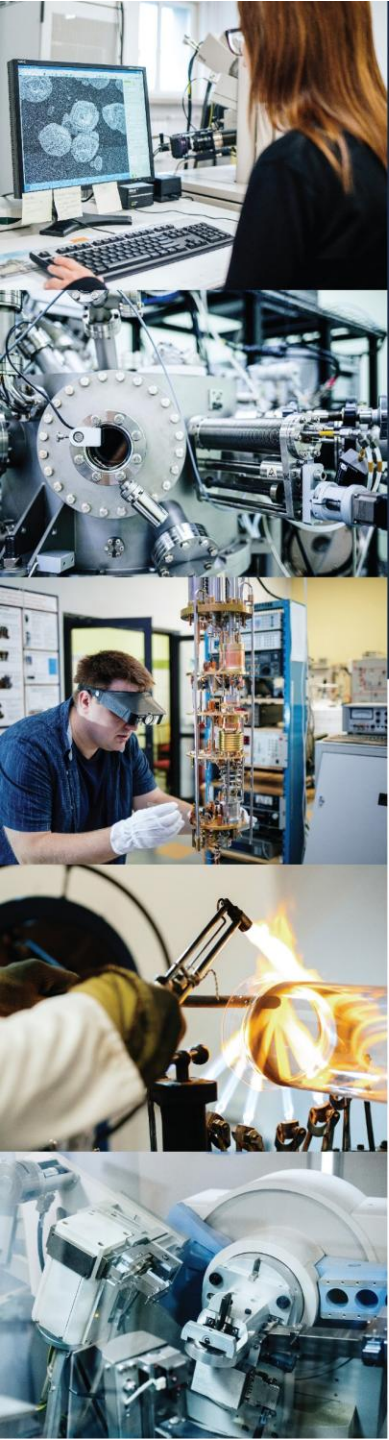


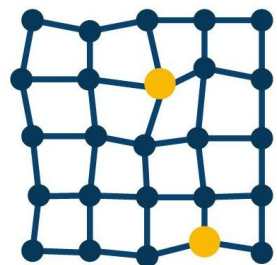


INSTITUTE OF LOW TEMPERATURE AND STRUCTURE RESEARCH
POLISH ACADEMY OF SCIENCES

W. Strek, R. Tomala, P. Wiewiórski, M. Stefański, M. Samsel-Czekala

Modelling of laser-induced white emission of graphene

Institute of Low Temperature and Structure Research,
Polish Academy of Sciences, Wroclaw, Poland



EuroDIM15
Timisoara, Romania, 2026



ILT&SR structure

- Division of Nanomaterials Chemistry and Catalysis
- Division of Low Temperature and Superconductivity
- Division of Magnetic Research
- Division of Structure Research
- **Division of Optical Spectroscopy** →





Materials Letters
Volume 335, 15 March 2023, 133851



Electric field driven self-assembly of dissolved graphene foam particles in a capillary

P. Wiewióński, W. Strek, R. Tomala, M. Stefanski

RESEARCH ARTICLE | MAY 31 2023

Influence of vacuum level on laser induced white emission of graphene foam

M. Oleszko; A. Felix; R. Tomala; M. Chaika; W. Strek

Check for updates

Appl. Phys. Lett. 122, 221901 (2023)
<https://doi.org/10.1063/5.0153405>

OPEN

Light: Science & Applications (2015) 4, e237; doi:10.1038/lsa.2015.10
© 2015 CIOMP. All rights reserved 2047-7538/15
www.nature.com/lsa



ORIGINAL ARTICLE

Laser-induced white-light emission from graphene ceramics—opening a band gap in graphene

Wiesław Strek¹, Bartłomiej Cichy¹, Lukasz Radosinski², Paweł Gluchowski¹, Lukasz Marciniak¹, Mikołaj Łukaszewicz¹ and Dariusz Hreniak¹



Solid State Communications
Volume 371, 1 October 2023, 115274



Current driven red emission from graphene foam

P. Wiewióński, R. Tomala, M. Stefanski, W. Strek



Optics Communications
Volume 514, 1 July 2022, 128140



Laser driven coherent white emission of graphene bulb

M. Oleszko, W. Strek, R. Tomala

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Laser induced white lighting of graphene foam

Wiesław Strek, Robert Tomala, Mikołaj Łukaszewicz, Bartłomiej Cichy, Yurii Gerasymchuk, Paweł Gluchowski, Lukasz Marciniak, Artur Bednarkiewicz & Dariusz Hreniak

THE JOURNAL OF
PHYSICAL
CHEMISTRY
C
A JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

This article is licensed under CC-BY 4.0

ARTICLE

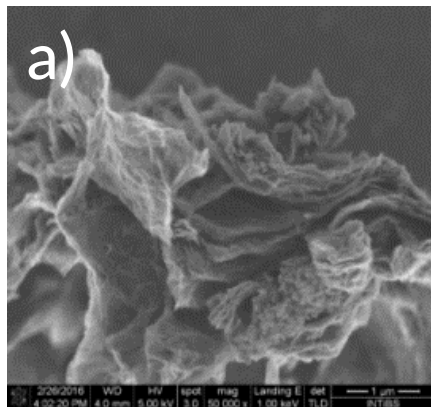
Closed Circle Measurements of Laser-Induced White Emission of Graphene Foam

Mykhailo Chaika,* Vitalii Boiko, Mateusz Oleszko, Robert Tomala, and Wiesław Stręk

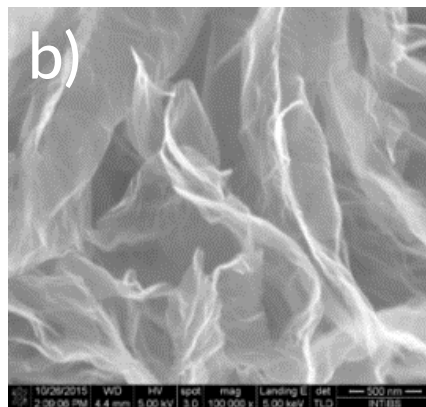
Cite This: J. Phys. Chem. C 2024, 128, 8351–8356

Read Online

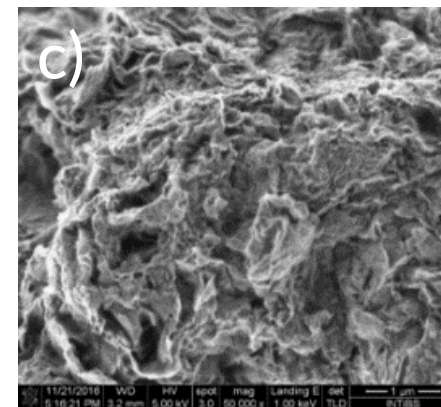
Graphene-type materials



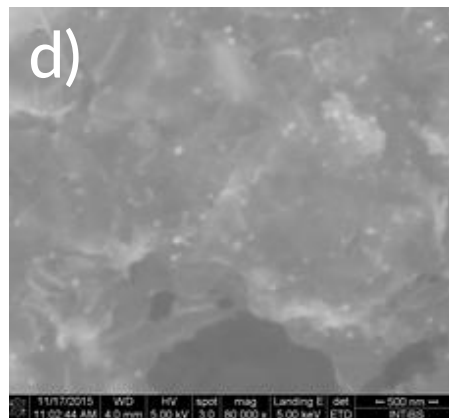
Expanded graphene flakes (3-8 layers)



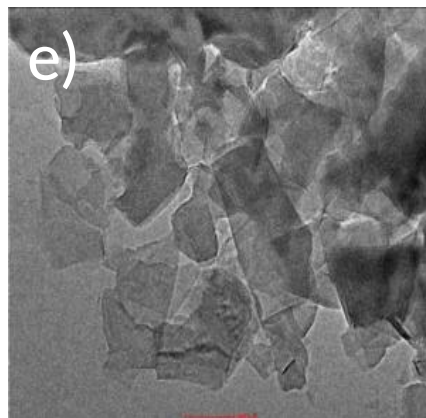
Pyrolyzed graphene flakes (1-2 layers)



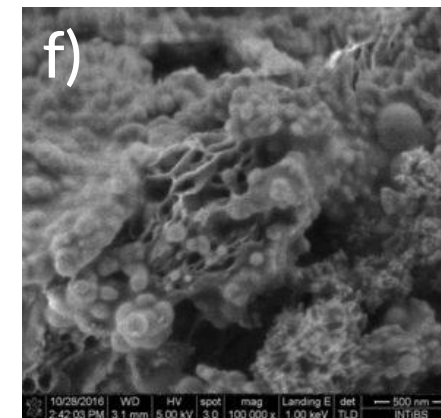
Graphene foam



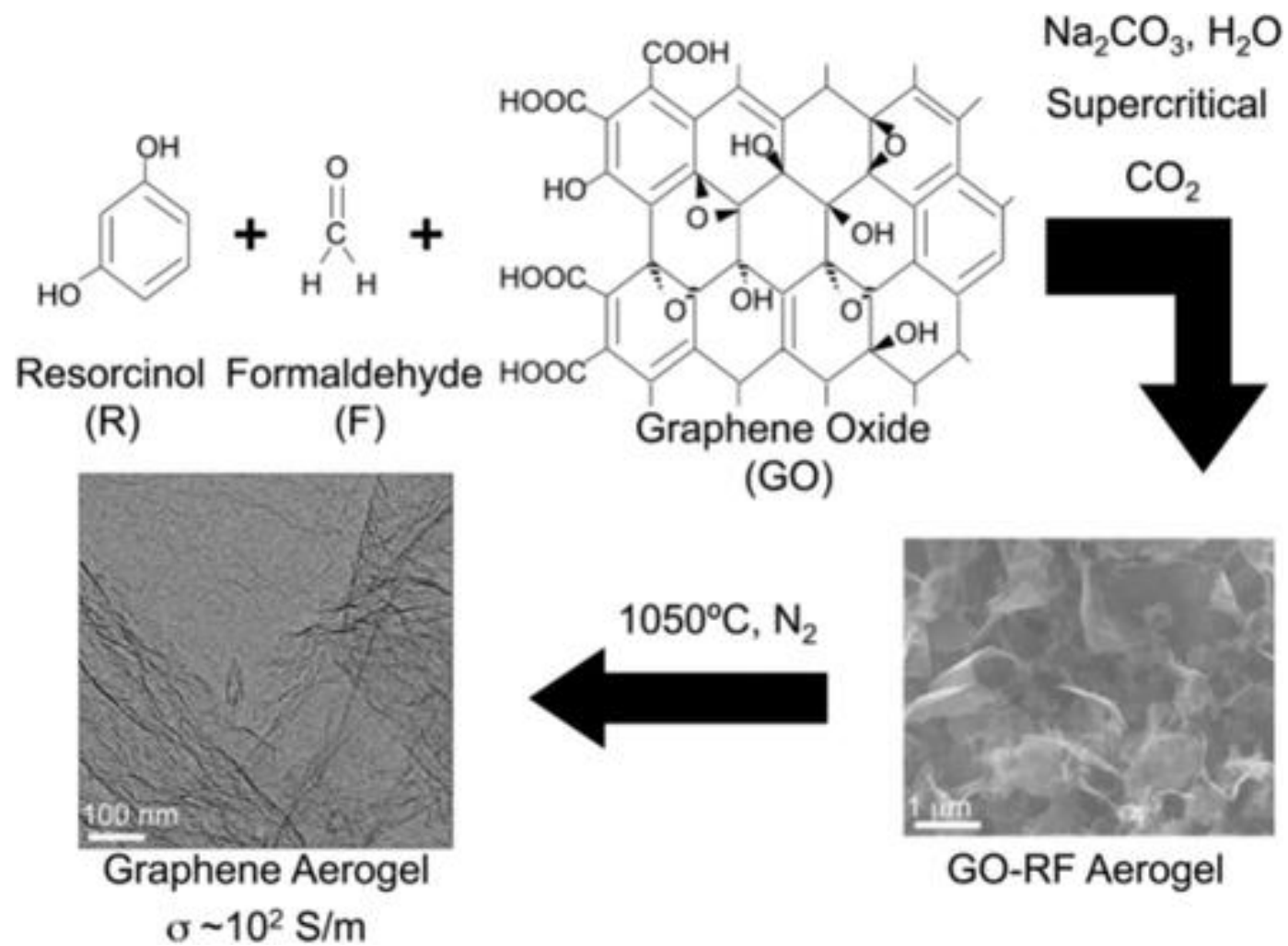
Graphene intercalated with Ag, Au, Fe nanoparticles



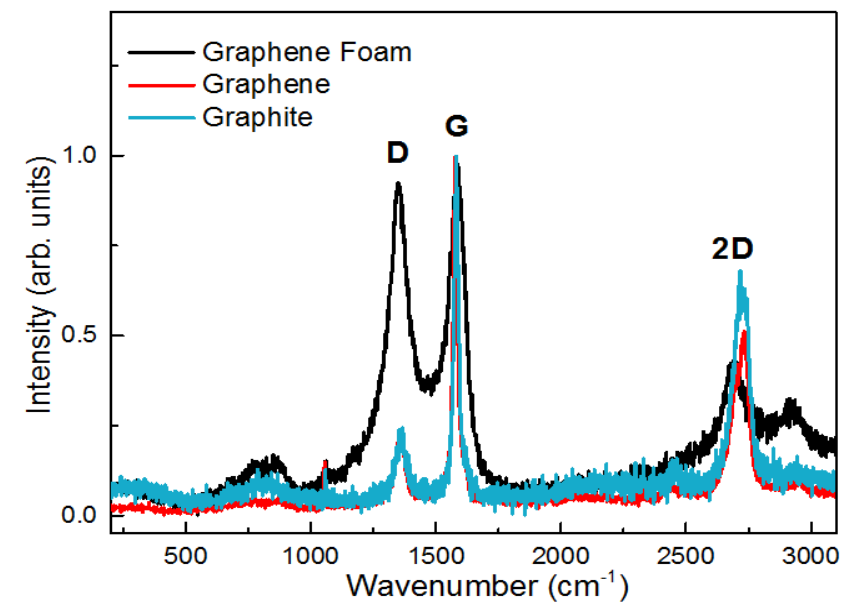
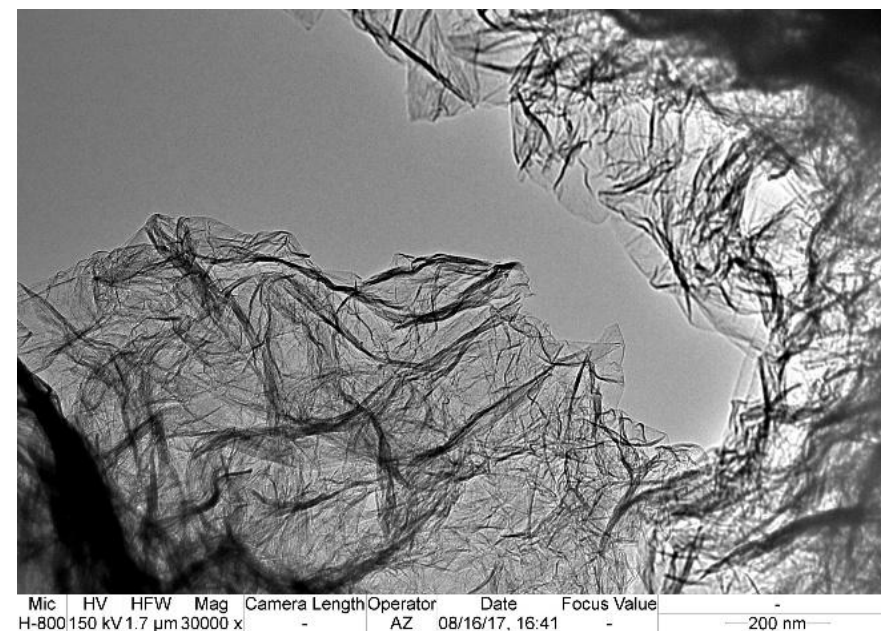
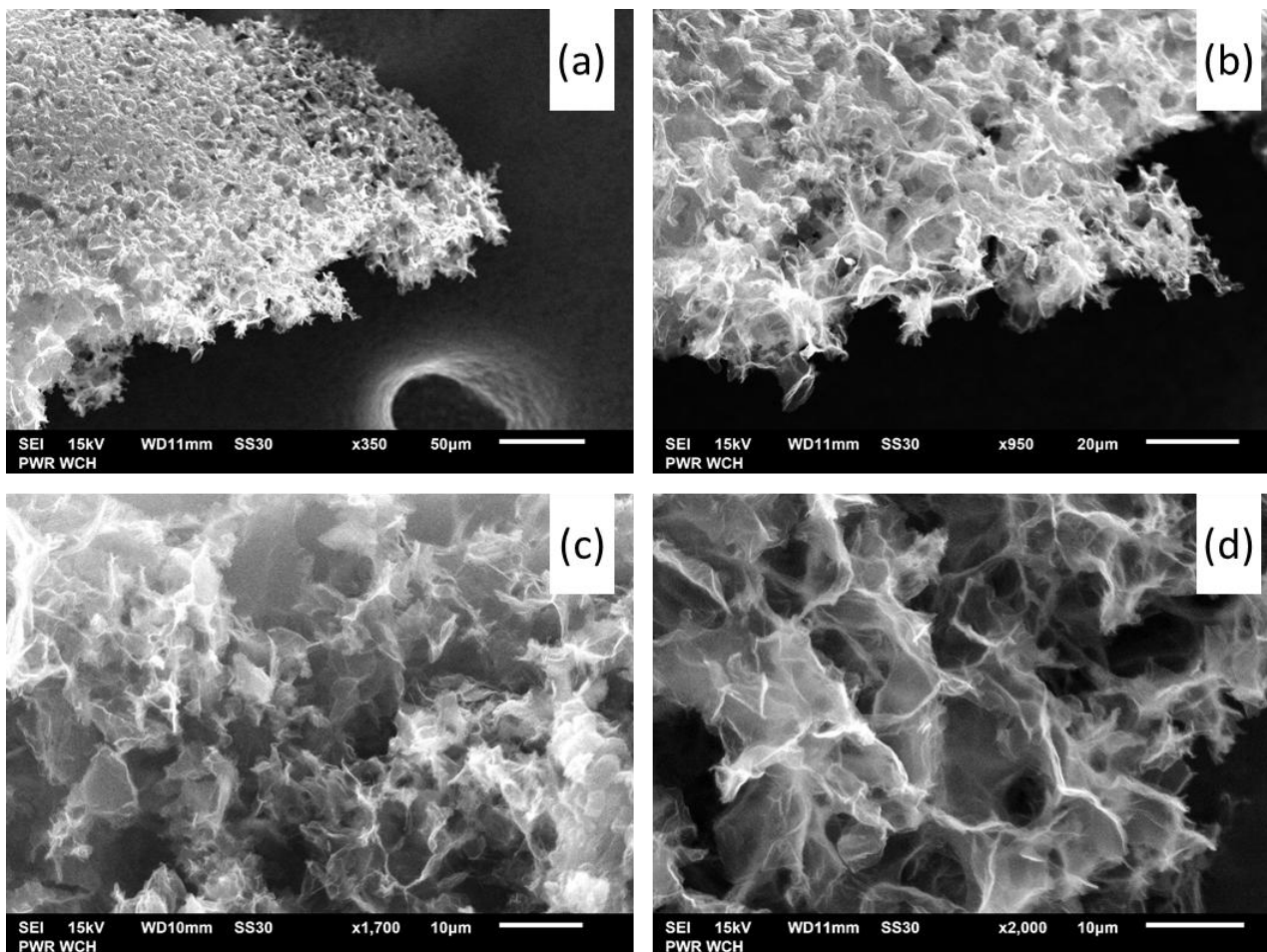
Graphene-nanosilica composites



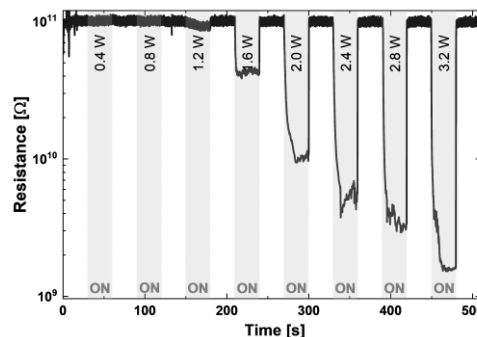
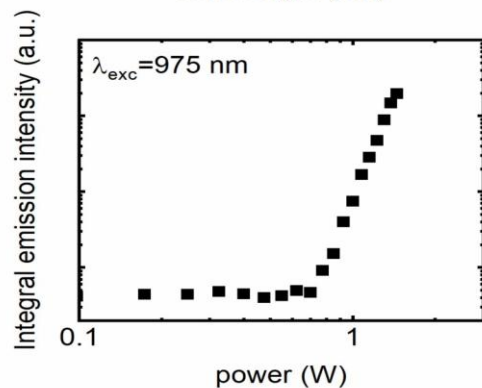
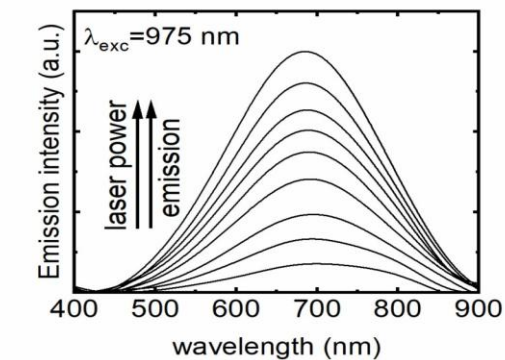
Reduced graphite oxide



