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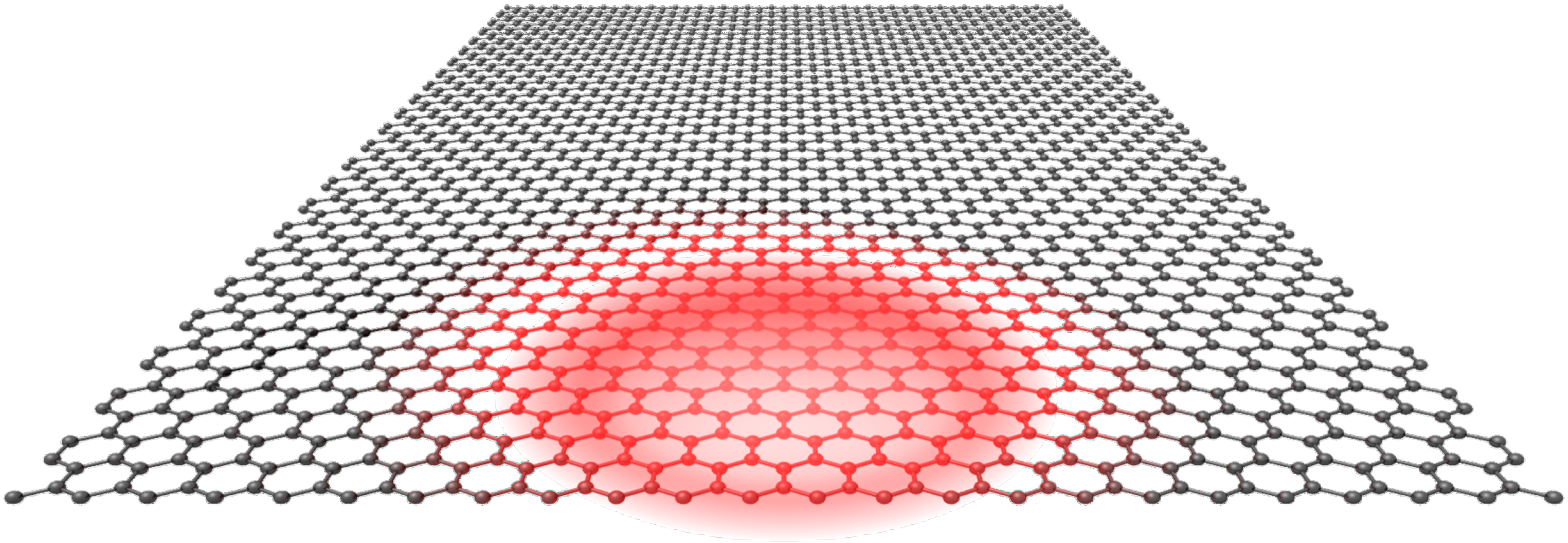
ENhanced Photoresponse of HOt CArriers through Lifetime engineering



