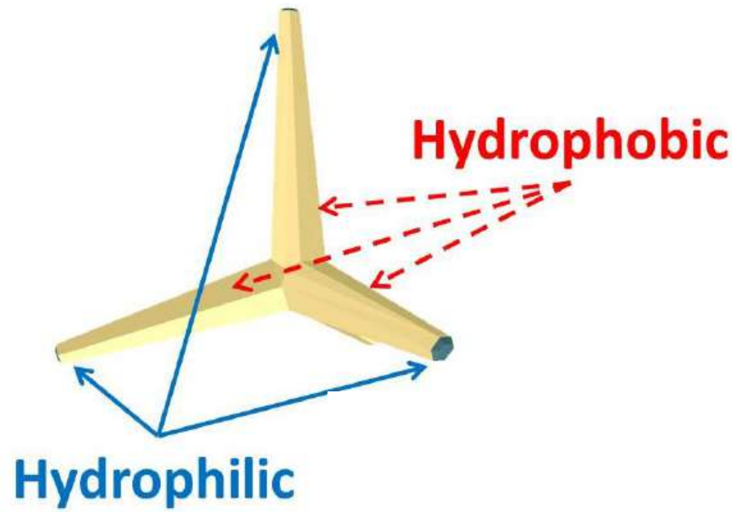


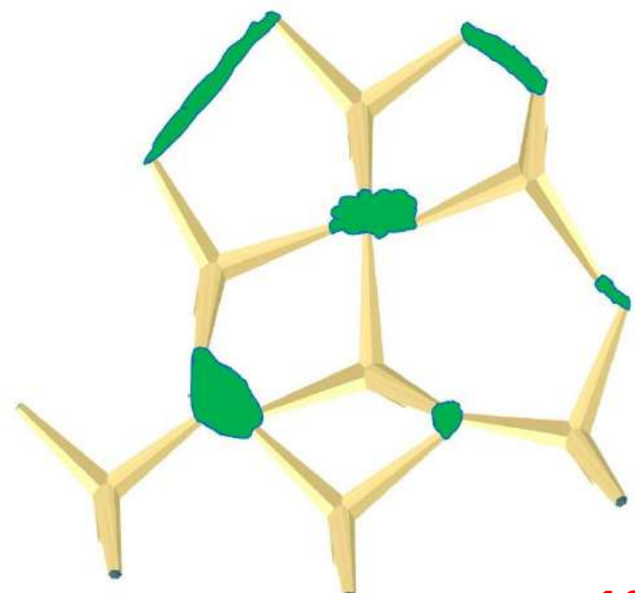
(a) I-V characteristics in air; (b) Influence of vacuum on the electrical resistance; (c) Electrical resistance as a function of the sample temperature

Future perspectives for the development of multifunctional aerogalnite-polymer nanocomposite architectures