Structure and morphology of graphene



Laser induced white emission- LIWE



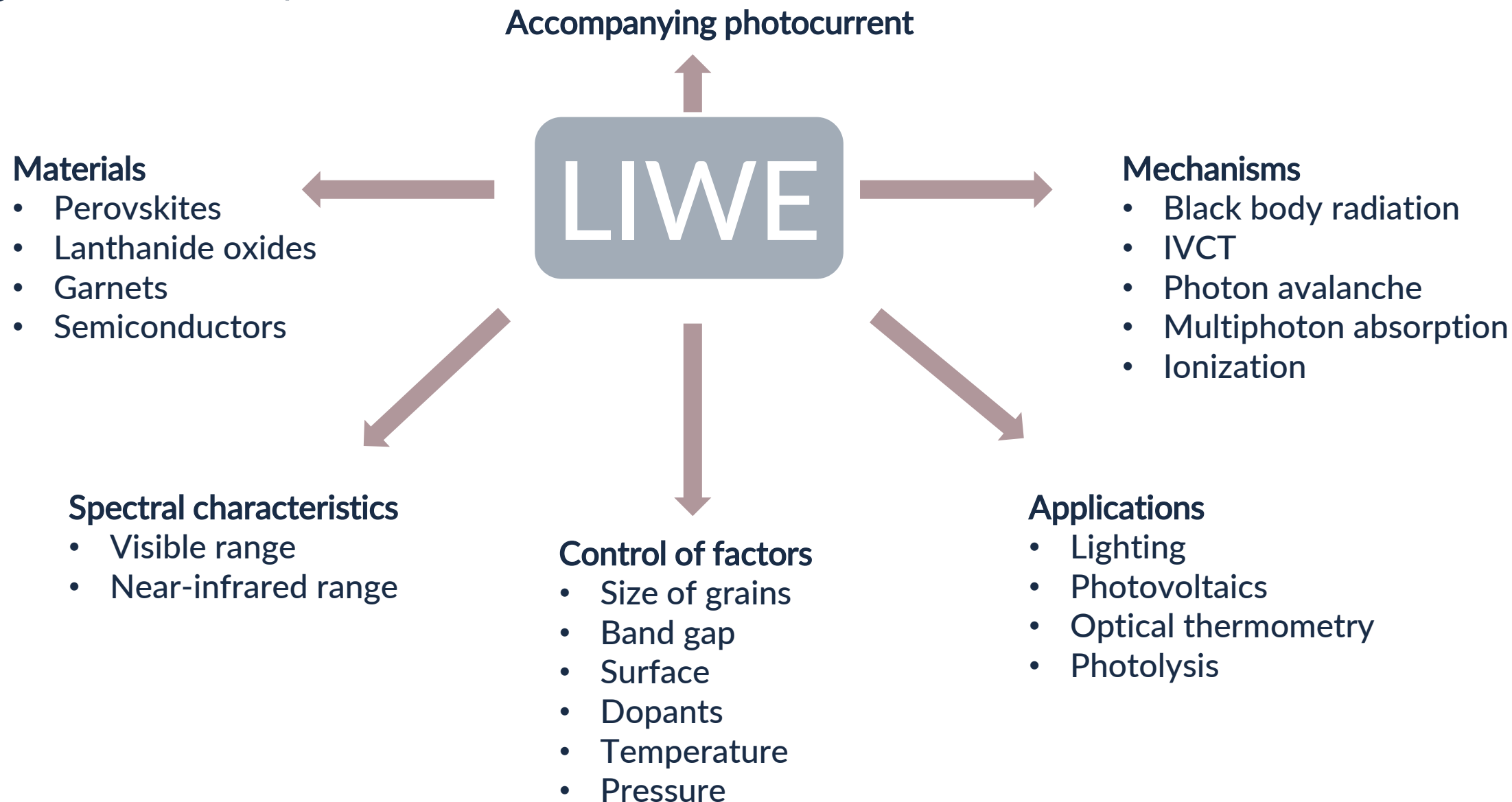
$$I \propto P^N$$

- **Threshold behavior**
- **Non-linear process**
- **Dependence of excitation power density**



Visible white light generated by irradiating material with a continuous infrared laser.

What is important?



Comparison of LIWE and eye sensitivity

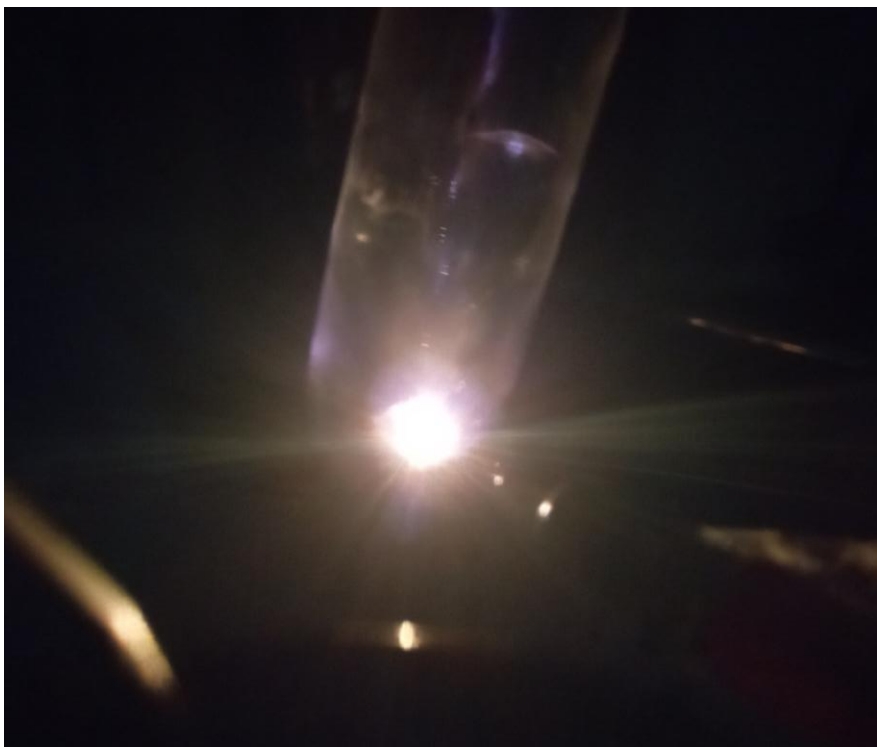
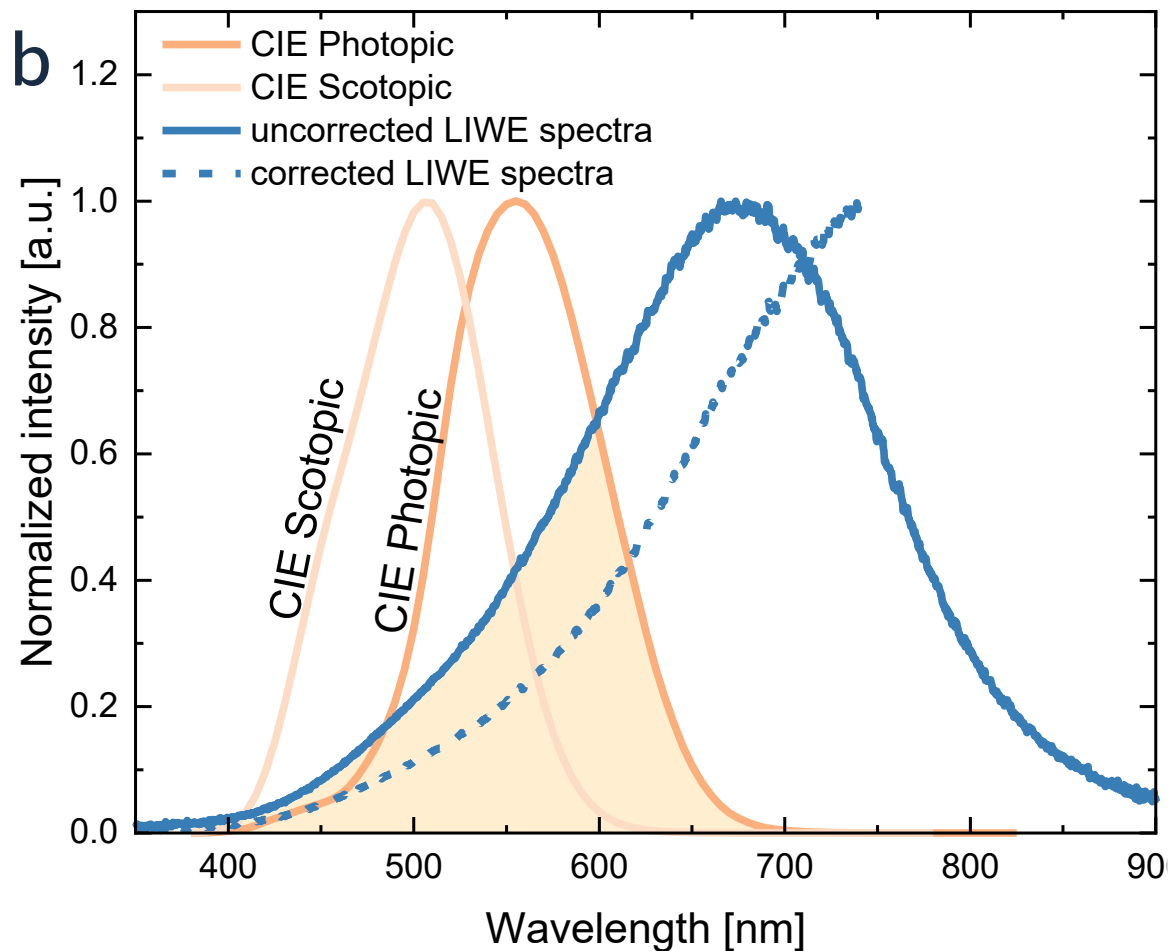
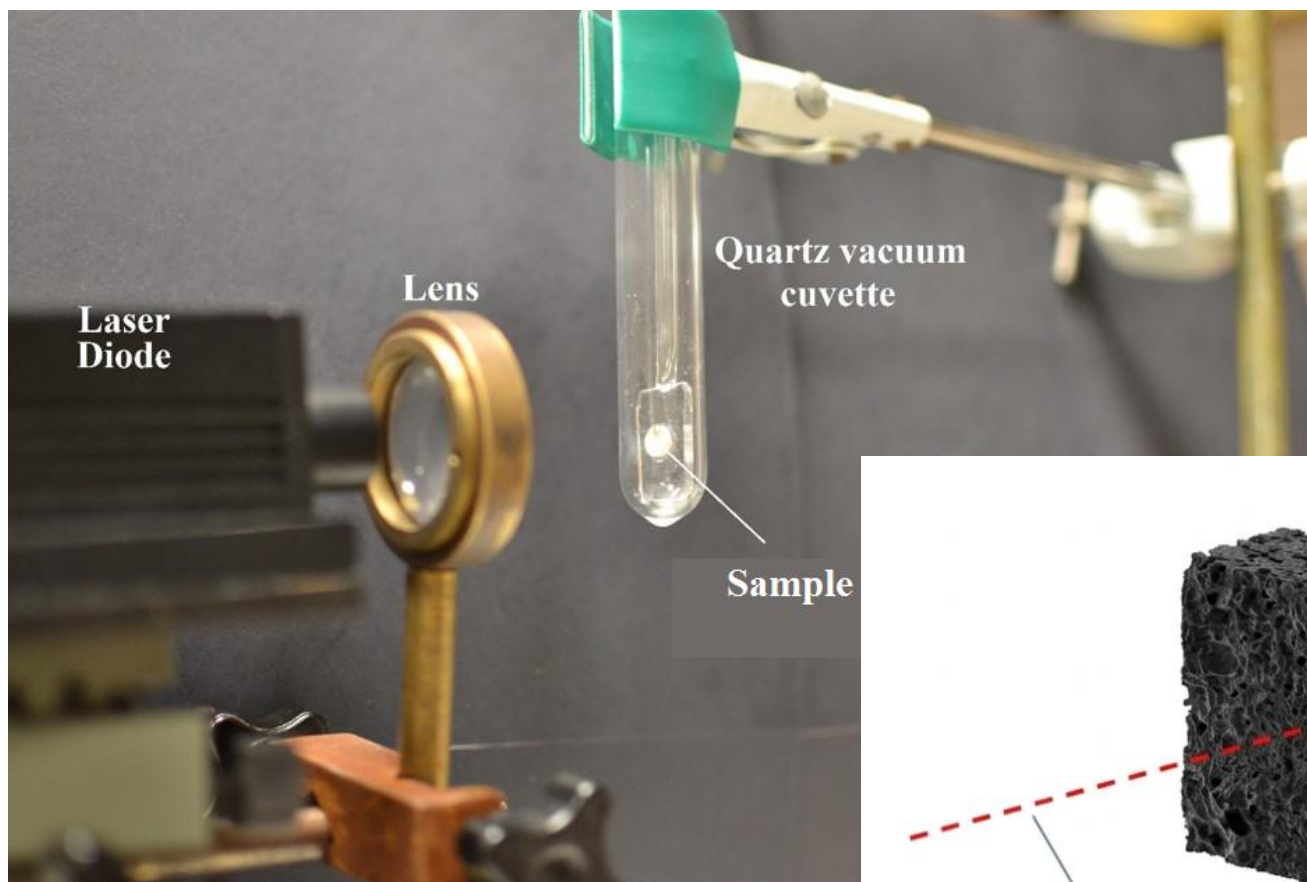
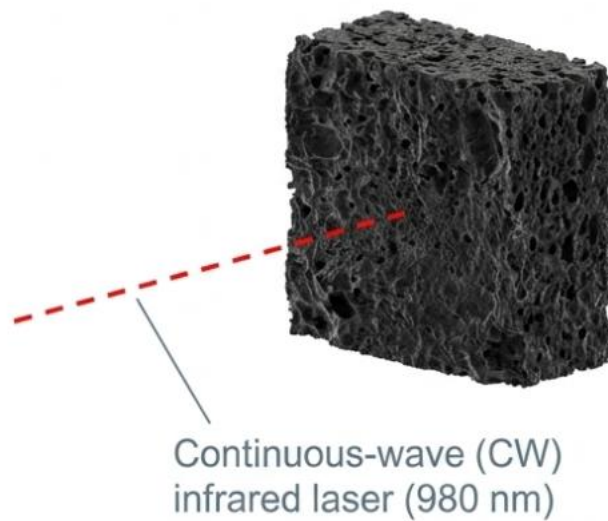
a**b**

Figure 4. Image of white emission upon 975 nm CW laser irradiation (a), the spectra comparison of LIWE and eye sensitivity (b).

Scheme of the measurement system



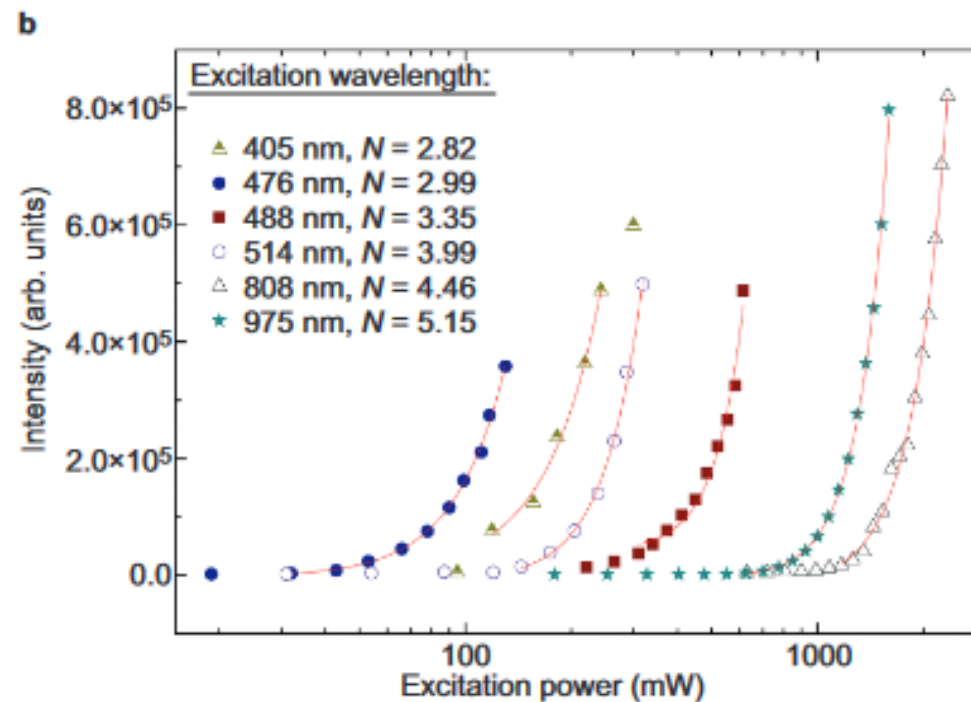
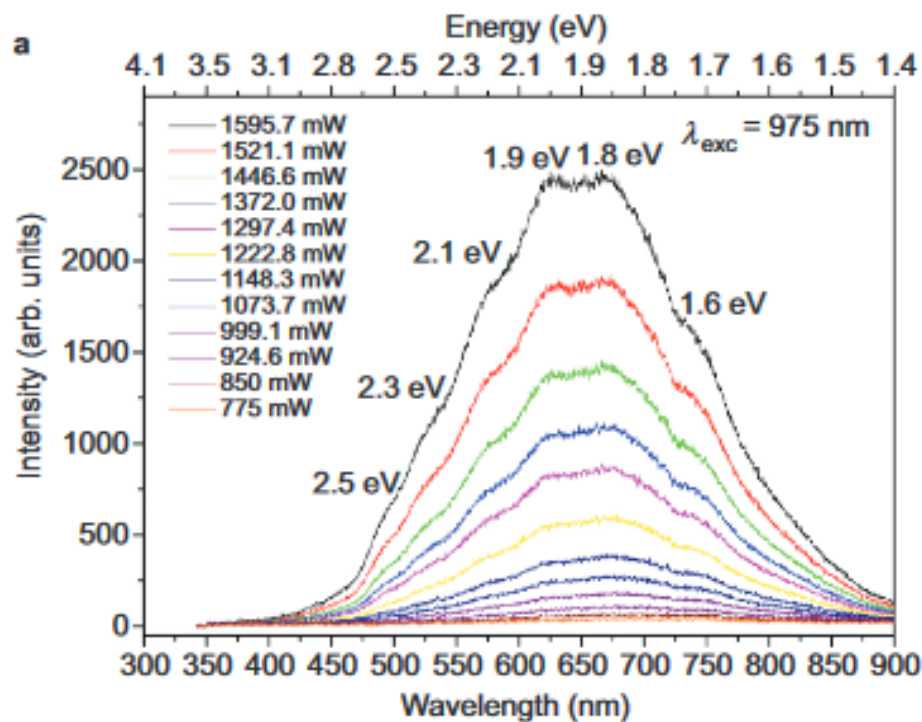
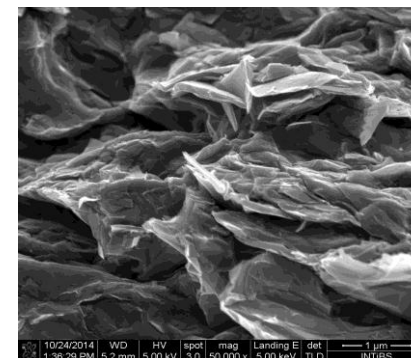
Visible light is generated by irradiating a graphene target