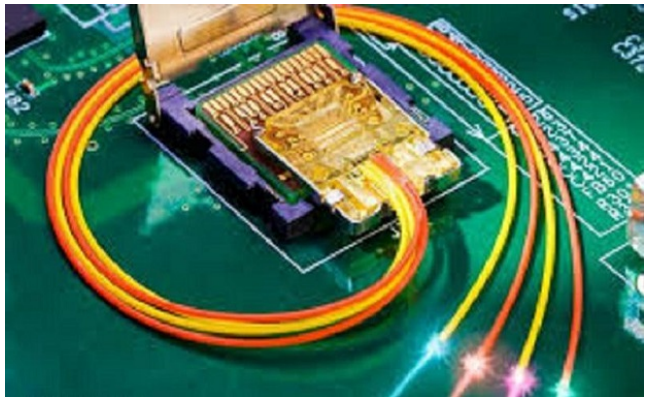
FLAG-ERA 2022 Project Workshop

21 March 2022

FLAG-ERA

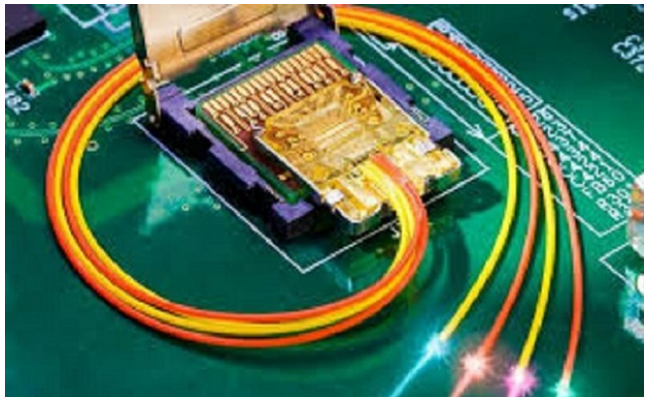
GRAPHENE FLAGSHIP

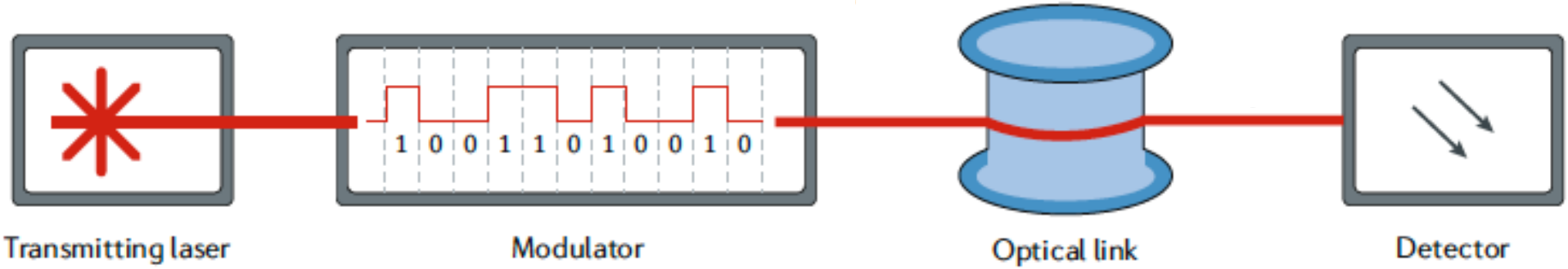
Motivation: optical interconnects



- Using light to transmit signals
- Fast-growing, billion-dollar industry
- Great opportunities for graphene

Motivation: optical interconnects

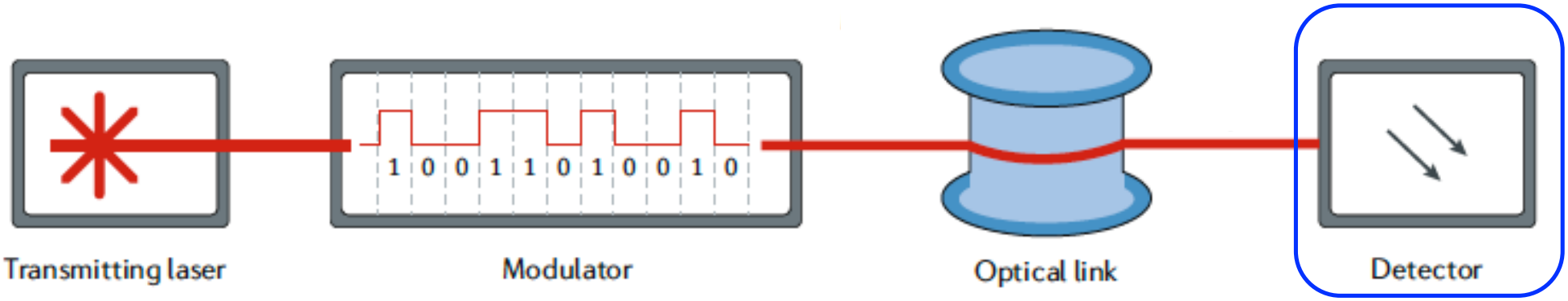




Nat. Rev. Mater. **3**, 392 (2018)

Photodetectors

- High responsivity
- Large bandwidth
- Low dark current



Nat. Rev. Mater. **3**, 392 (2018)