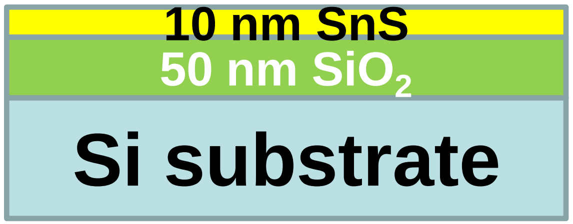
Submarine

Aero-GaN

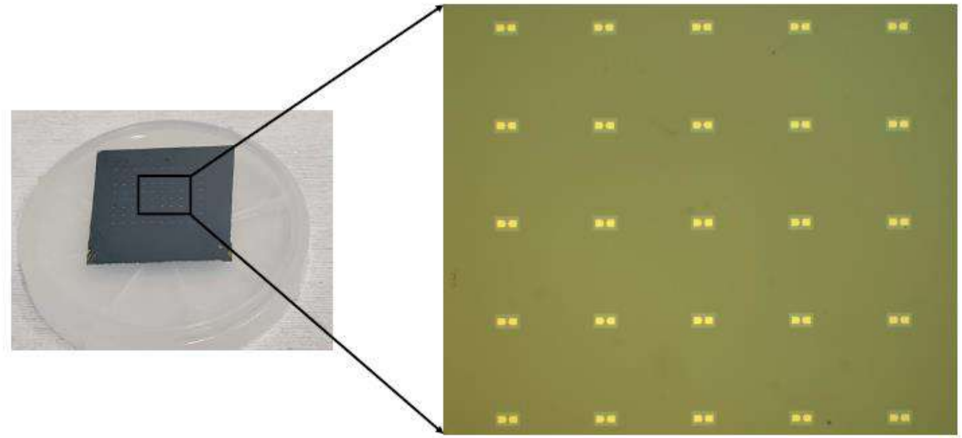


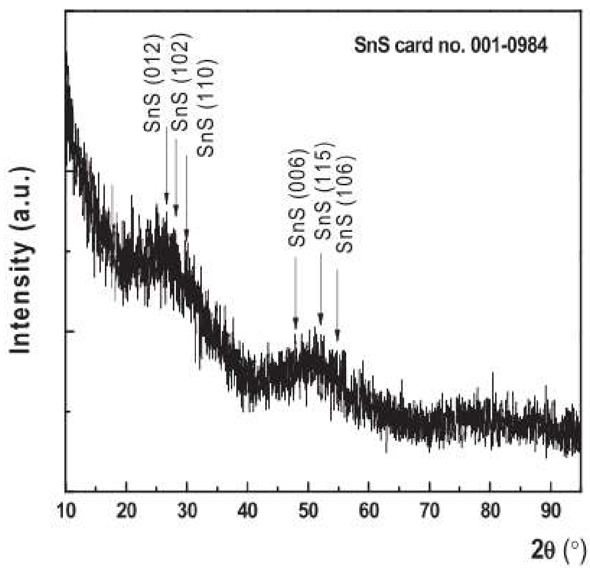


Ultrathin SnS field-effect transistors

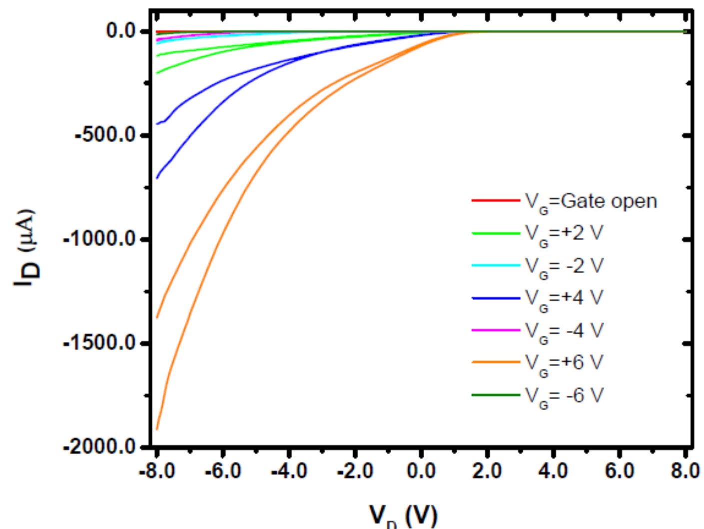


Ultrathin layer of SnS deposited by RF sputtering





GI-XRD pattern at incidence angle of 0.5°. Diffraction features were identified as overlapped reflections of SnS.



I–*V* characteristics for the SnS FETs with W = 0.5 μm and L = 2 μm: I_D–V_D dependence at different V_G values;

The 5th International Conference on Nanotechnologies and Biomedical Engineering

ICNBME-2011

ICNBME-2013

ICNBME-2015

ICNBME-2019

ICNBME-2021

- Technical University of Moldova
- Academy of Sciences of Moldova
- State University of Medicine and Farmacy, Moldova
- Moldavian Society of Biomedical Engineering
- In collaboration with The International Federation for Medical and Biological Engineering
- Supported by European Commission under the Grant #810652 “NanoMedTwin”

http://www.icnbme.sibm.md/

Conclusion

• A novel nanotechnology, the so-called Surface Charge Lithography, has been developed which enabled one to fabricate GaN-based ultrathin membranes for electronic and photonic applications. As a result, memristive membrane arrays as well as flexible two-dimensional photonic crystals with embedded waveguides, beam splitters and ring resonators have been demonstrated;

• Promising applications of GaN nanostructures and their networks have been identified in memristive devices, pressure sensors, materials shielding in X-band and THz regions, microrobotics etc.;

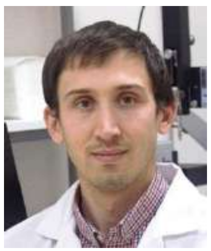
• Aerogalnite – the first artificial material with duel hydrophobic-hydrophilic properties was developed. Further, we explored prospects of its implementation in pressure sensors and electromagnetic shields against gigahertz and terahertz radiations as well as in microfluidics, microrobotics and biomedicine.

• GaN/ZnO hollow nanoparticles were developed and their biocompatibility and uptake by living cells have been demonstrated.