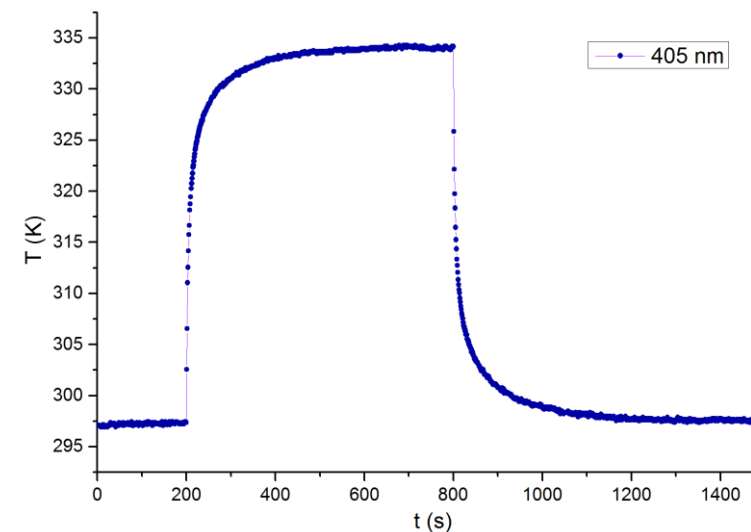
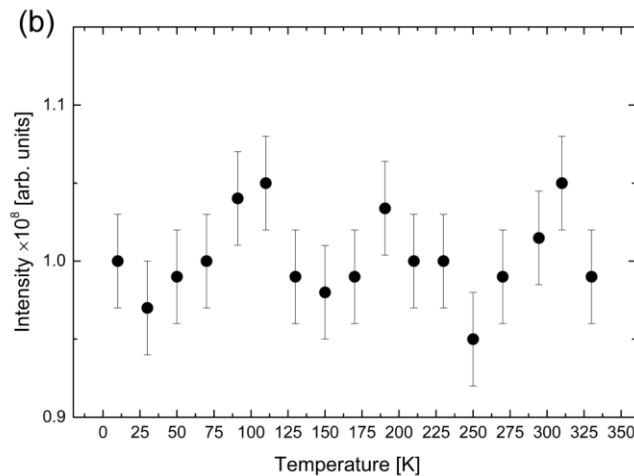
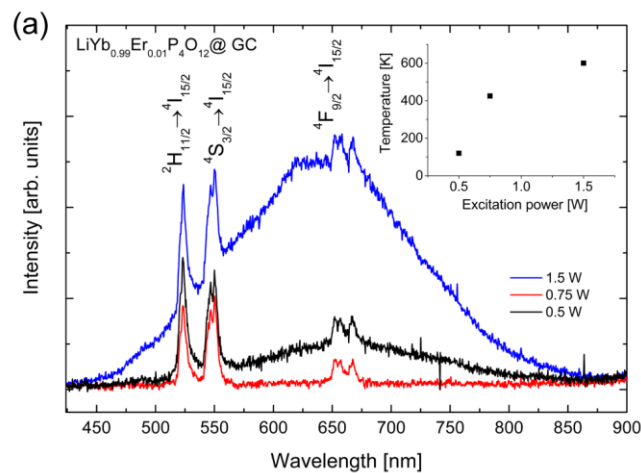
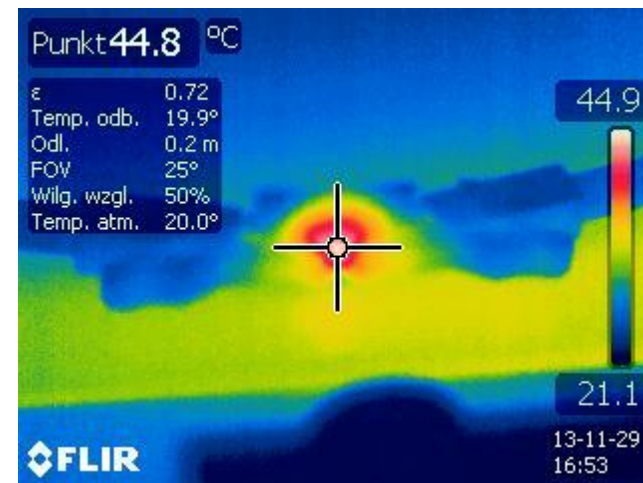
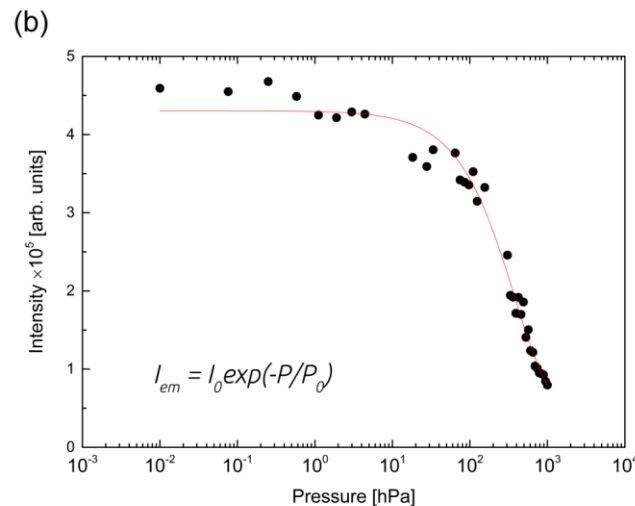
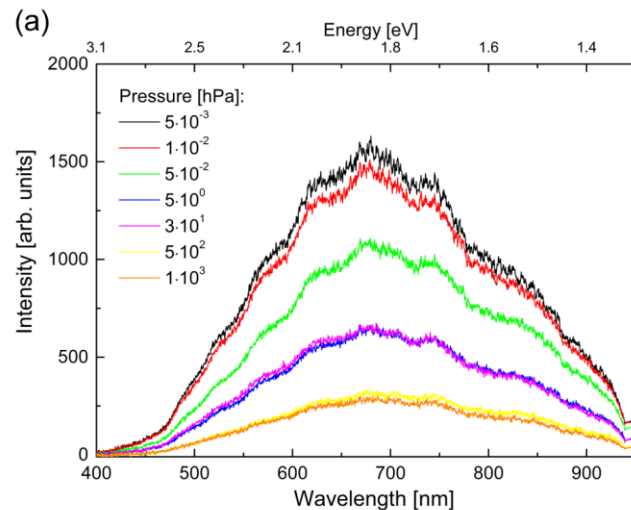
ORIGINAL ARTICLE

Laser-induced white-light emission from graphene ceramics—opening a band gap in graphene

Wiesław Strek¹, Bartłomiej Cichy¹, Łukasz Radosiński², Paweł Gluchowski¹, Łukasz Marciniak¹,
Mikołaj Łukaszewicz¹ and Dariusz Hreniak¹



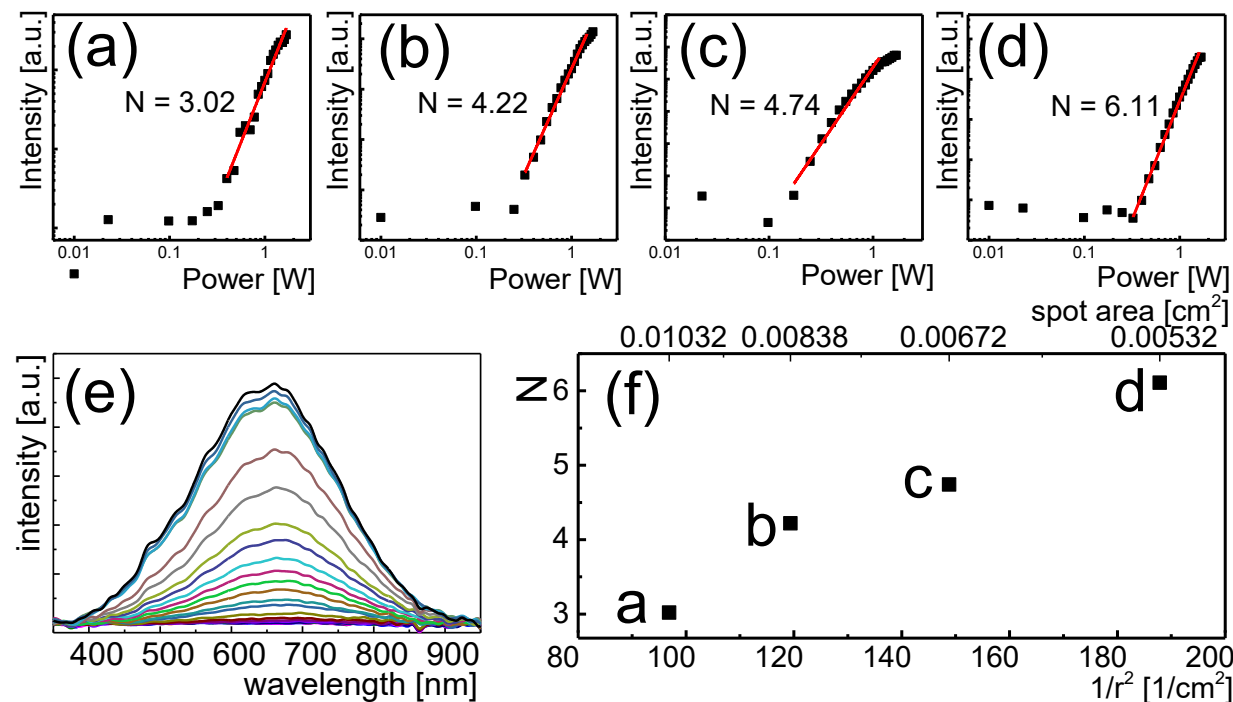
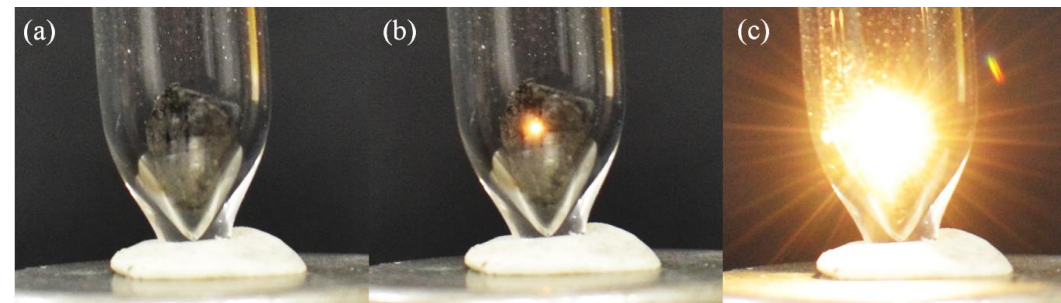
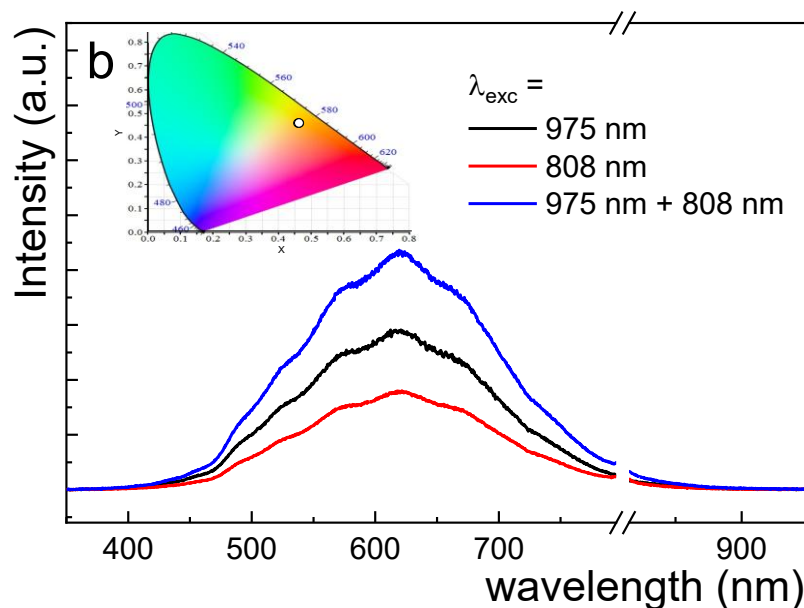
Estimation of effective temperature of emitting sample



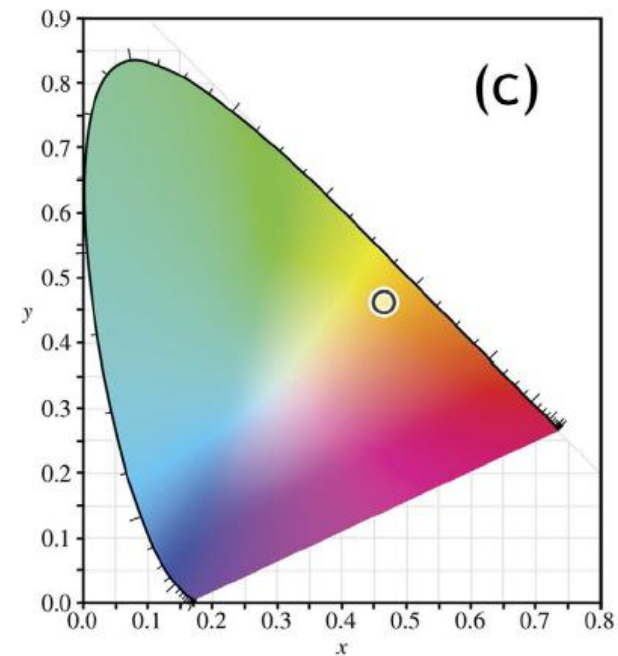
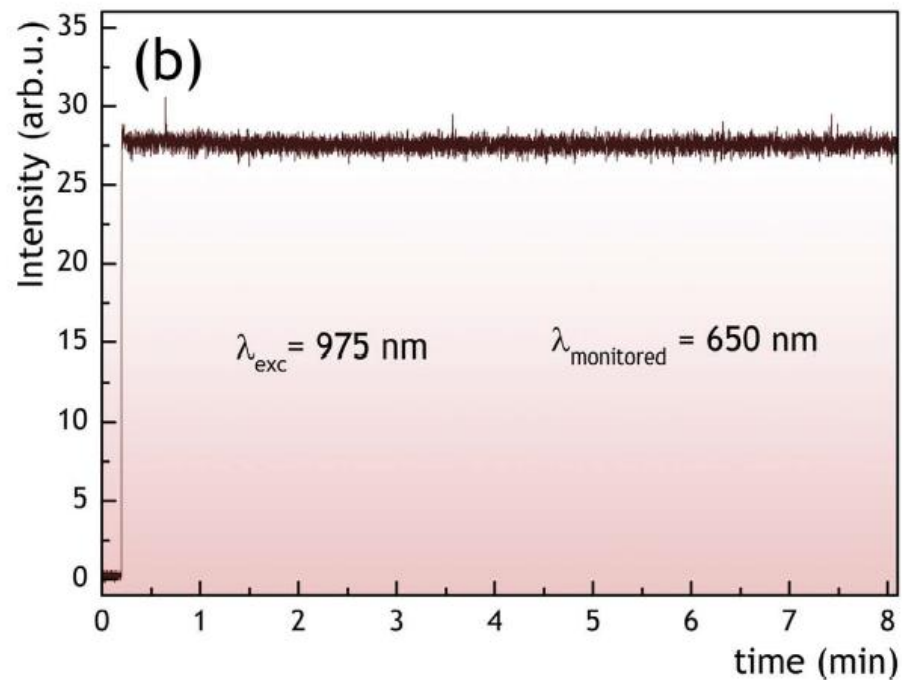
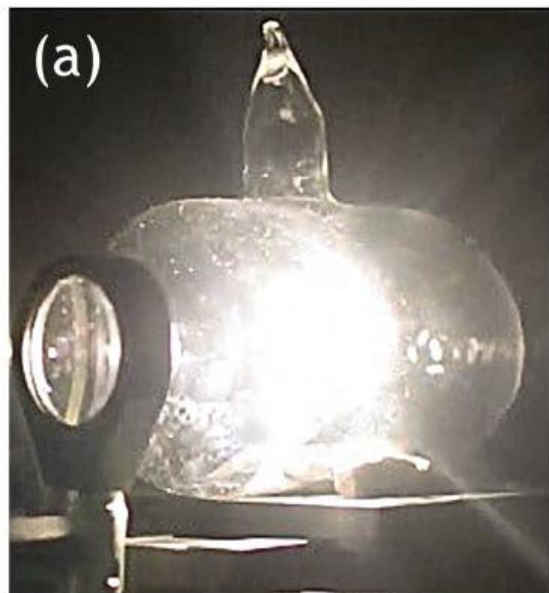
SCIENTIFIC REPORTS

OPEN Laser induced white lighting of graphene foam

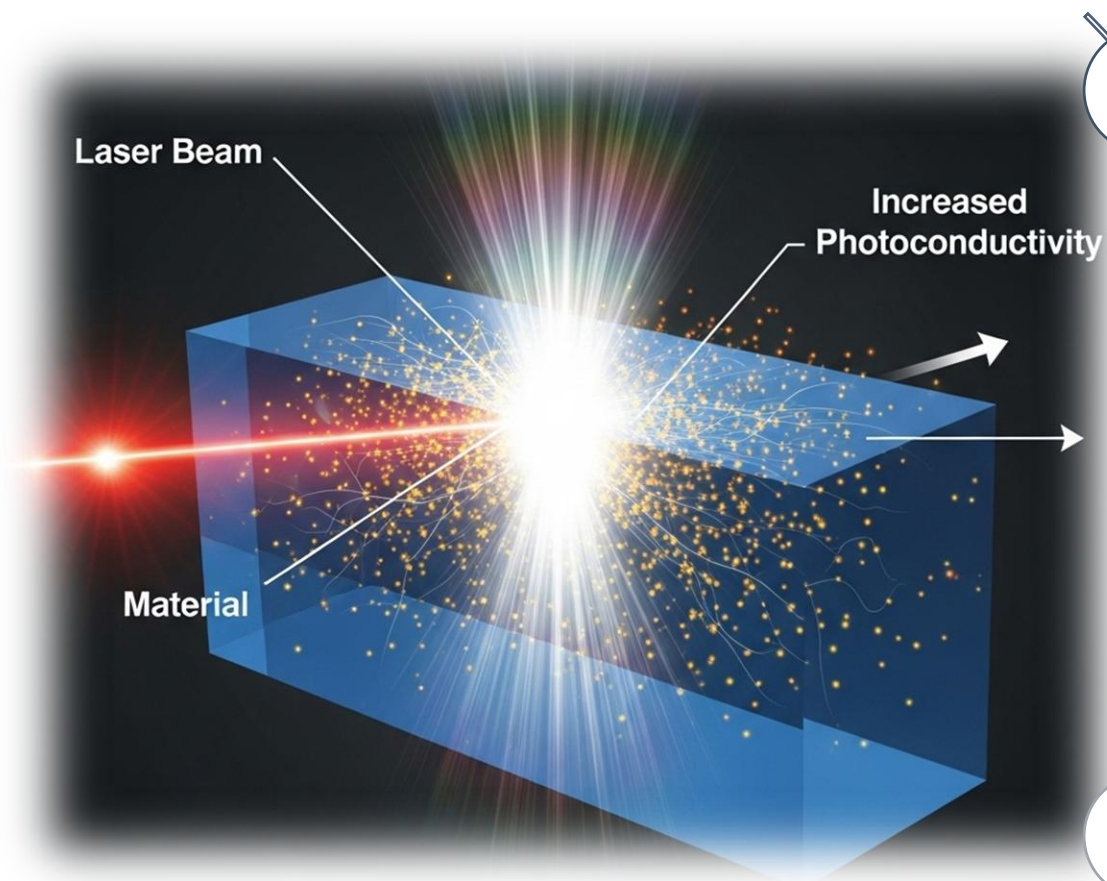
Wiesław Strek, Robert Tomala, Mikołaj Łukaszewicz, Bartłomiej Cichy, Yuriy Gerasymchuk, Paweł Gluchowski, Łukasz Marciniak, Artur Bednarkiewicz & Dariusz Hreniak



Graphene foam – emission stability

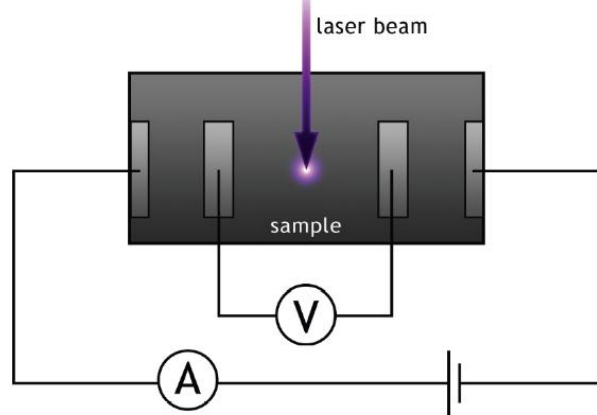
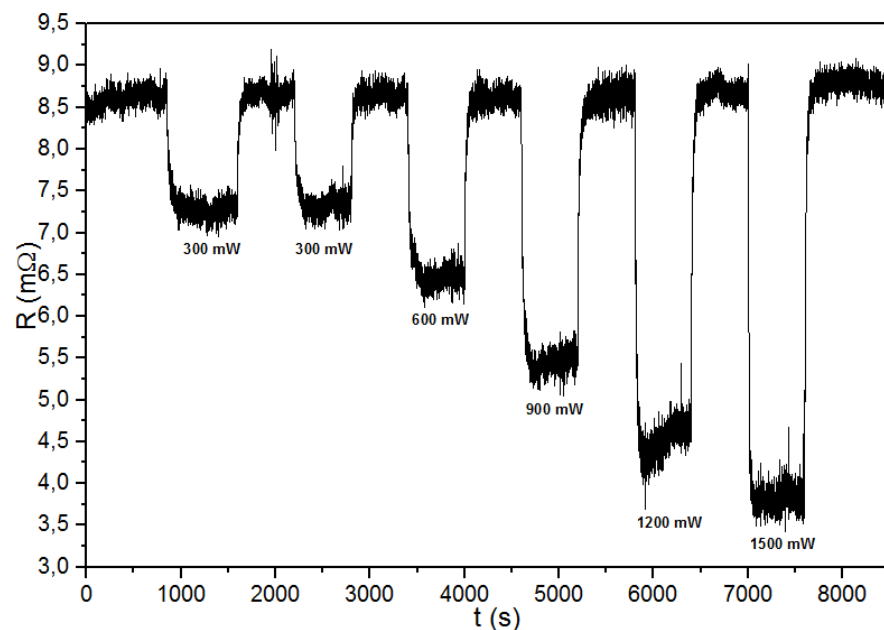


Why photoconductivity is important?