Photodetectors

- High responsivity
- Large bandwidth
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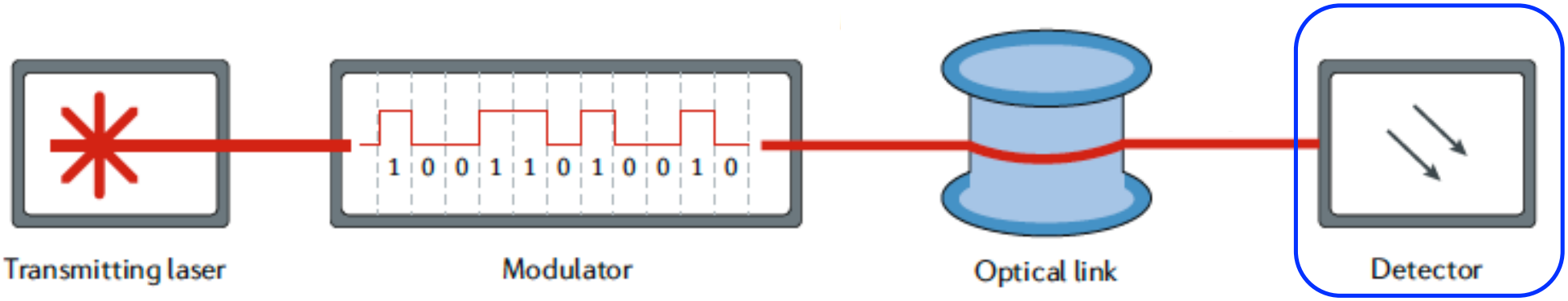
Graphene-integrated photonics



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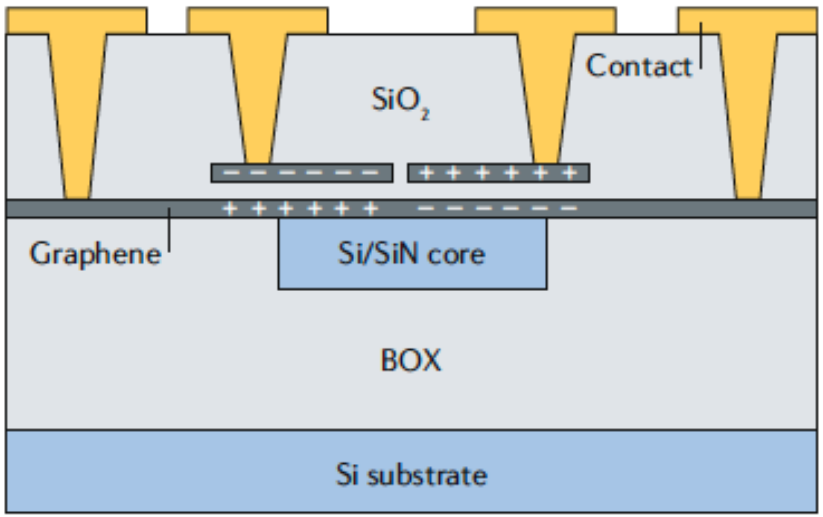
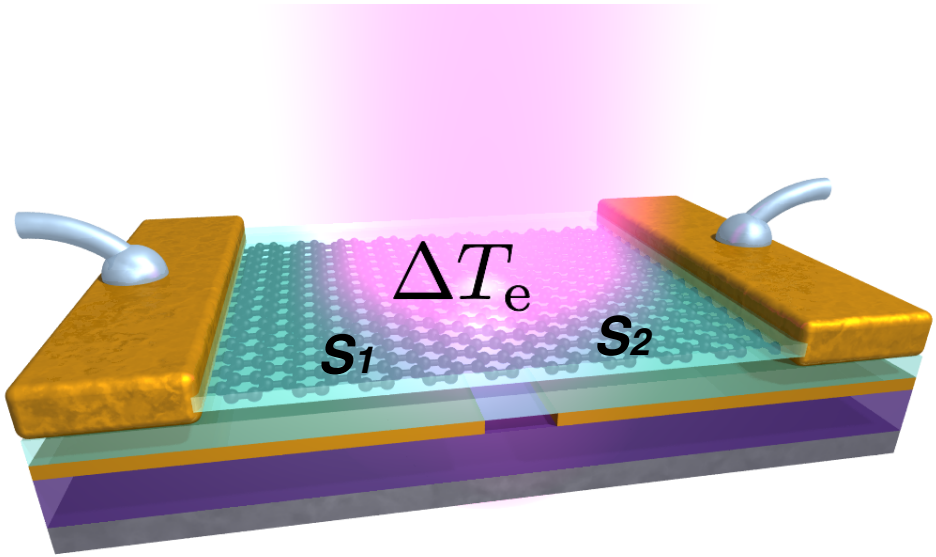
Graphene-integrated photonics