PhD theses elaborated at the National Center for Materials Study and Testing

Dr. Vitalie Postolache (2019)

"Physical properties of one-and bi-dimensional semiconductor structures and composites"



Dr. Tudor Braniste (2017)

"Two- and three-dimensional nanoarchitectures based on GaN for engineering applications"

Dr. Olesea Volciuc (2011)

"Luminescence and THz wave emission from nanostructured materials based III-V semiconductor compounds"

Dr. Eduard Monaico (2009)

"Morphology and optical properties of porous stuctures on the basis of II-VI semiconductor compounds"

Dr. Alexandru Burlacu (2017)

"Luminescence and laser effects in ZnO nanostructured films and microstructures grown by chemical vapor deposition and electrochemical deposition"

Dr. Mihai Enache (2015)

"Morphology and optical properties of semiconductor and dielectric matrices based nanocomposits from InP, Al_2O_3 and TiO_2"

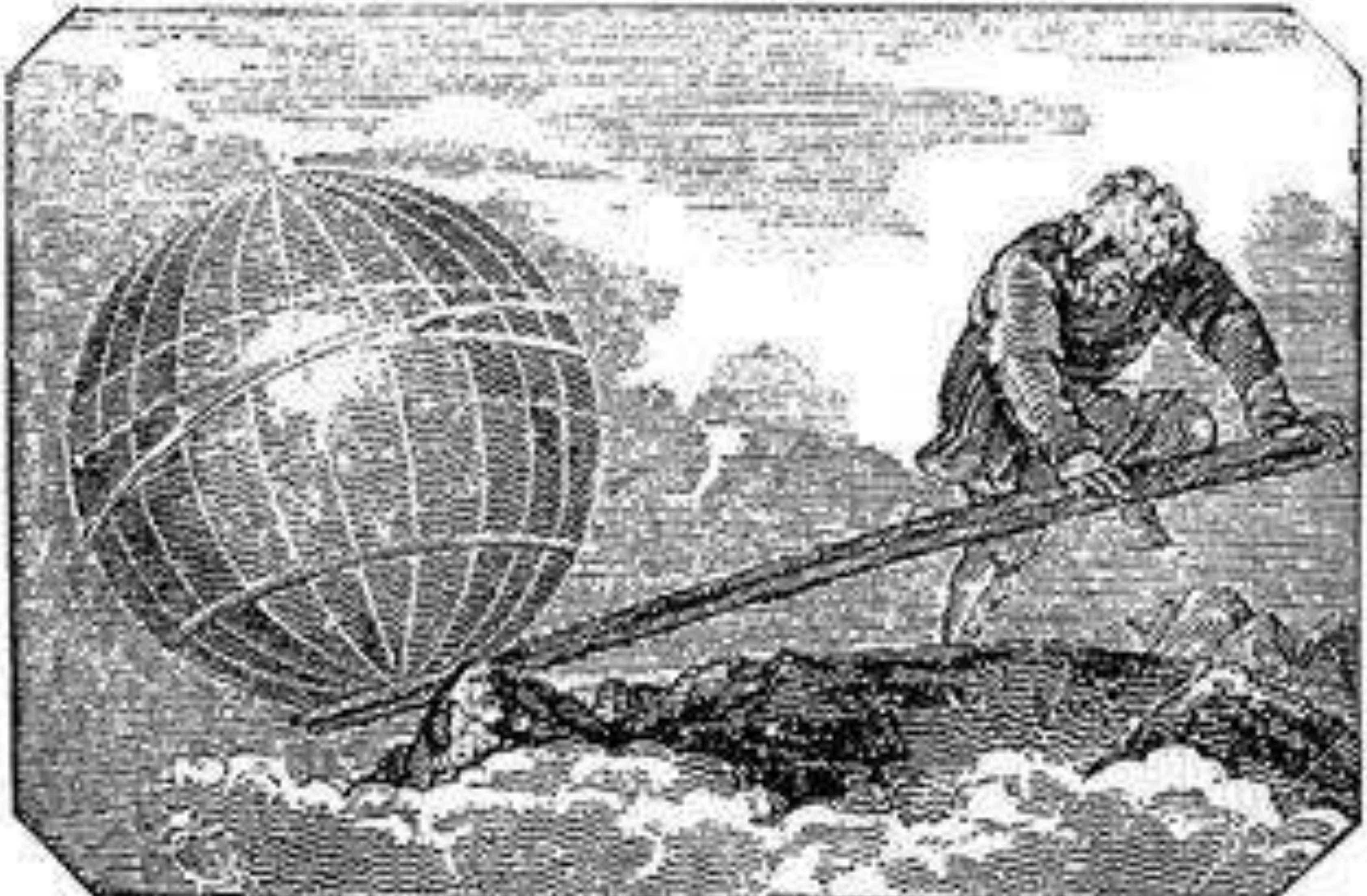
Dr. Lilian Sîrbu (2011)

"Fabrication and study of low-dimensional structures based on GaN"

Dr. Veaceslav Popa (2005)

"Morphology, luminescence and electrophysical properties of meso- and nanostructures based on GaN"

Knowledge moves the world



Thank you

for your kind attention!