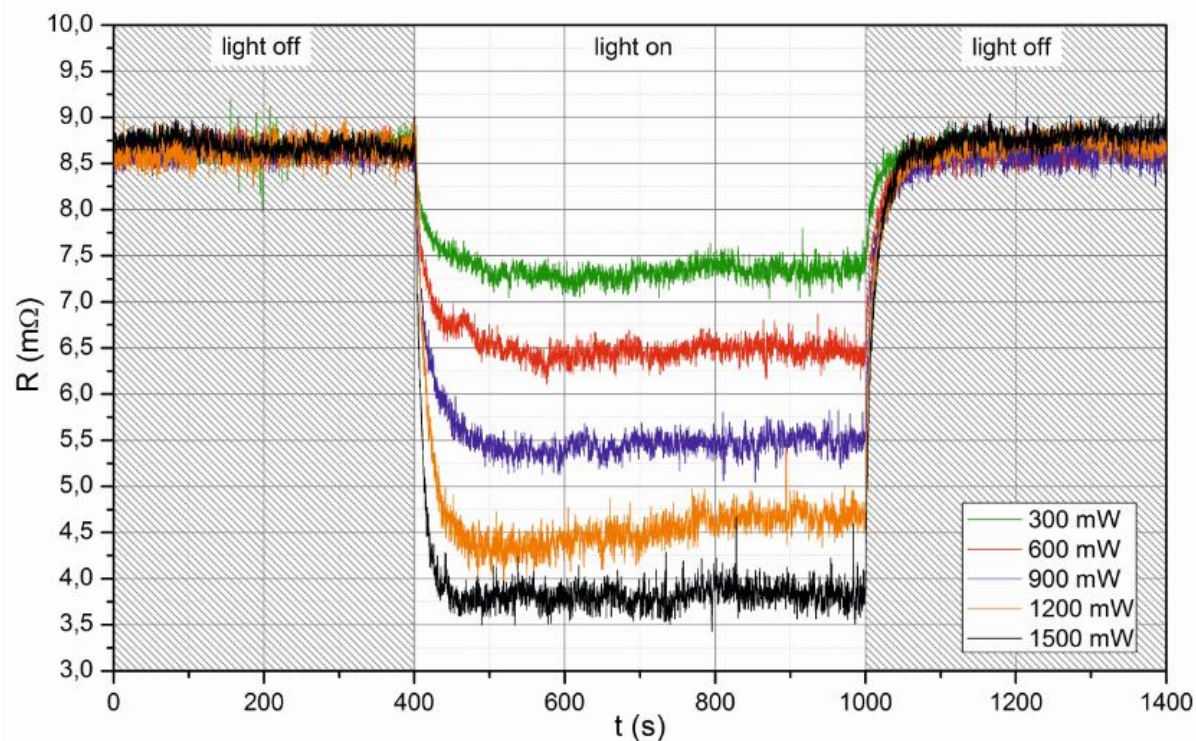


- Supporting the LIWE phenomenon
- Increased conductivity
- Effective energy absorption
- Increased free charge carriers
- Lowering the excitation threshold
- Programmable optoelectronic devices

Temporal change in the sample resistivity

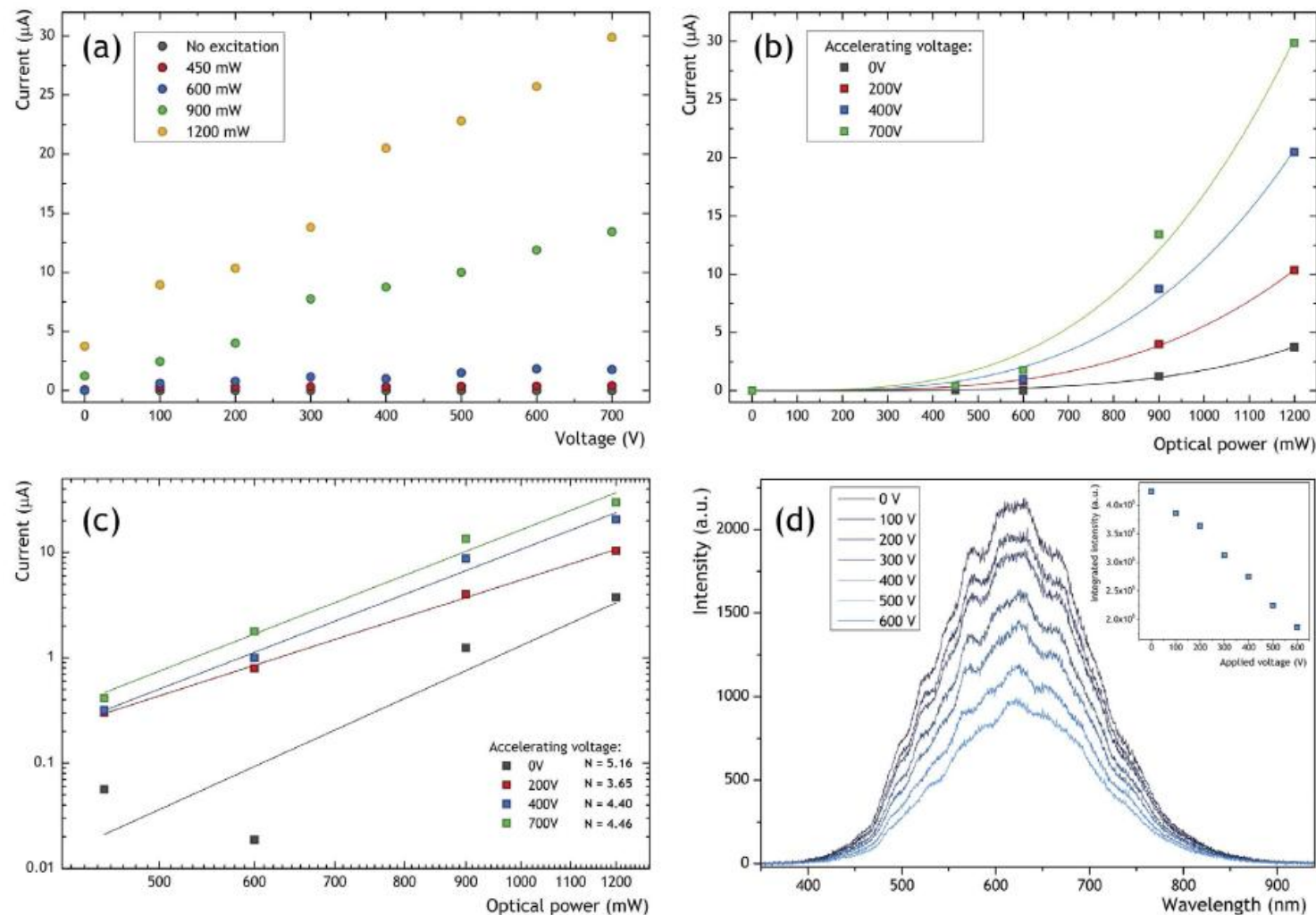


Single turn on/turn off resistance changes



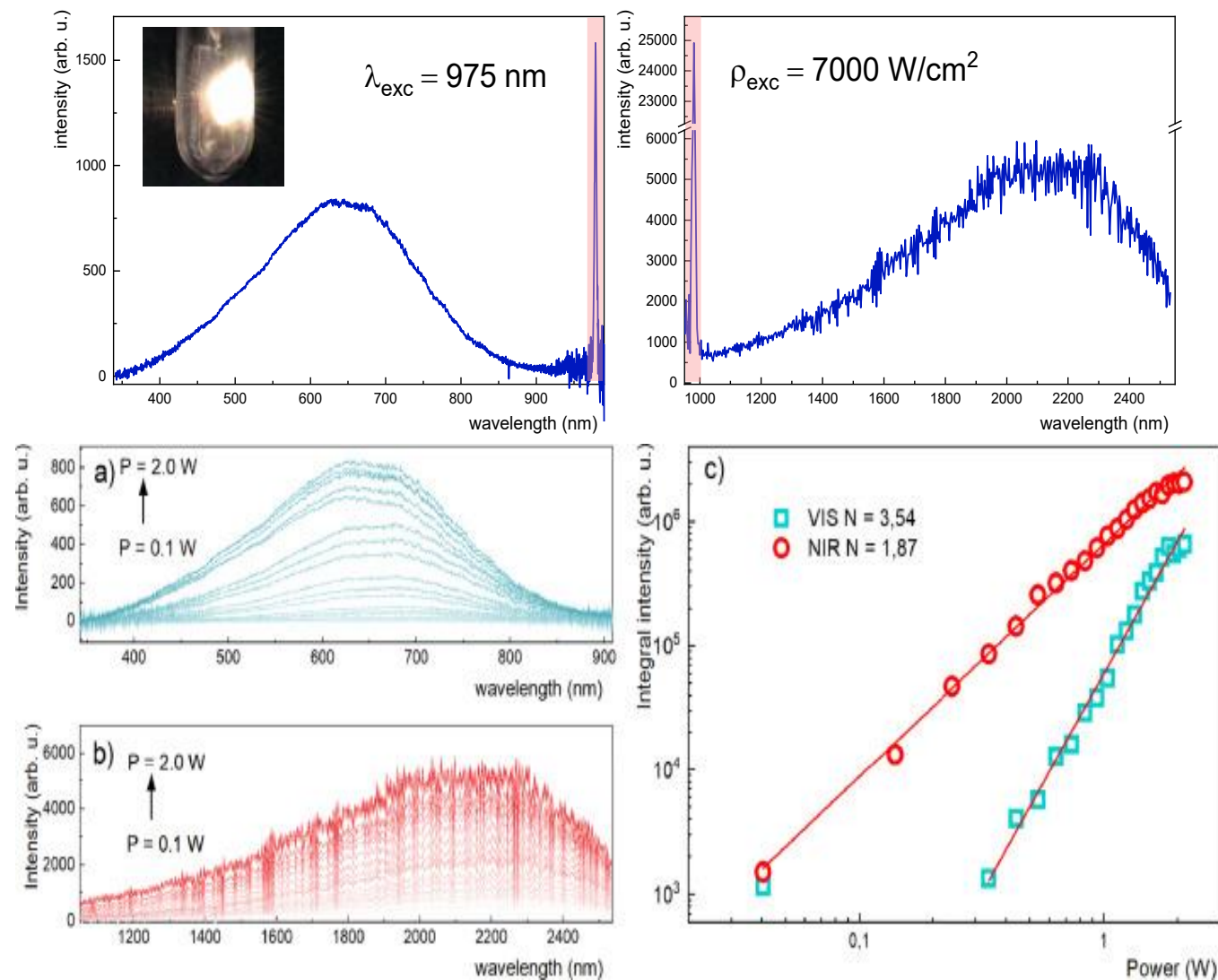
Photocurrent measurements + hot electrons generation

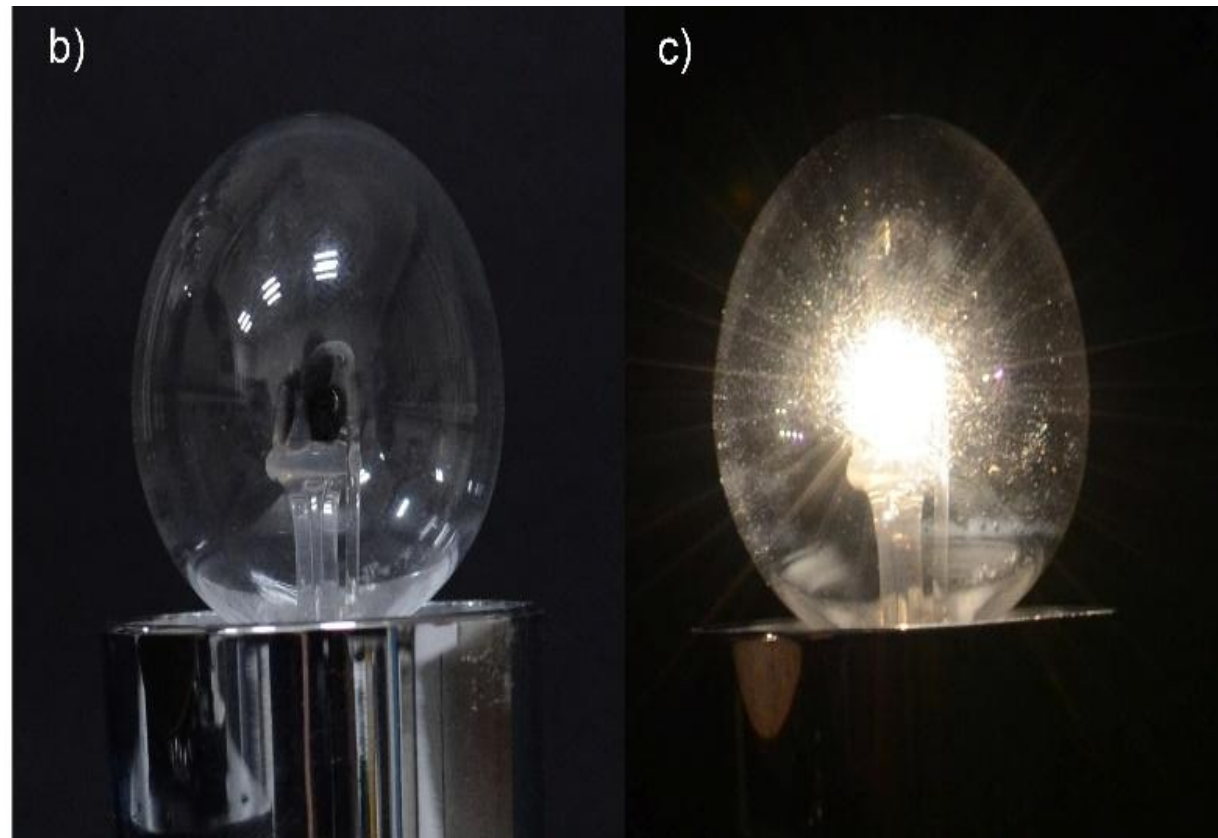
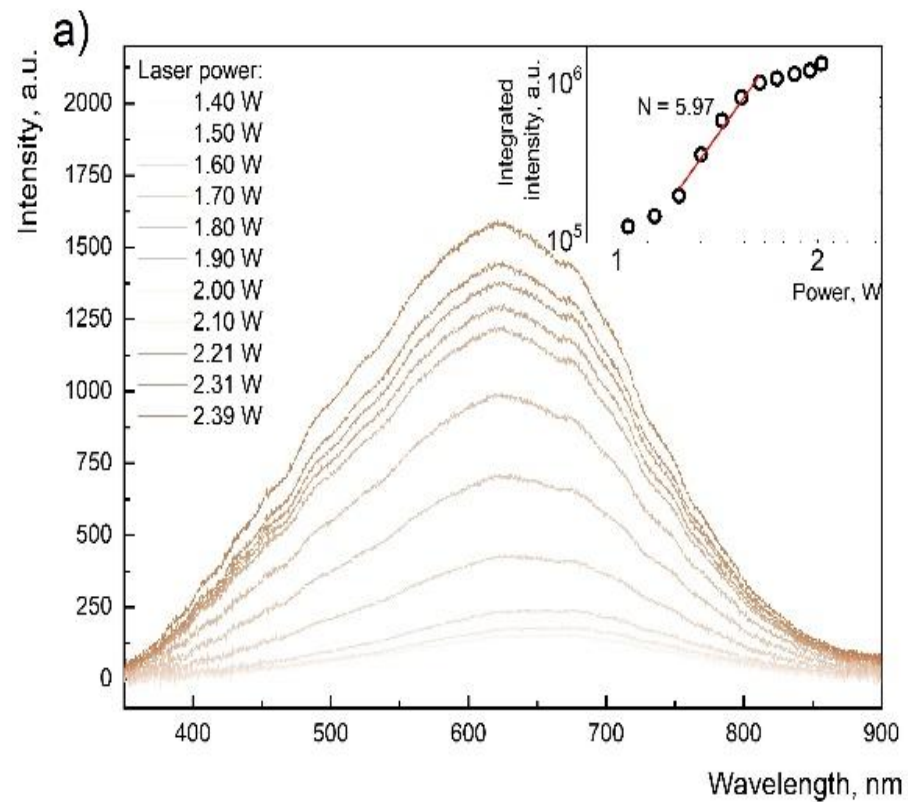
Applied electric field influence



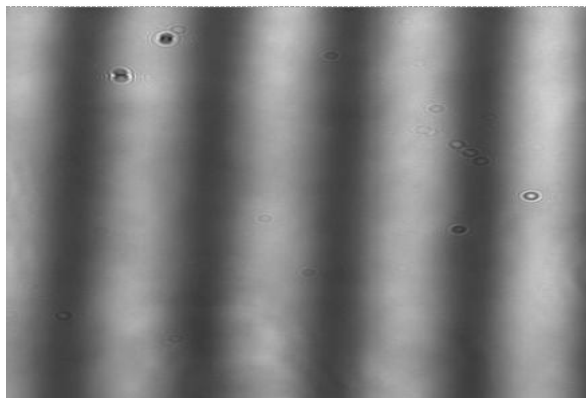
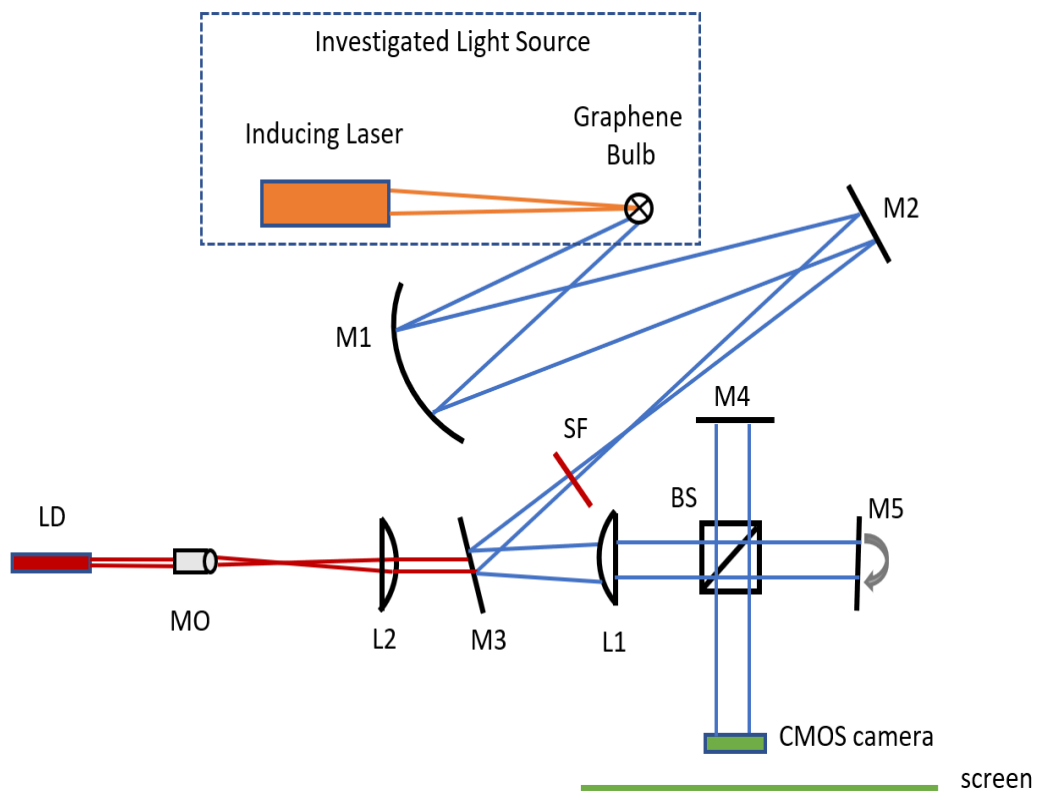
Graphene foam emission

Visible and NIR broadband emission

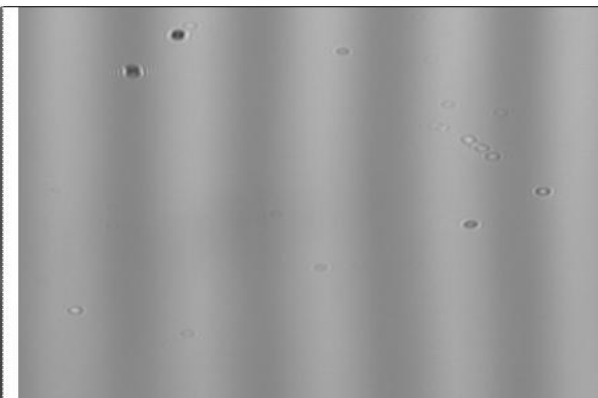




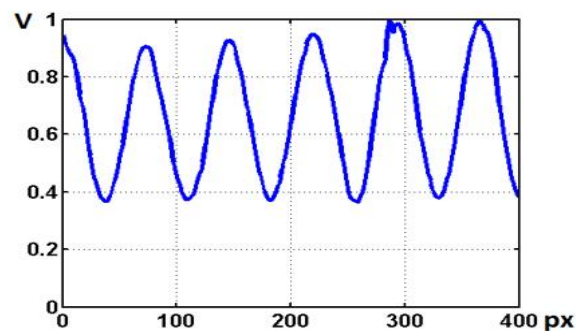
Coherence properties of graphene light – entrance do White Laser?