Nat. Rev. Mater. **3**, 392 (2018)

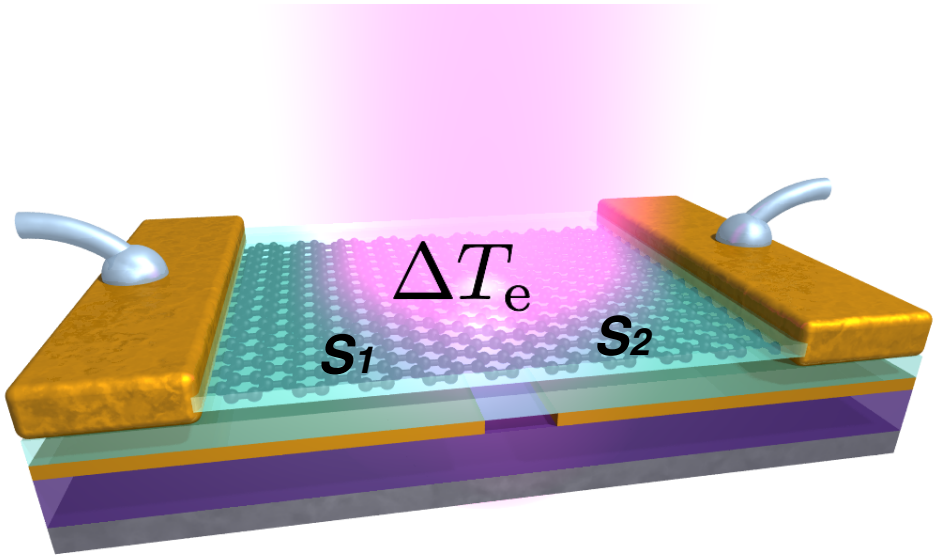
Graphene-based photodetectors

- High responsivity
- Large bandwidth
- Low dark current
- Scalable production



$$V_{\mathrm{PTE}} = (S_2 - S_1)\Delta T_e$$

Graphene-based photodetectors



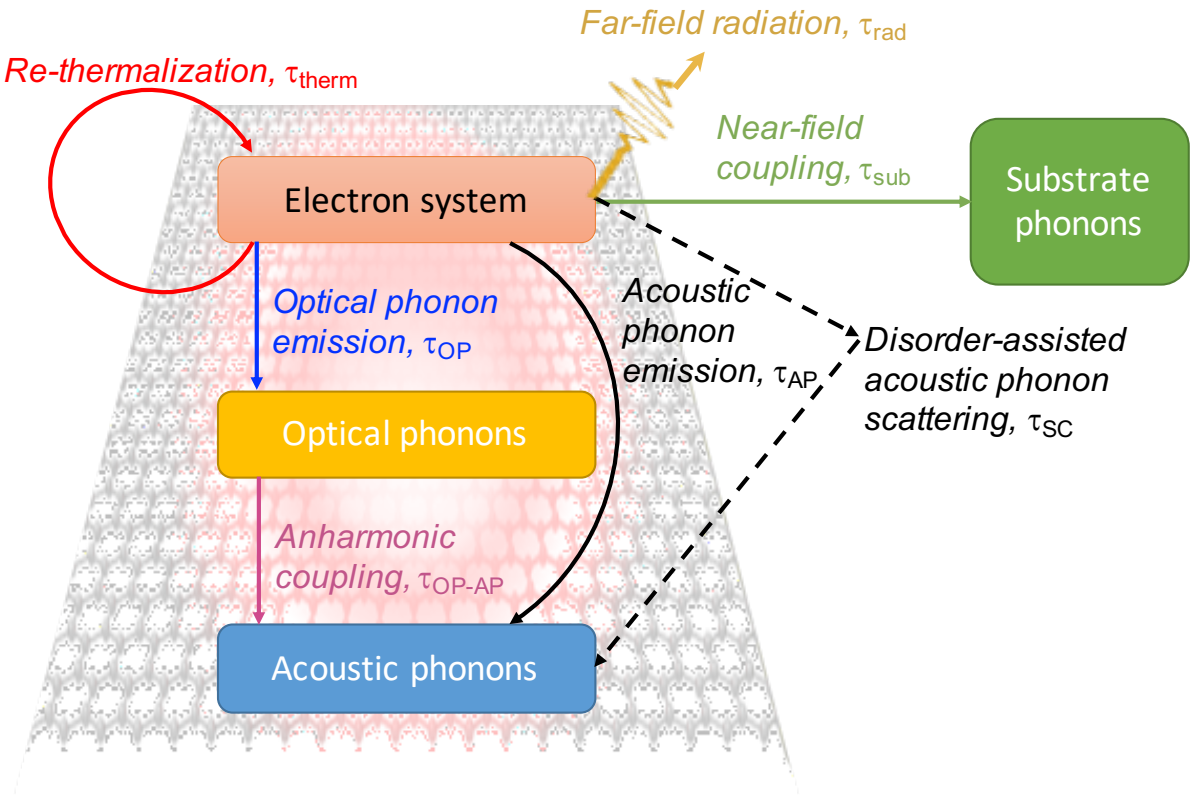
Larger ΔT_e gives larger responsivity

Longer cooling time gives larger ΔT_e