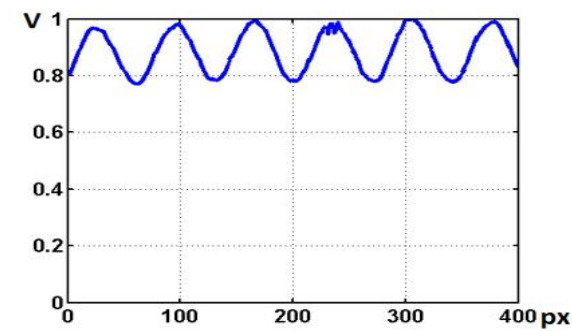
(a)



(b)



(c)

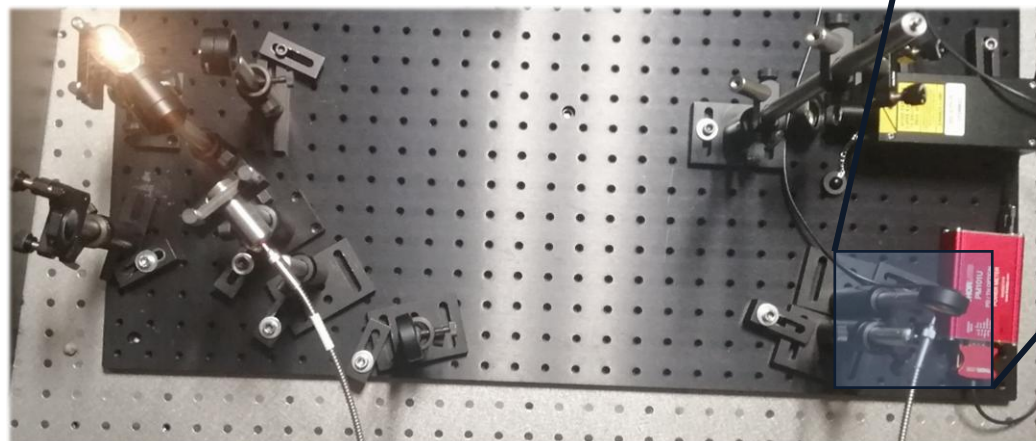
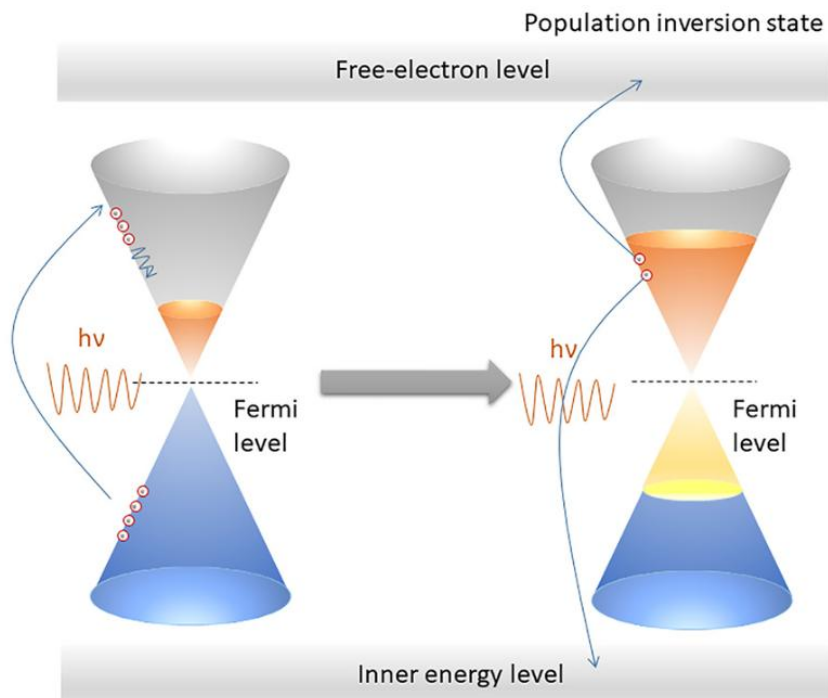


(d)

Coherence properties of graphene light – entrance do White Laser?

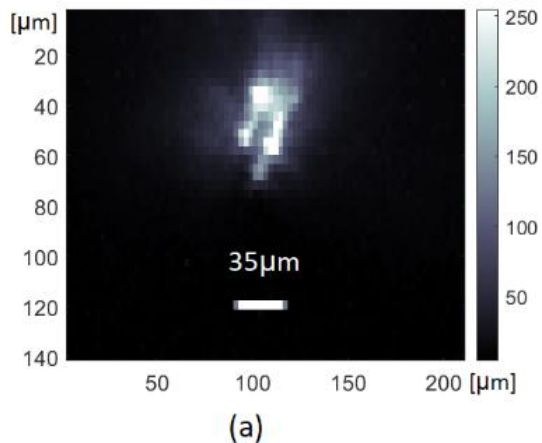
- ✓ Inversion of population
- ✓ Coherence
- ✓ High power density
- ✓ White laser???

- emissivity depends on morphology, porous structure of graphene foam is an advantage
- emissivity higher than for an electric lamp with tungsten filament
- decay of light power over time

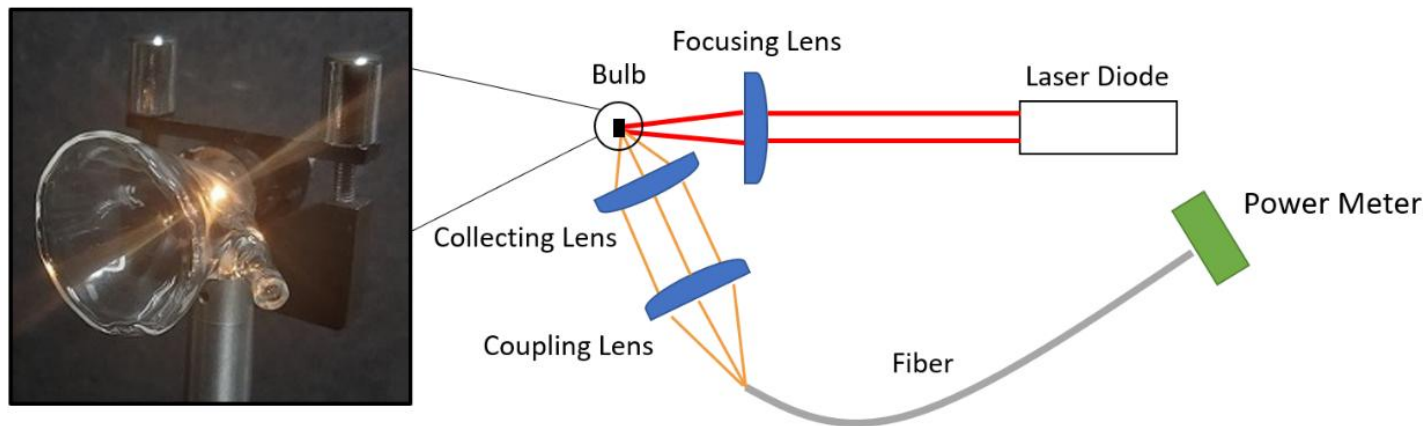
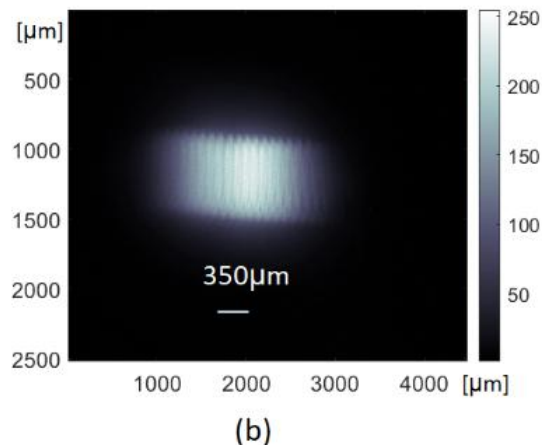


Graphene light - point source

Graphene bulb

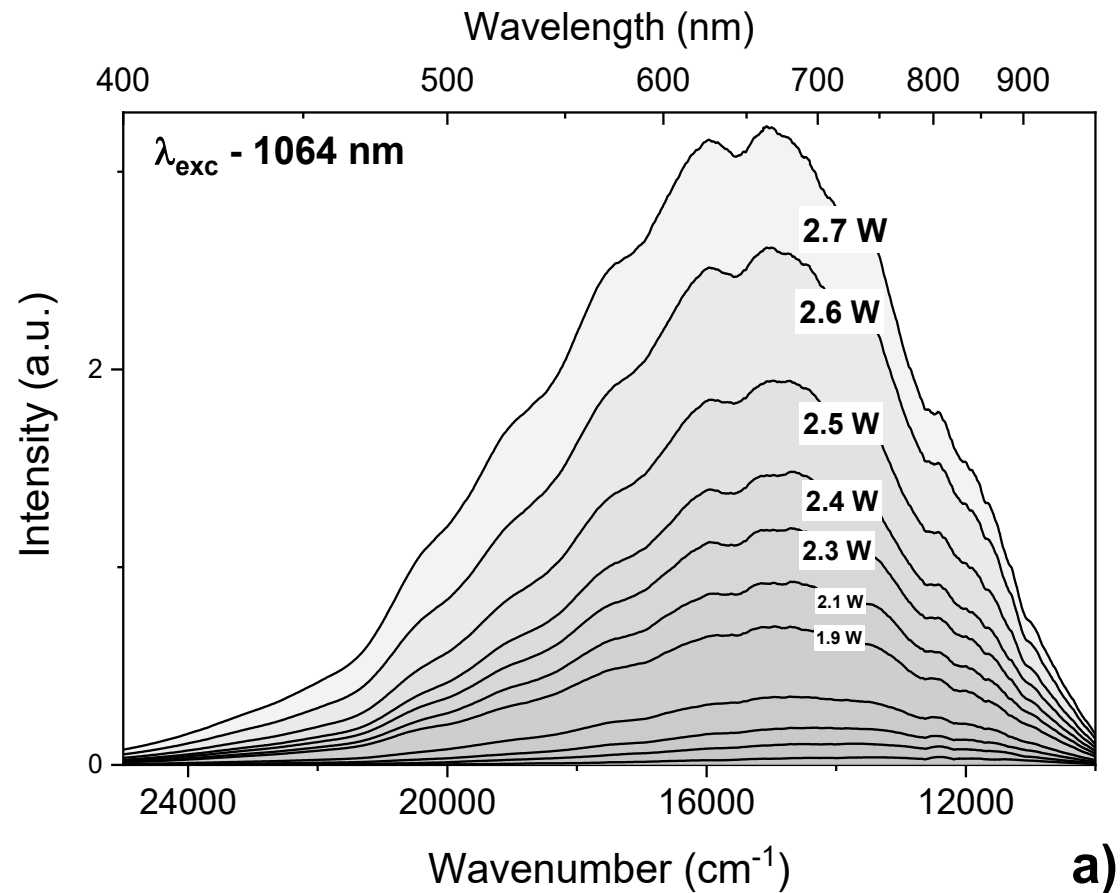
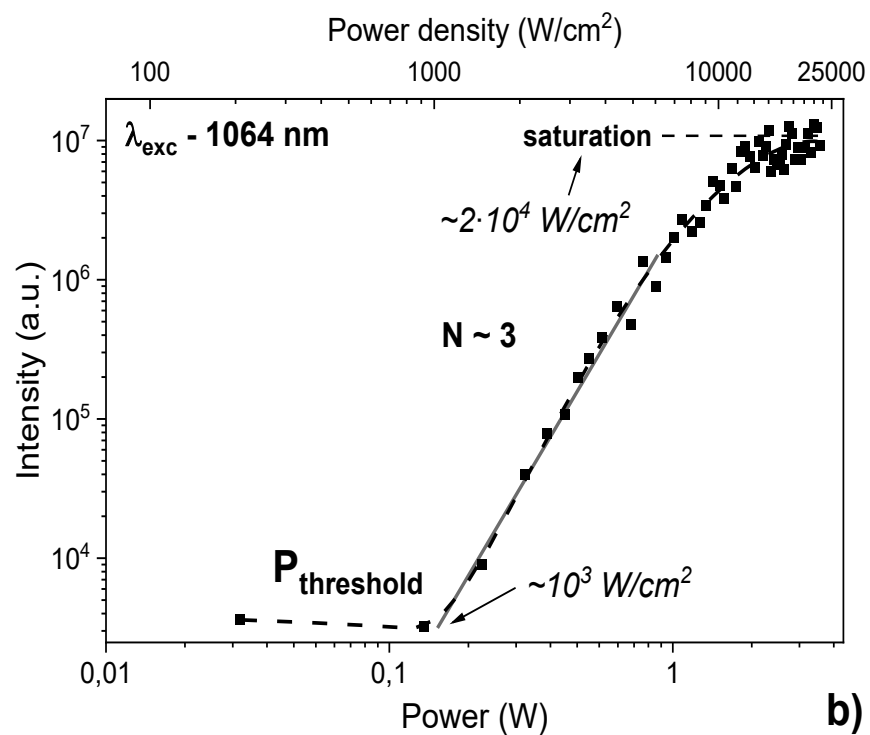


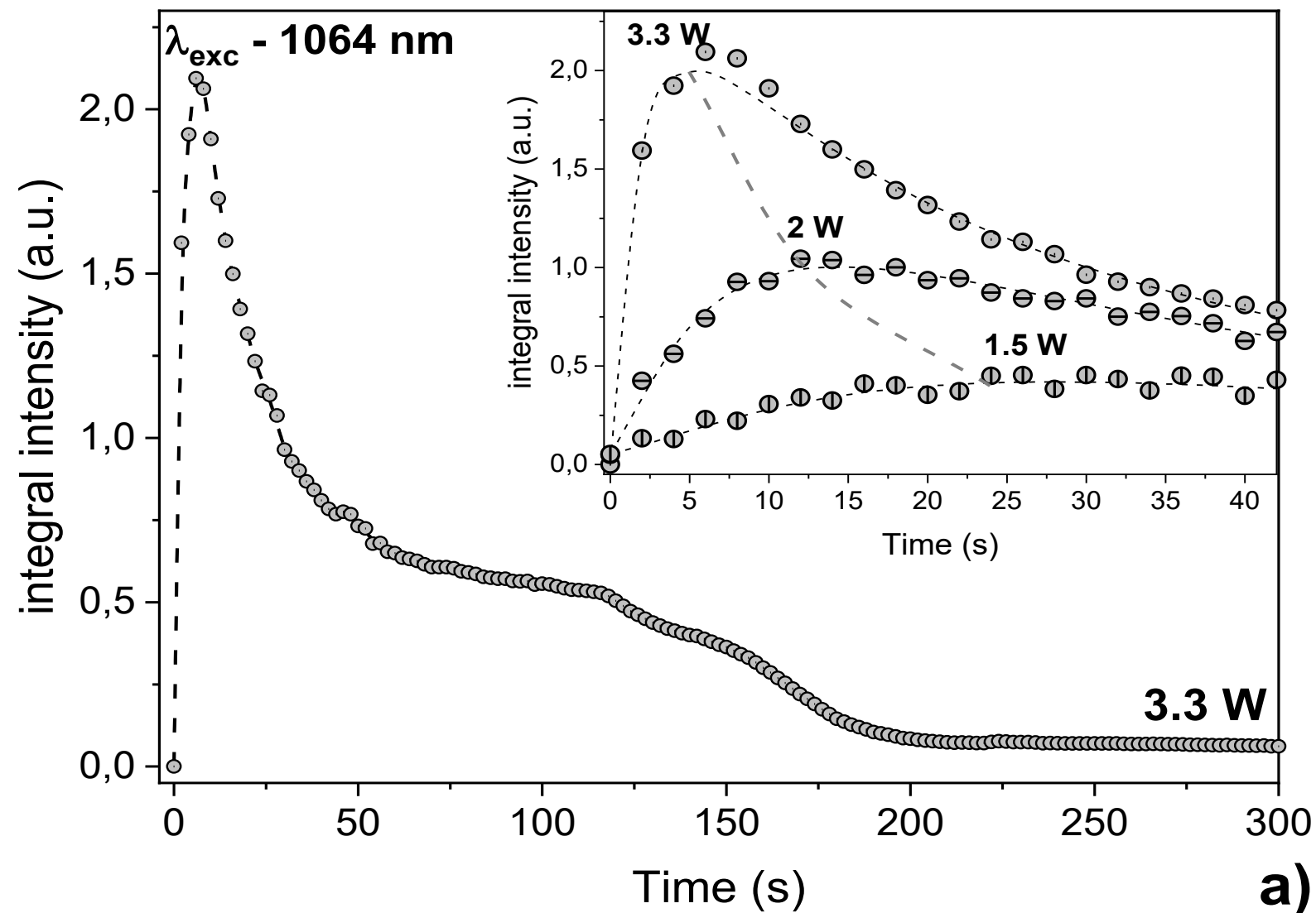
Tungsten bulb



	Graphene Bulb Power [mW]	Tungsten Bulb Power [mW]
Input	0,77	13
1500 μm fiber	0,42	3,86
400 μm fiber	0,16	0,36