$$V_{\mathrm{PTE}} = (S_2 - S_1)\Delta T_e$$

➢ **Engineer longer cooling time**

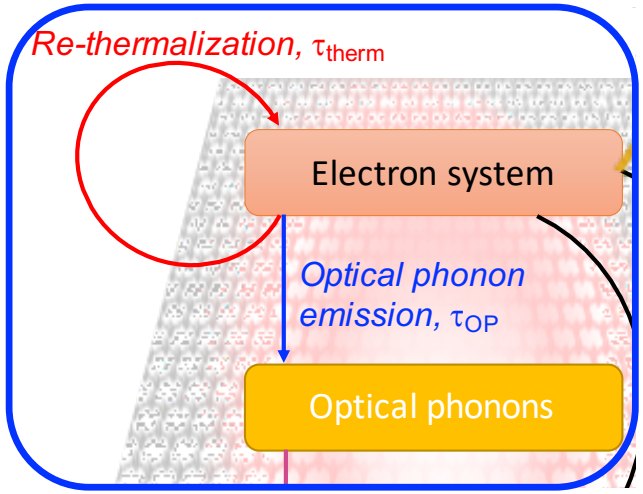
Hot-carrier cooling in graphene



➢ **Engineer longer cooling time**

Nanoscale **13**, 8376 (2021)

Hot-carrier cooling in graphene



Hot-Carrier Cooling in High-Quality Graphene Is Intrinsically Limited by Optical Phonons