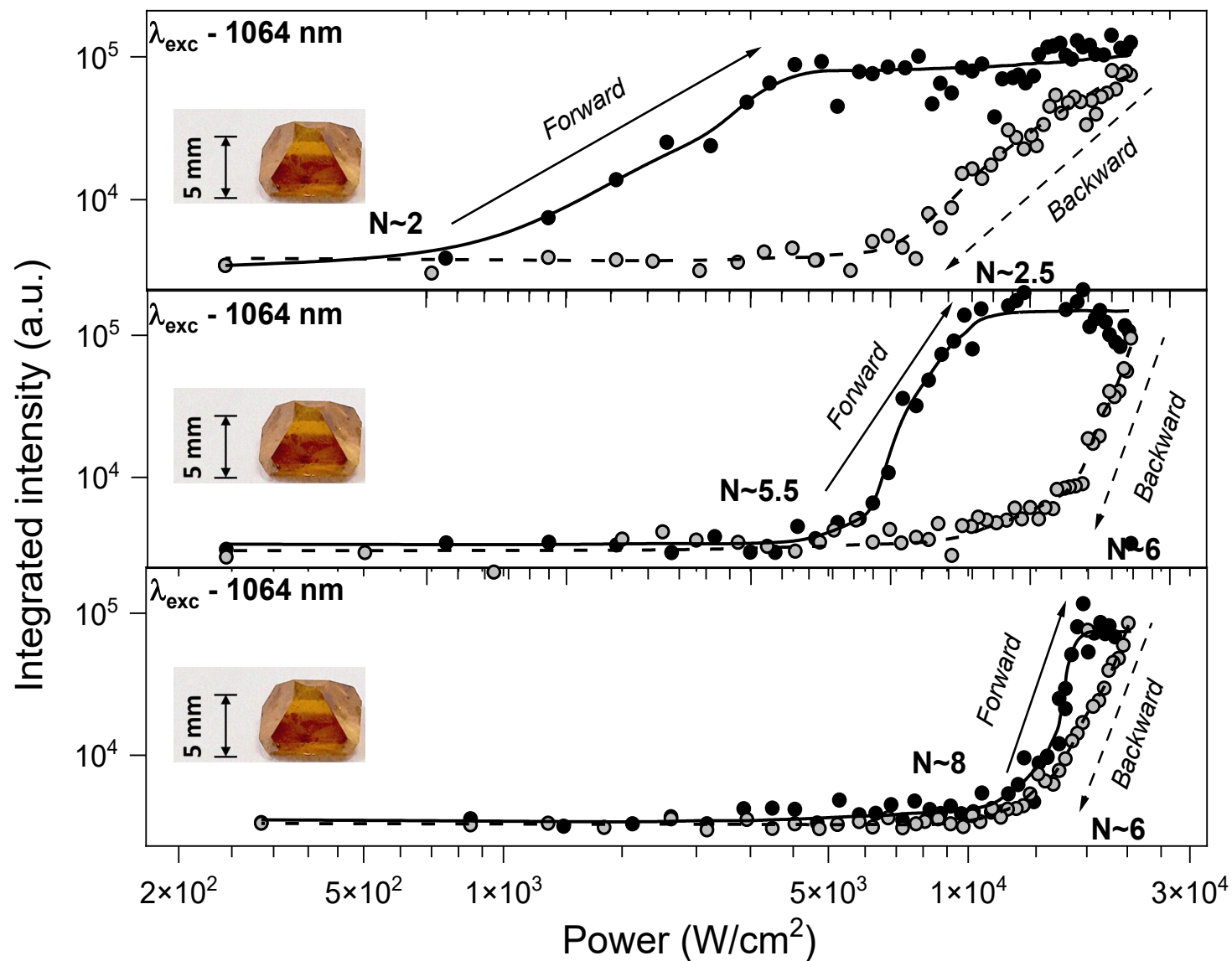
Diamond single crystals



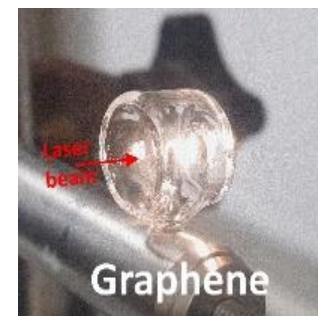
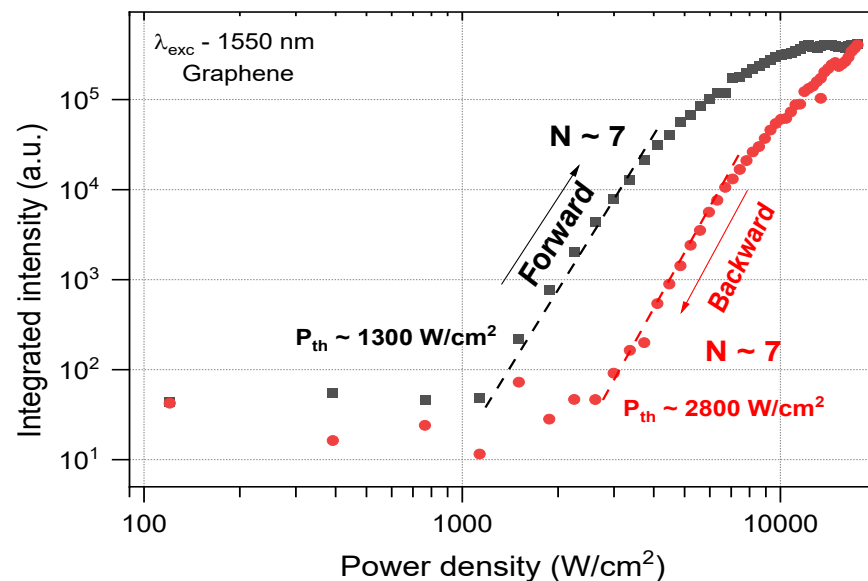
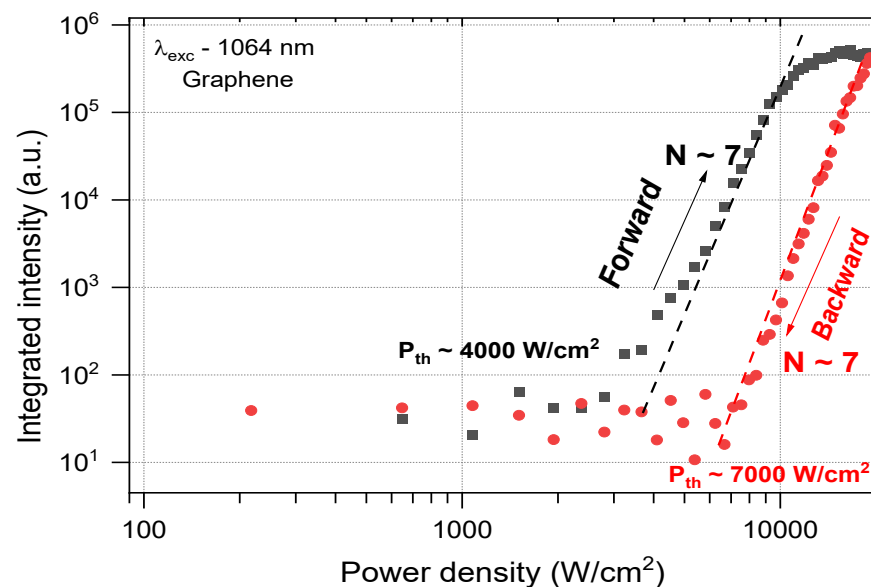
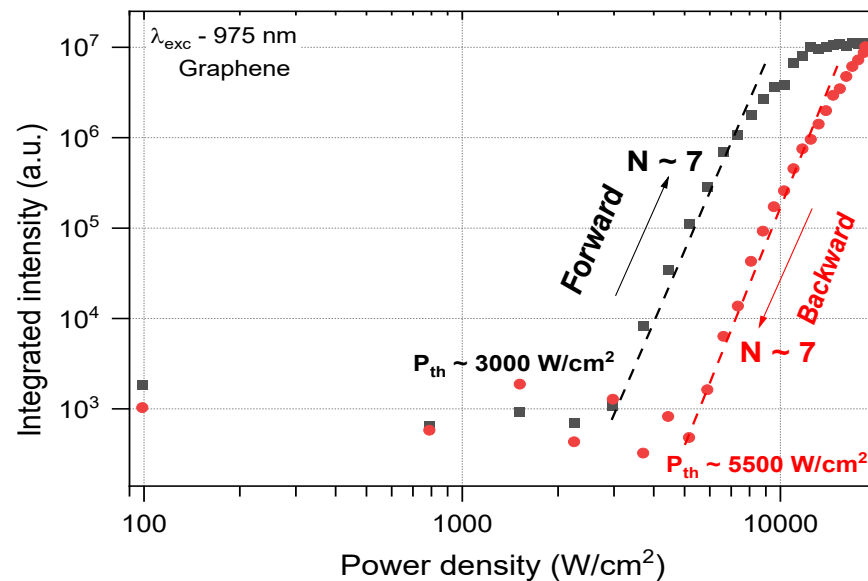
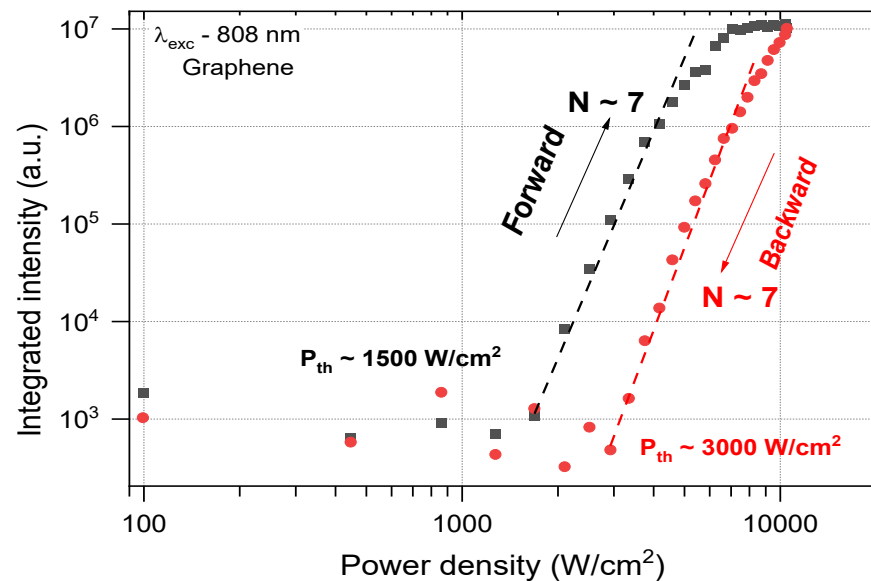


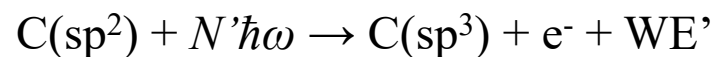
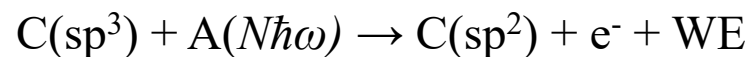
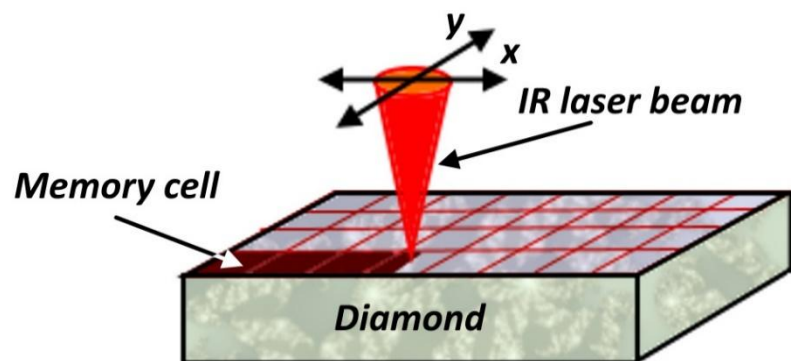
The time evolution
of LIWE intensity
of diamond crystal

Diamond single crystals – hysteresis loop

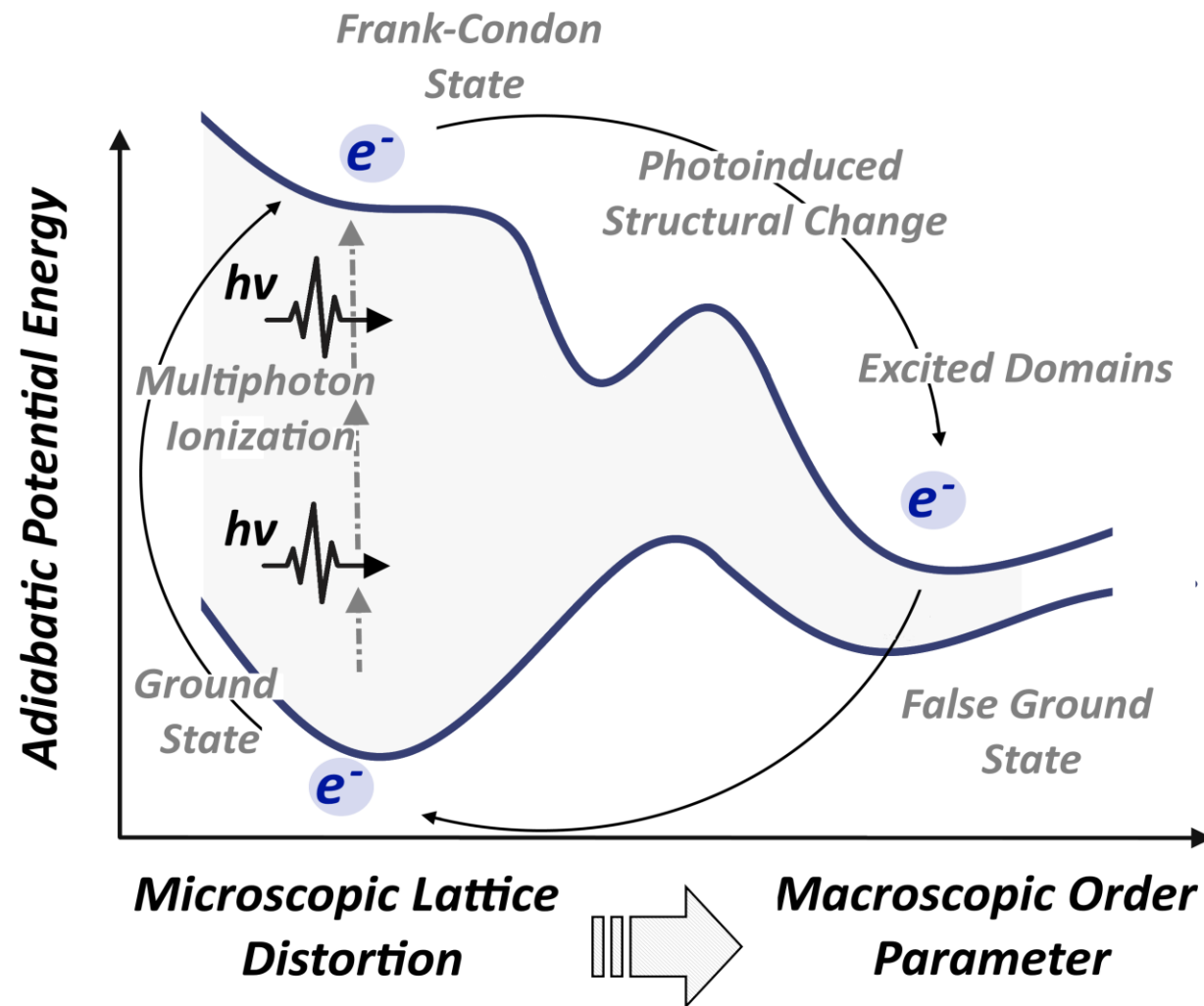


Hysteresis loop – graphene foam

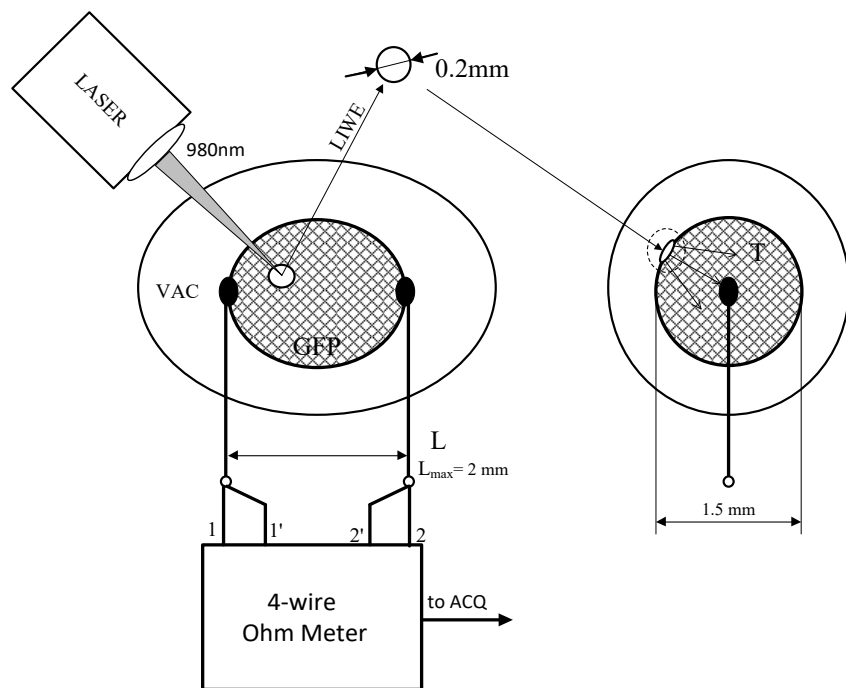




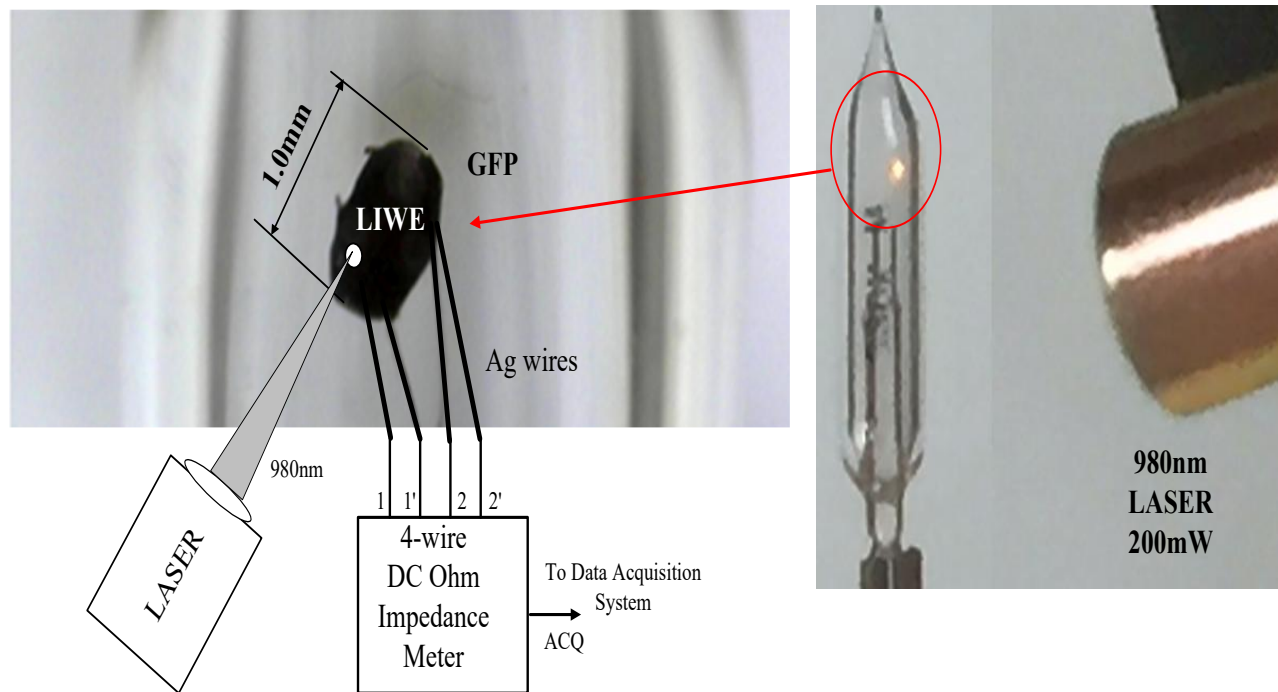
Schematic and conceptional natures of photo-induced structural phase transition



The new investigation of photoresistivity of Graphene foam



The measurement scheme of electric resistivity of graphene foam sample under irradiation with a focused beam of laser diode.



The photo of graphene foam sample with electrodes.

Chemical Physics Letters 893 (2026) 142848



Contents lists available at ScienceDirect

Chemical Physics Letters

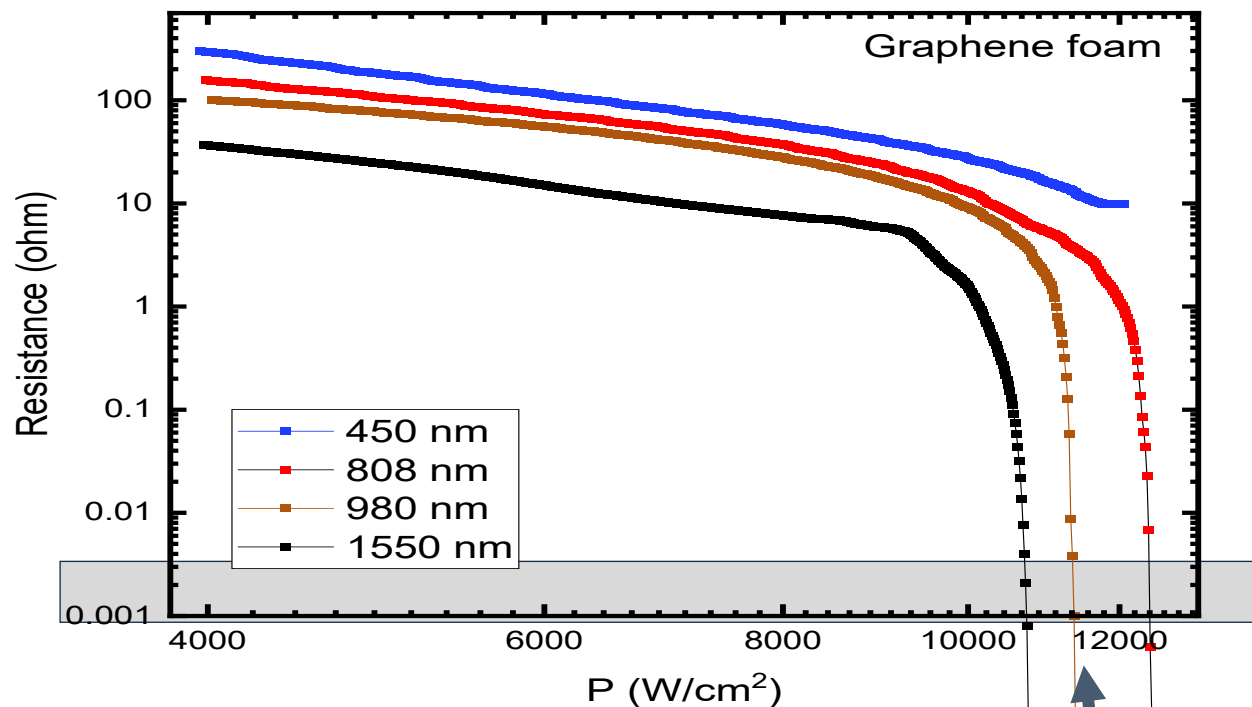
journal homepage: www.elsevier.com/locate/cplett

Influence of laser-induced white emission on the resistivity of graphene foam

P. Wiewióński, R. Tomala, M. Stefanski*, A. Musiałek, M. Samsel-Czekala, W. Strek

Institute of Low Temperature and Structure Research, Polish Academy of Sciences, 50-422 Wrocław, Poland

The new investigation of photoresistivity of Graphene foam

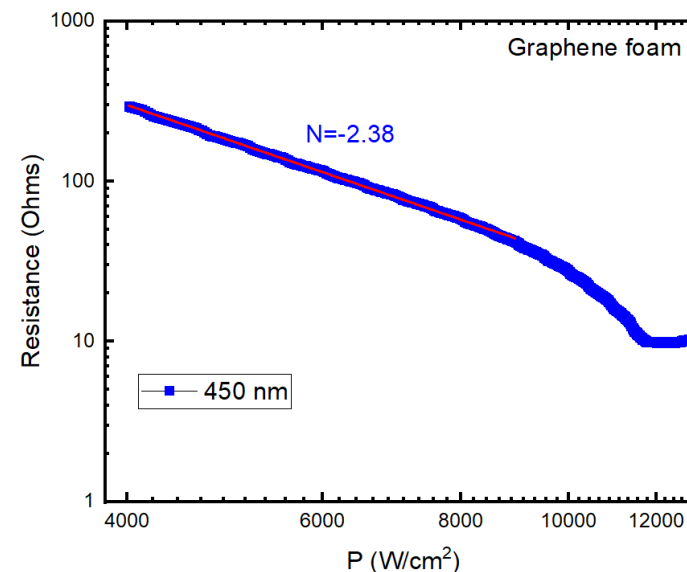
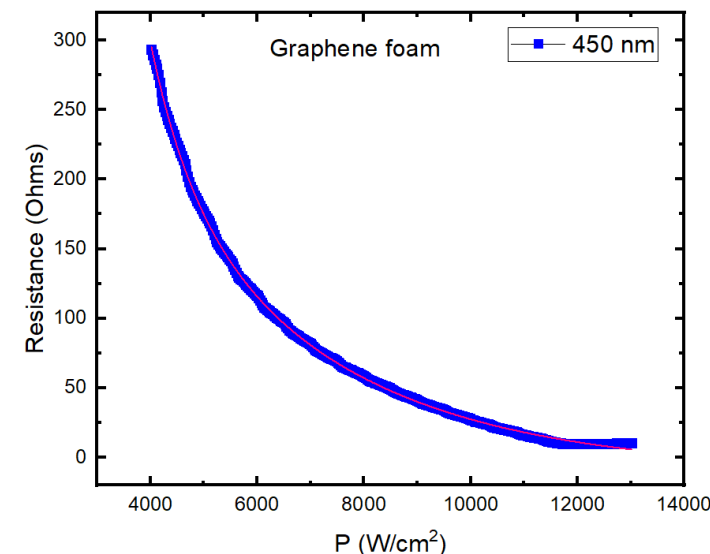


$$I(\text{LIWE}) \propto P_L^N$$

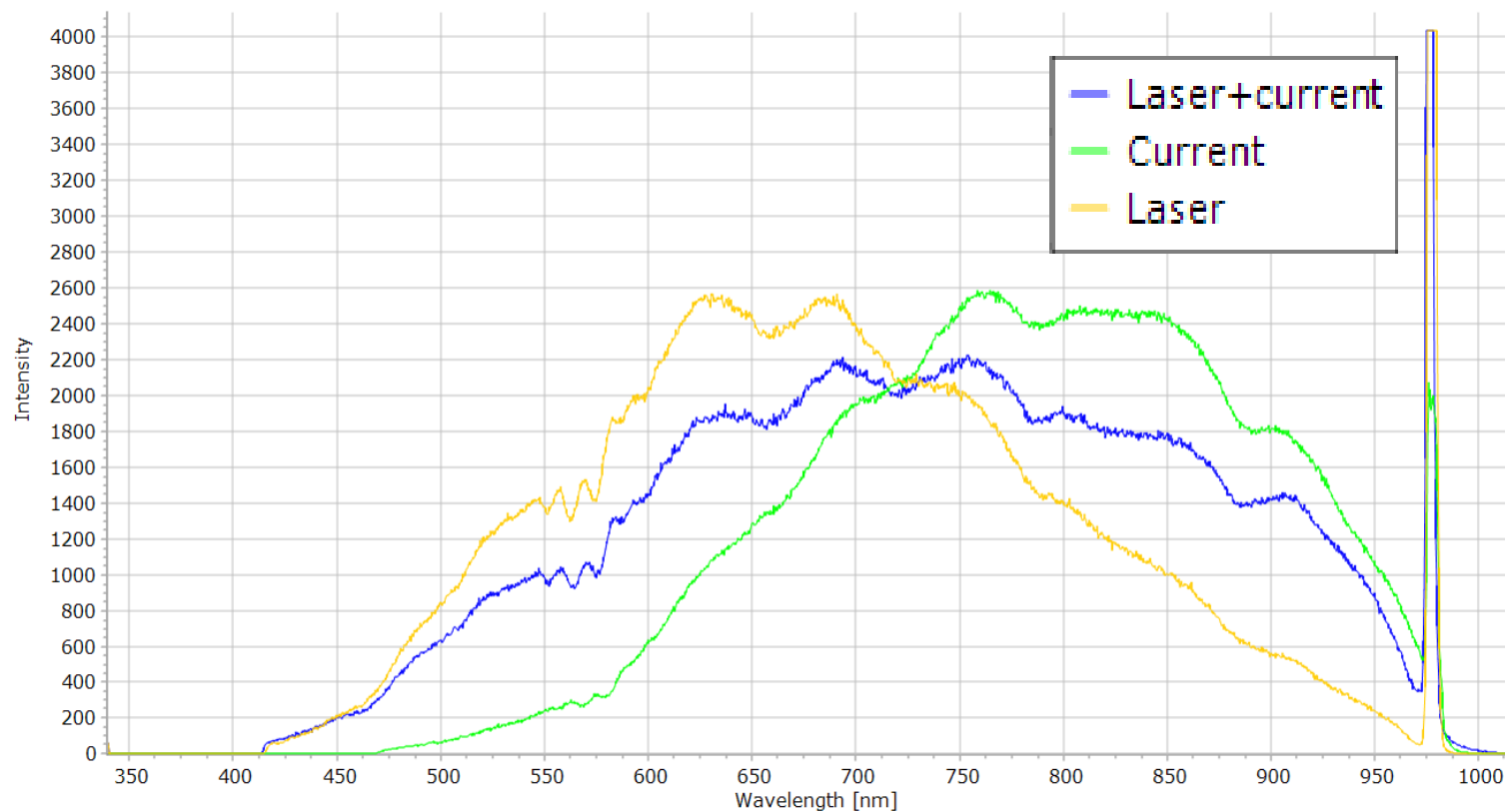
$$I(\text{LIPC}) \propto P_L^{N'}$$

Almost to zero !!

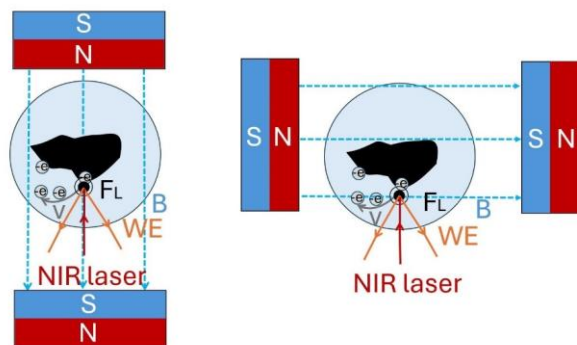
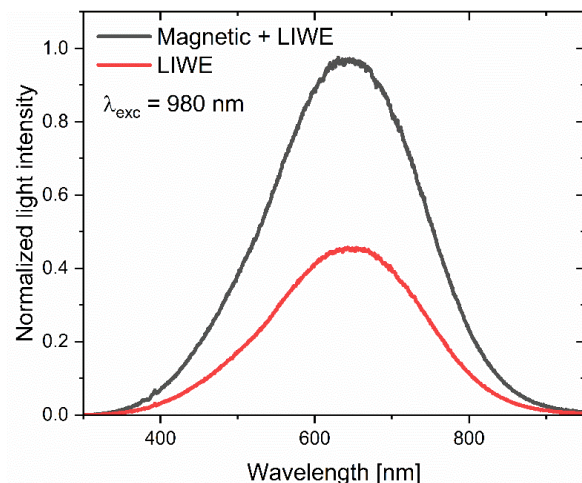
It is connected with a formation of photon coupled pair of electrons ($e-h\omega-e$).



Excitation method – simultaneous laser, current and ionization



Magnetic field effect on laser induced emission of graphene foam

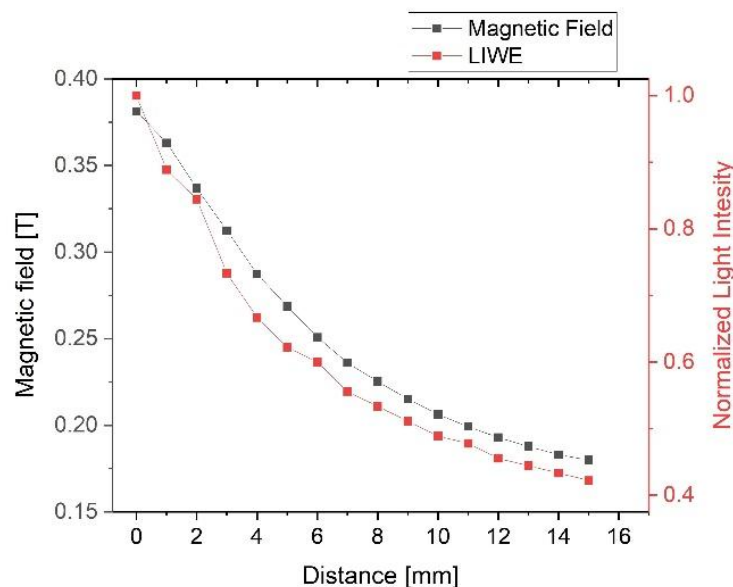


(a)

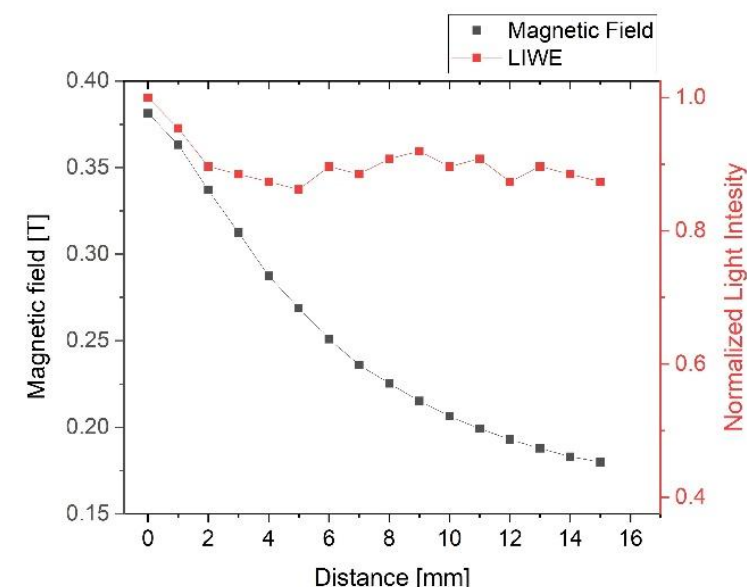
(b)

The influence of magnetic field on the LIWE intensity in terms of the Lorentz force F_L

$$F_L = q(E + v \times B)$$



(a)



(b)

RESEARCH ARTICLE | SEPTEMBER 01 2025

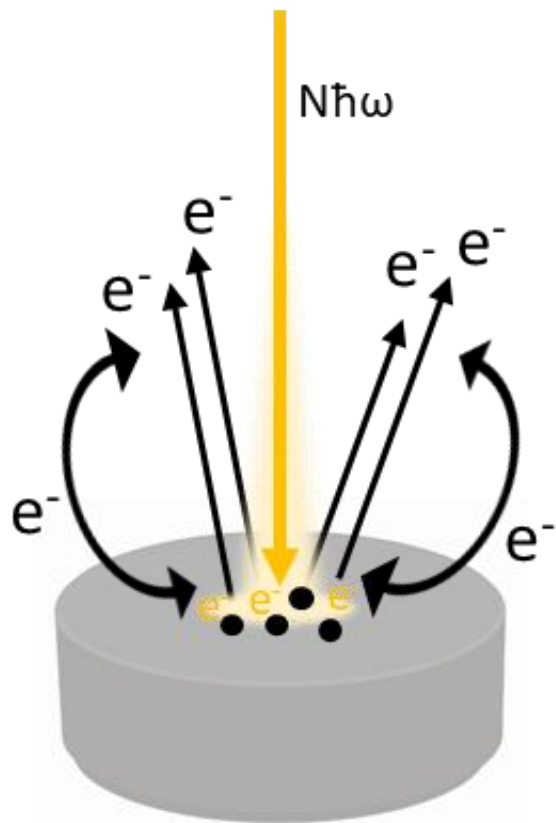
Magnetic field effect on laser-induced white emission of graphene foam

Special Collection: To the 75th Birthday of Professor Andrzej Jeżowski

M. Oleszko ; R. Tomala ; A. Musialek ; P. Wiewiórski ;
M. Kowol ; W. Strek

The vector configuration illustrating magnetic field applied to LIWE of GF. a) in case of the magnetic field aligned parallel to the laser propagation direction, b) in case of the magnetic field aligned perpendicular to the laser propagation direction.

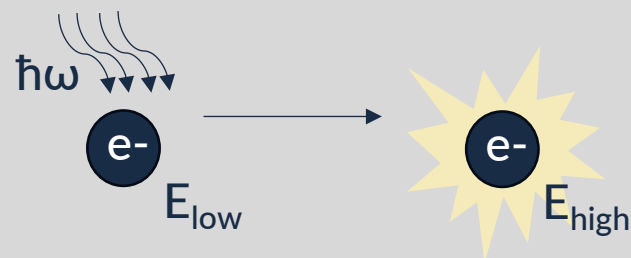
Chain reactions?



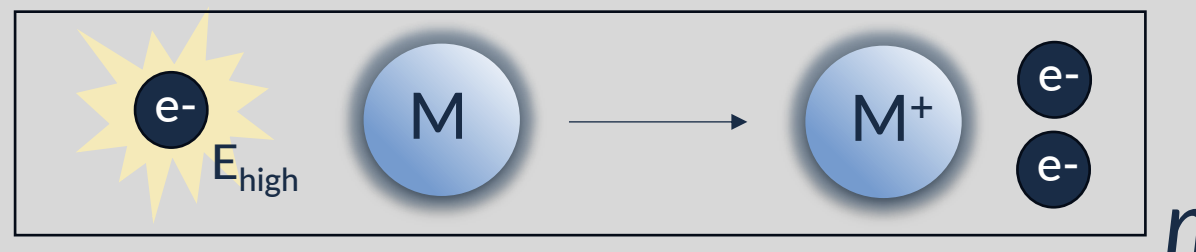
Initiation (Photoionization): $M + N\hbar\omega \rightarrow M^{++}e^{-}$



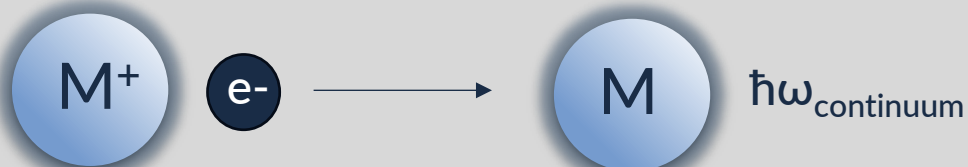
Reverse Braking Radiation: $e^{-}(E_{\text{low}}) + m\hbar\omega \rightarrow e^{-}(E_{\text{high}})$

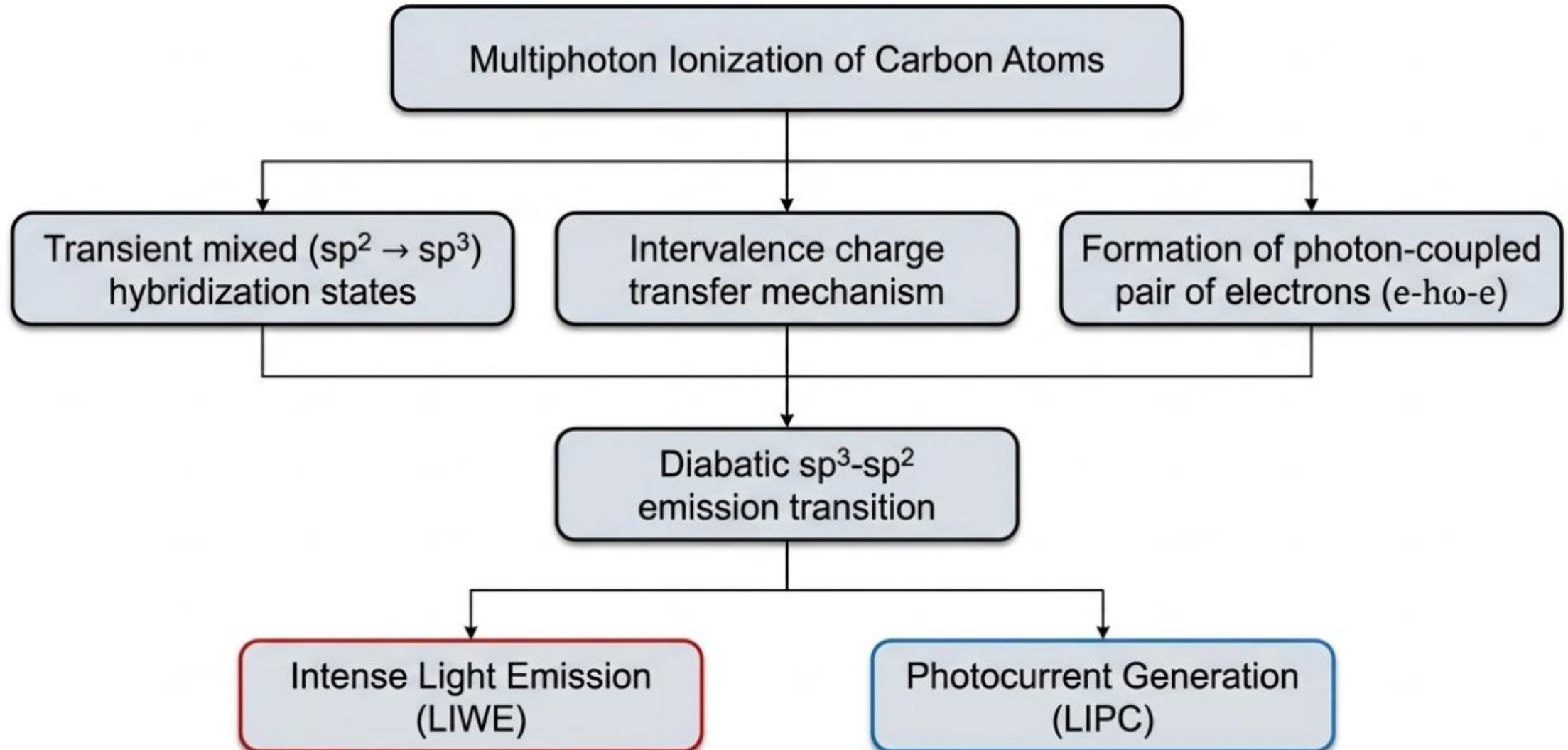


Propagation (Collision Ionization): $[e^{-}(E_{\text{high}}) + M \rightarrow M^{++} + 2e^{-}]_n$



Termination (Recombination/Emission):





Lighting

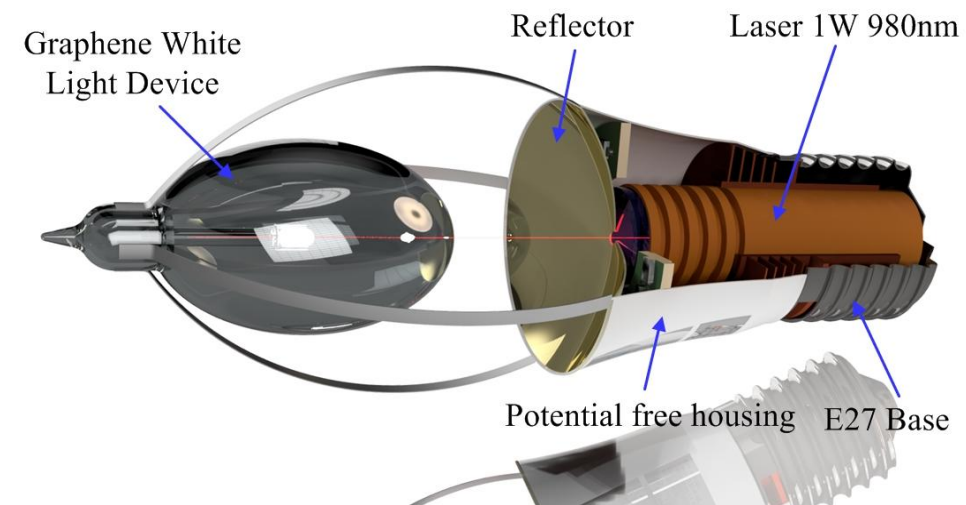
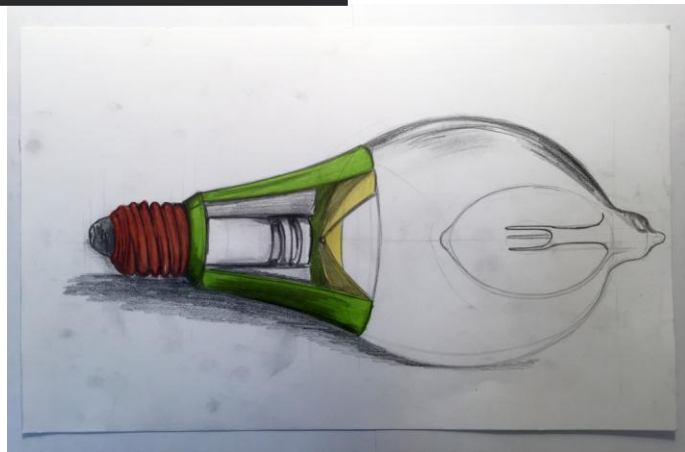
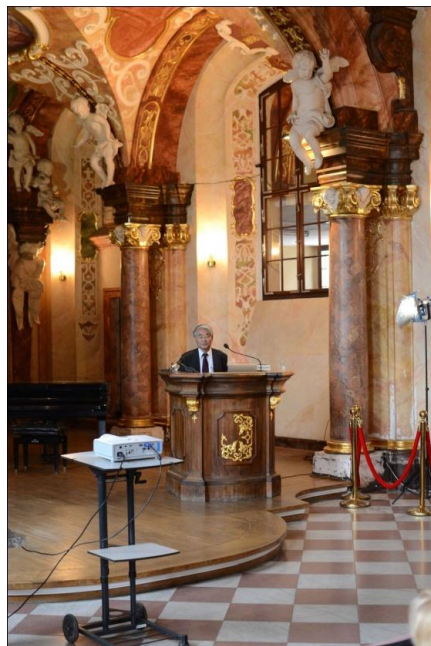
Photoconductivity