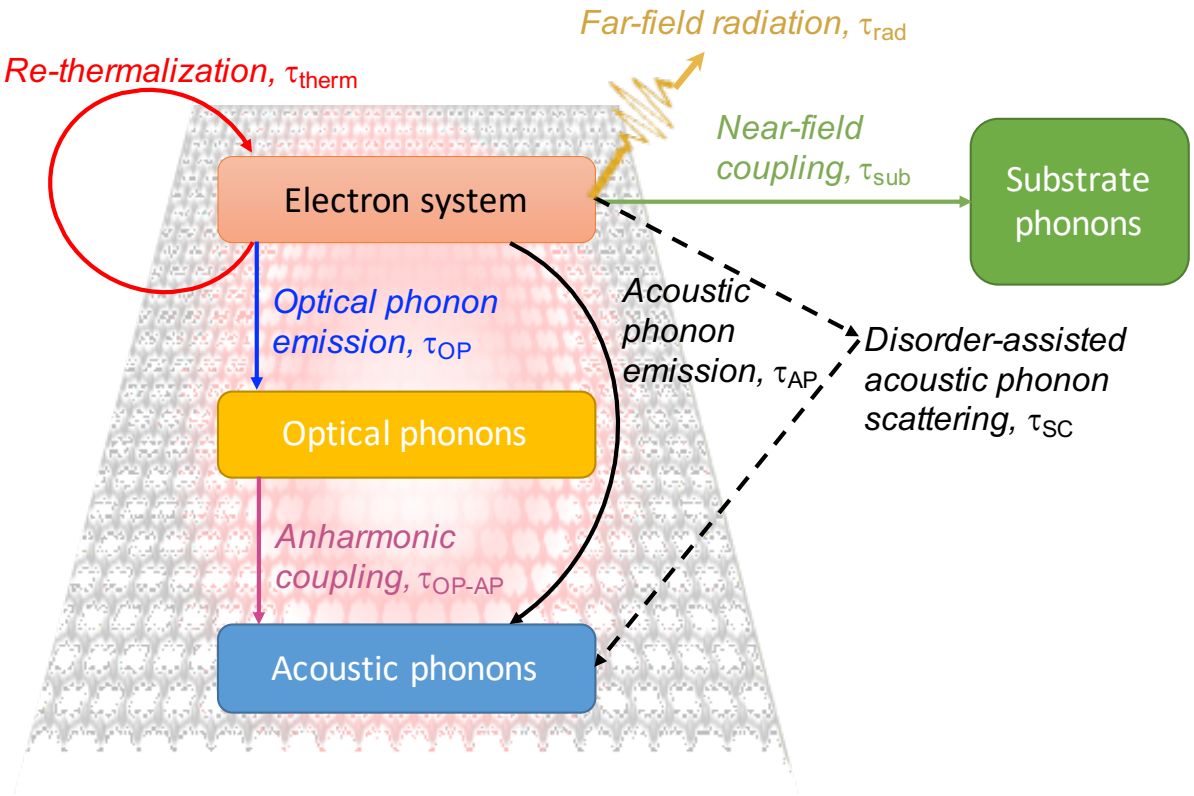
Eva A. A. Pogna, Xiaoyu Jia, Alessandro Principi, Alexander Block, Luca Banszerus, Jincan Zhang, Xiaoting Liu, Thibault Sohier, Stiven Forti, Karuppasamy Soundarapandian, Bernat Terrés, Jake D. Mehew, Chiara Trovatello, Camilla Coletti, Frank H. L. Koppens, Mischa Bonn, Hai I. Wang, Niek van Hulst, Matthieu J. Verstraete, Hailin Peng, Zhongfan Liu, Christoph Stampfer, Giulio Cerullo, and Klaas-Jan Tielrooij*

Cite This: https://doi.org/10.1021/acsnano.0c10864 Read Online

➢ **Engineer longer cooling time**

ACS Nano **15**, 11285 (2021)