Generation of free electrons

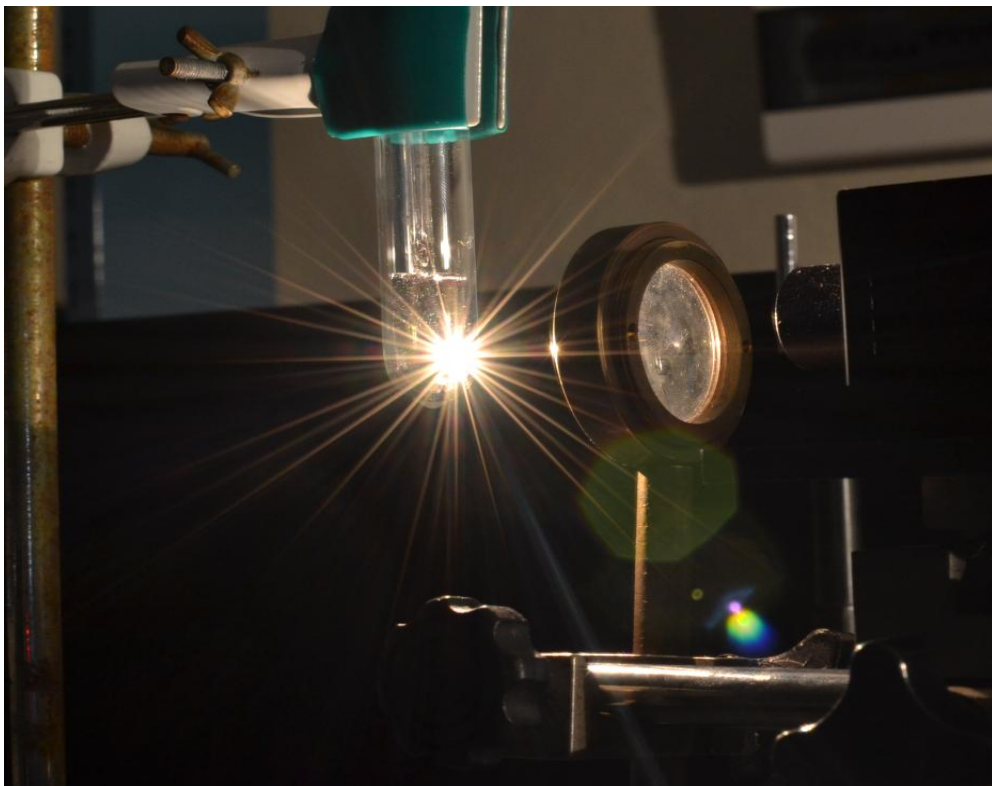
Memory via local ionization (hysteresis)

Hydrogen generators

Graphene Innovations – lighting from concepts to implementation



The development of Invention



The First Laboratory Demonstrator

Graphene as light source



Edison-type bulb

The d

From idea to prototypes

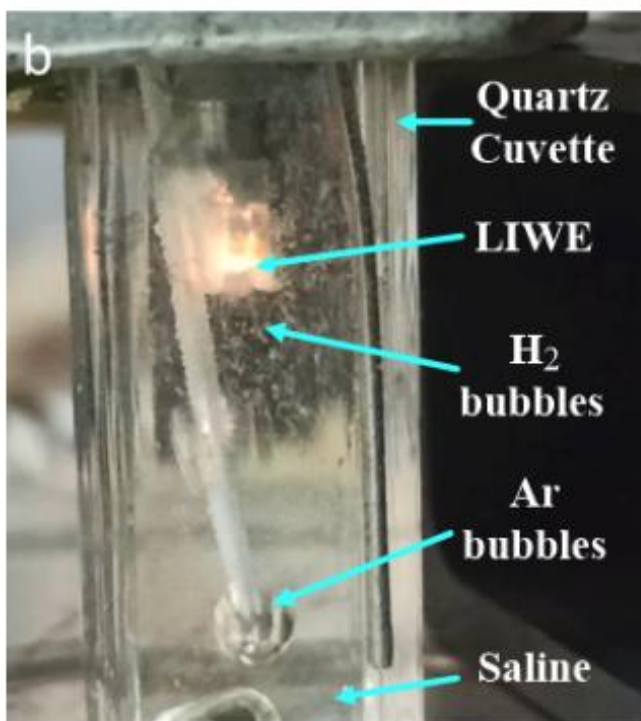
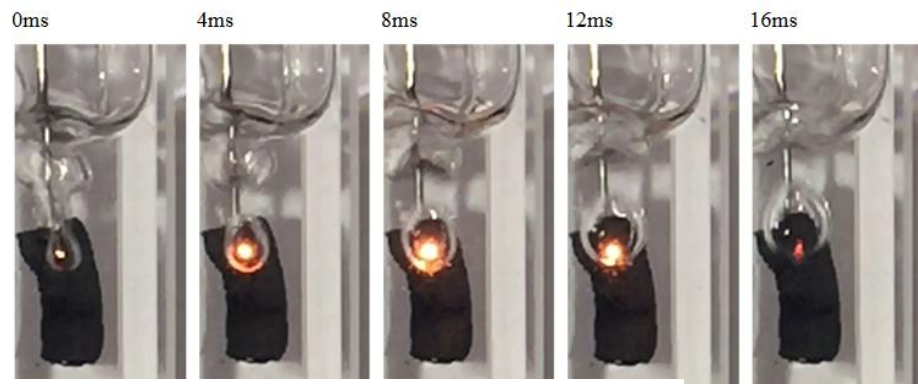
Graphene bulb with build-in reflector for automotive application



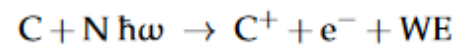
The First Laboratory Demonstrator

Edison-type bulb

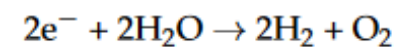
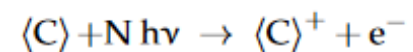
Applications -Hydrogen generation



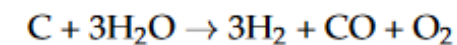
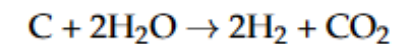
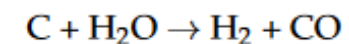
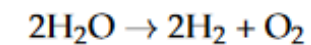
Multiphoton absorption



Laser-induced splitting of water in the presence of graphene

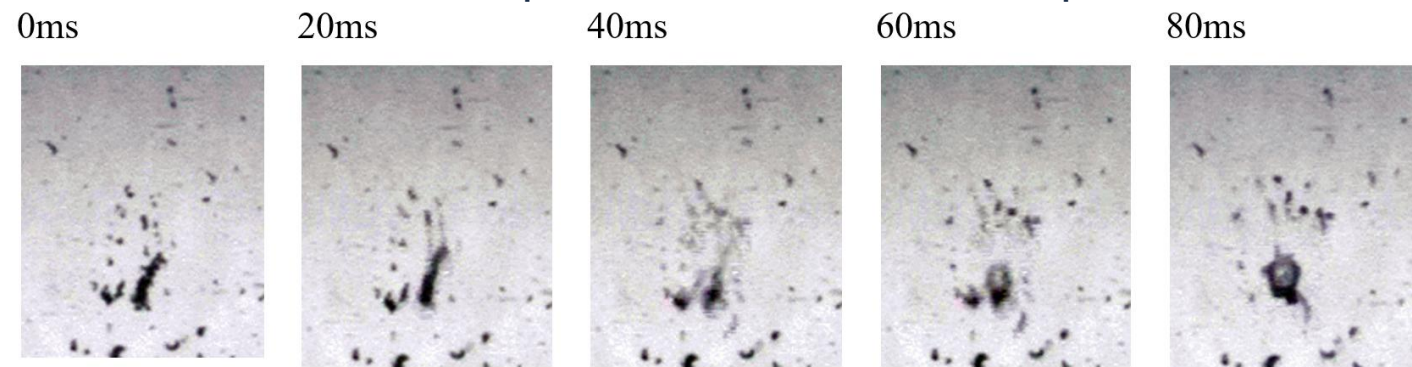


The splitting of water by electrolysis

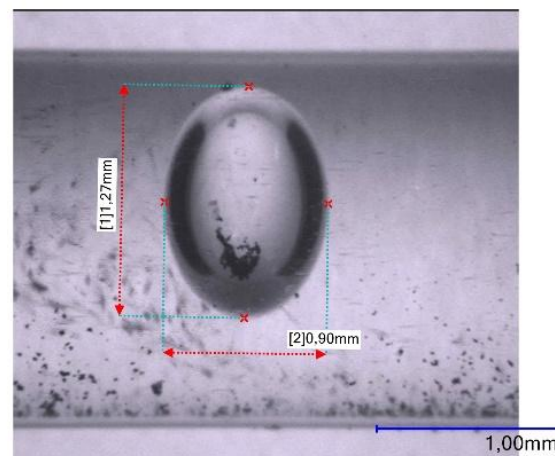
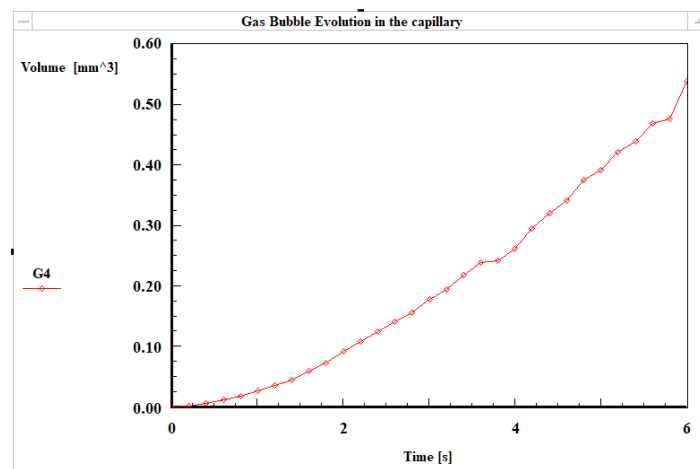


Kinetics of laser-induced single bubble on Graphene foam

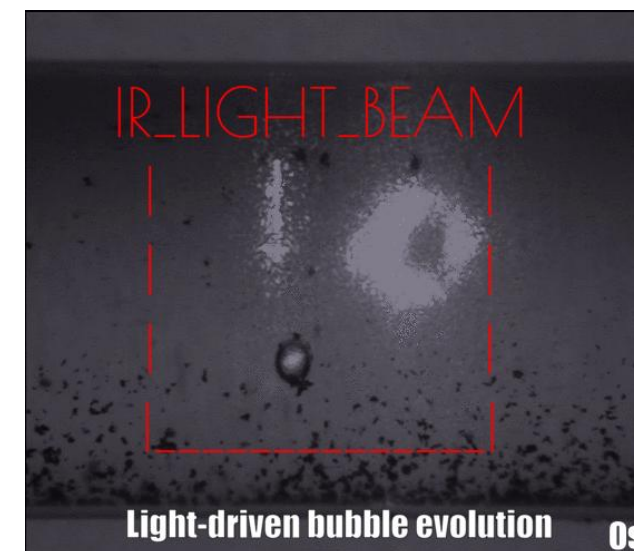
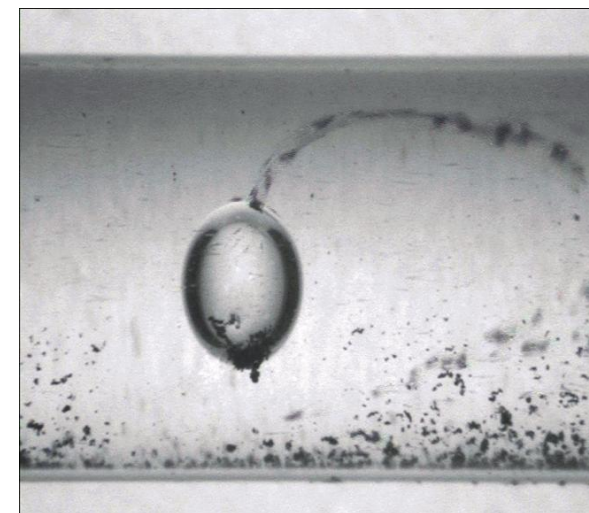
Initiation process of bubble on Graphene



Suspended bubble by Graphene flow

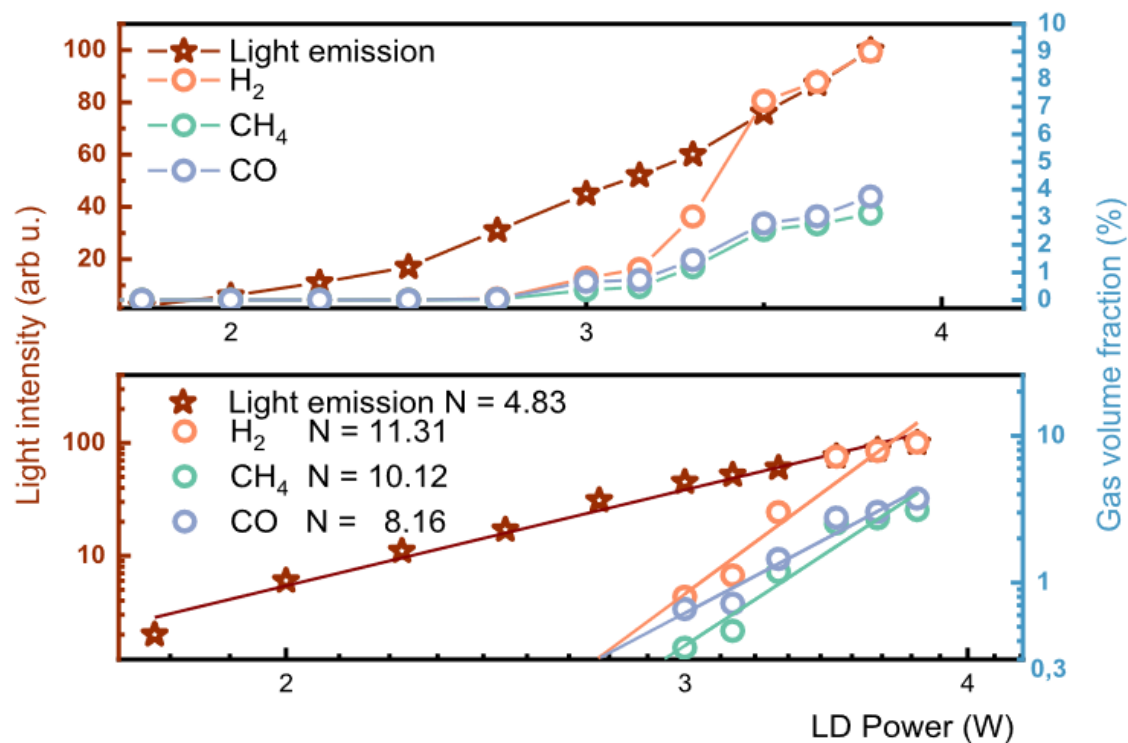


Graphene bubble interactions



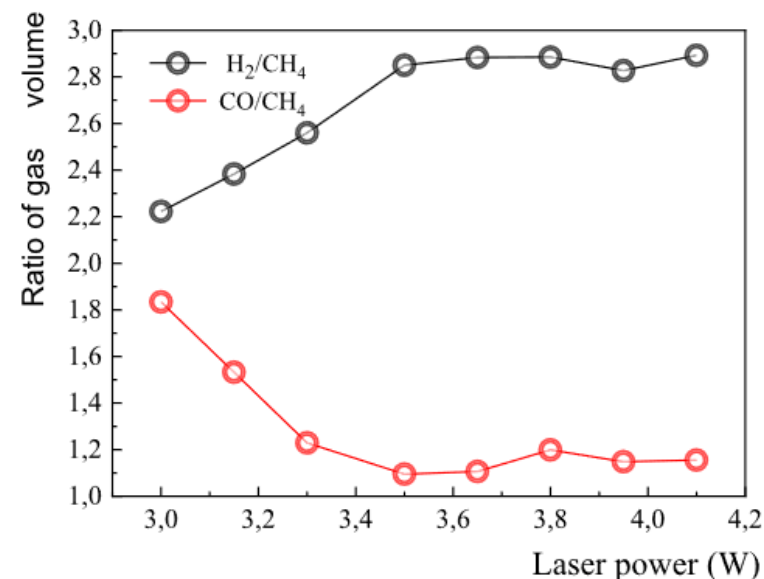
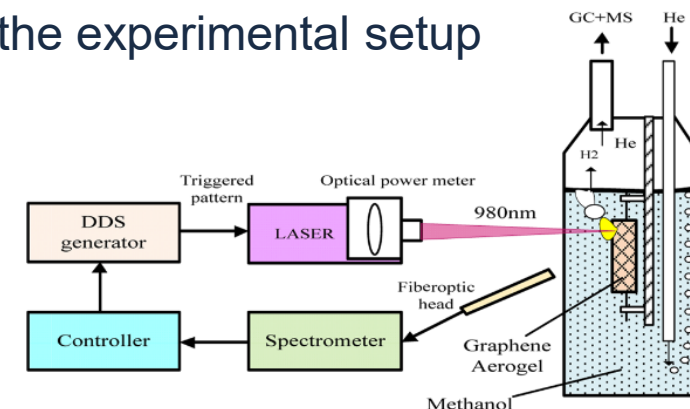
Applications -Hydrogen generation

Influence of excitation laser power on light emission and the volumes of generated gases



Comparison of LI light emission intensity and emitted gas fractions (H₂, CO, and CH₄) of the GA scaffold on excitation LD power in log/log scale

Scheme of the experimental setup



Influence of excitation laser power on H₂ and CO gas products because of photoreformation of CH₃OH solution with graphene foam as the photocatalyst

LIWE phenomenon is the broadband emission characterized by:

- Low temperature emission excitation threshold
- Exponential increase of intensity with excitation power
- Saturation for high excitation power
- Laser induced efficient photocurrent
- Laser induced emission of electrons
- Laser induced cooling
- Dependence on atmospheric ambient pressure
- Dependence on concentration of impurity metal ions
- Short rise and decay times
- Surface related point emission

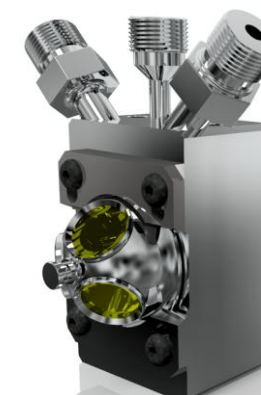
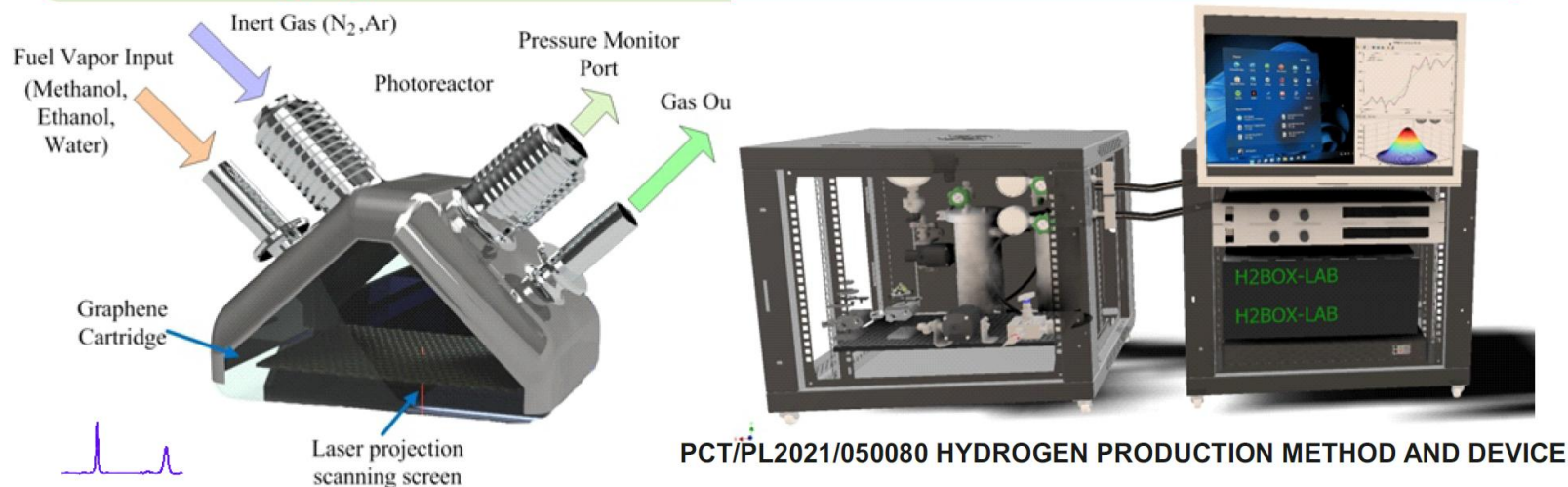
1. Interaction of laser emission with graphene target is associated with multiphoton ionization process responsible for intense light emission and electron ejection. This phenomena is the main feature of INTiBS LIGHT Technologies.
2. LIGHT Technologies is ready for industrial implementation.

Laser Induced Graphene Hydrogen Technologies (LIGHT)

Efficient Generation of Hydrogen by laser irradiation of Graphene based photocatalyst targets in the alcohols, water and their vapors in scalable broadband photocatalytic reactor (UV-VIS-IR) for renewable energy applications.



Graphene **Light**
Project



Visit us at www.h2lab.pl