Hot-carrier cooling in graphene



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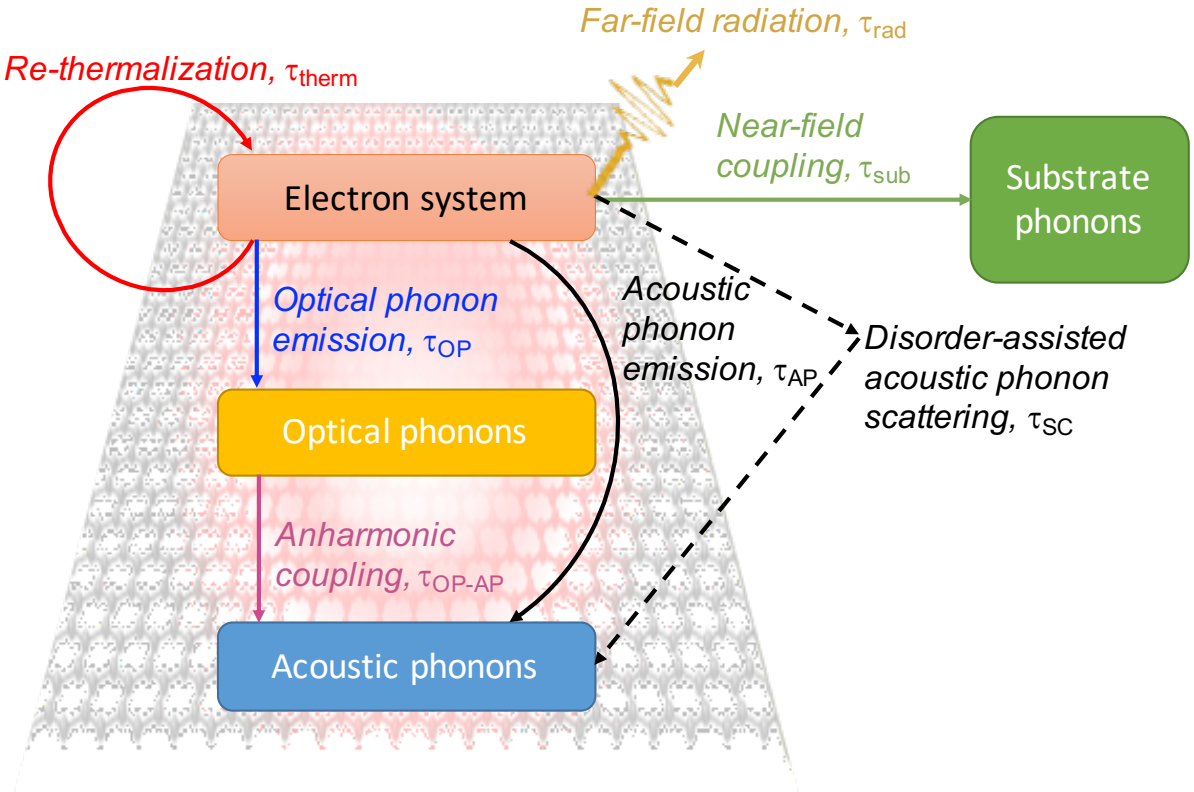
➢ **Engineer longer cooling time**

Hot-carrier cooling in graphene



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➢ **Engineer longer cooling time & using techniques with scalability potential**

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Interuniversity Microelectronics Centre

Leuven, Belgium

Ghent University

Ghent, Belgium

Max Planck Institute for Polymer Research

Mainz, Germany

Catalan Institute for Nano-science and Nanotechnology

Bellaterra (Barcelona), Spain

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ENhanced Photoresponse of HOt CArriers through Lifetime engineering

Technology coordination

Interuniversity Microelectronics Centre

Leuven, Belgium

Dr. Christian Haffner

Christian Haffner is a Principal Member of Technical Staff and was awarded the first tenure track position at IMEC. He is leading a research group that explores the limits of integrated electro-optical devices in the classical and quantum domain.

Dr. Steven Brems

Steven Brems is a senior researcher at IMEC, specializing in 2D materials, and team lead of Imec's *'Material transfer'* team.

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ENhanced Photoresponse of HOt CArriers through Lifetime engineering

GHENT UNIVERSITY

Ghent University

Ghent, Belgium

Prof. Dries Van Thourhout

Dries Van Thourhout is a professor at Ghent University. His focus is on silicon photonics and heterogenous integration. His research focuses on the design, fabrication and characterization of integrated photonic devices. Main topics involve Silicon nanophotonic devices and the integration of novel materials (III-V, graphene, ferro electrics, quantum dots, ...) on these waveguides to expand their functionality. He is working on applications for telecom, datacom, optical interconnect and sensing.

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Qiaoqing Yu, PhD student

MAX PLANCK INSTITUTE
FOR POLYMER RESEARCH

Prof. Mischa Bonn

Bonn serves as Max Planck Director and professor by special appointment in Amsterdam (Physics) and Mainz (Chemistry). The overall aim of Bonn's research is to reveal the structure and dynamics of molecules and charge carriers at interfaces, as well as transport of molecules and charge across those interfaces.

Max Planck Institute
for Polymer Research

Mainz, Germany

Dr. Hai Wang

Hai Wang is group leader at the Max Planck Institute for Polymer Research (MPIP). His research theme is to understand fundamentals of ultrafast charge carrier dynamics in low-dimensional materials and interfaces relevant for optoelectronics and energy conversion.

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Project coordination and management

ICN2 Institut Català de Nanociència i Nanotecnologia

EXCELENCIA SEVERO OCHOA

Catalan Institute for Nano-science and Nanotechnology

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Dr. Klaas-Jan Tielrooij

Klaas-Jan Tielrooij is the leader of the Ultrafast Dynamics in Nanoscale Systems group at the Catalan Institute of Nanoscience and Nanotechnology (ICN2) in Barcelona, Spain. His research interests are in the field of ultrafast dynamics, optoelectronics, nonlinear optics and light-matter interaction. His current research focuses on heat and charge transport in nanoscale material systems, in particular 2D materials.

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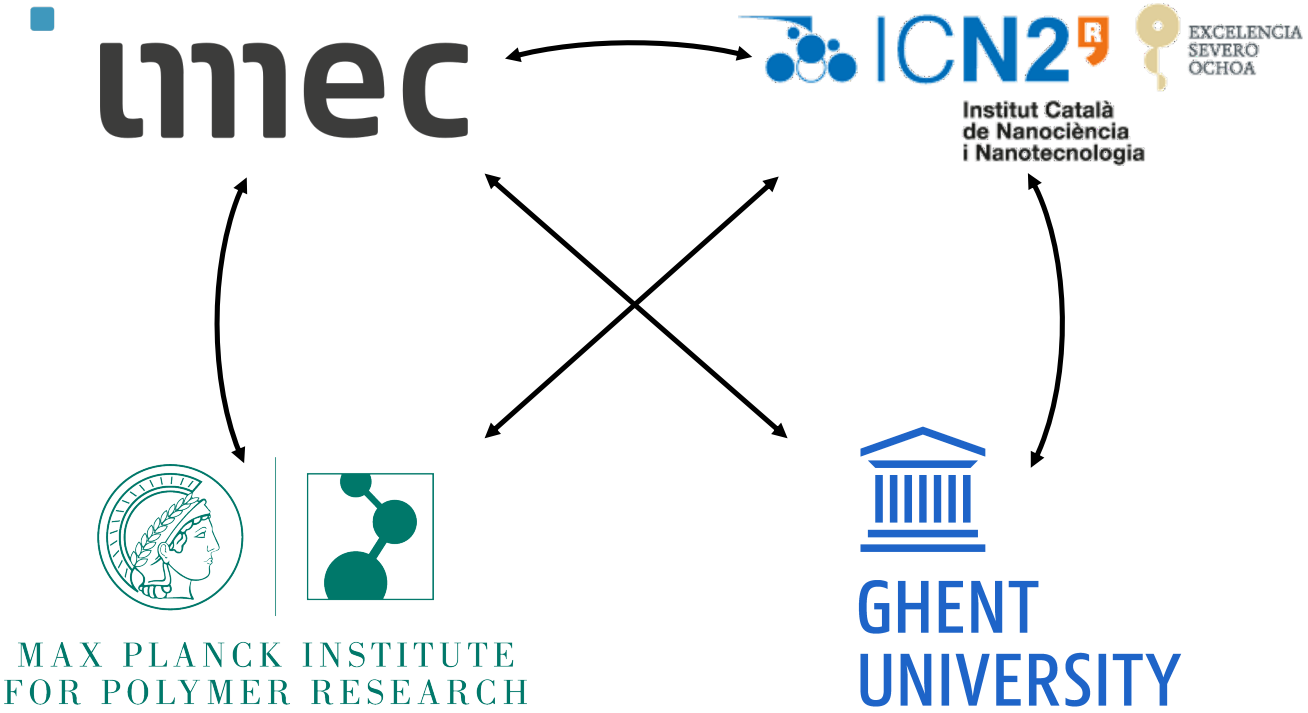

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