# Design and optimization of graphene photothermoelectric detectors

*Aron W. Cummings and Aleandro Antidormi*

Institut Català de Nanociència i Nanotecnologia

EXCELENCIA SEVERO OCHOA

## Introduction

**Graphene photodetectors** are highly promising

↓

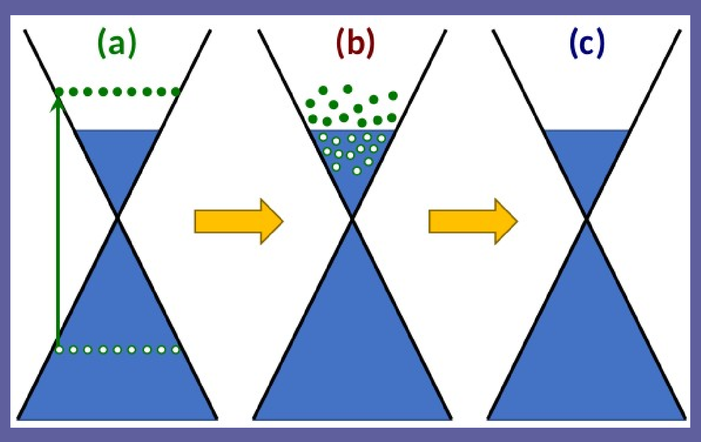
* broadband absorption
* fast carrier dynamics
* high electron temperature
* weak e-ph interaction

↓

Fast: ~100 Ghz

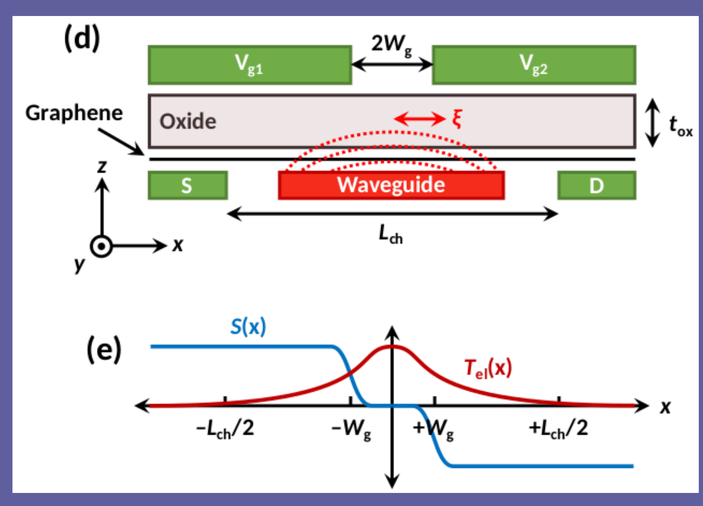
Sensitive: ~10 pW / √Hz

**Operating principle 1**




Antidormi and Cummings, *PRAppl* **15**, 054049 (2021)

**Operating principle 2**




## Methods

### Heat equation for electrons

$$\vec{\nabla} \cdot [\kappa(x,y)\nabla T_{\mathrm{el}}(x,y)] - \gamma(x,y)C_{\mathrm{el}}(x,y)T_{\mathrm{el}}(x,y) + P(x,y) = 0$$

### Figures of merit

$$\text{Photovoltage: } V_{\mathrm{PTE}} = \int S(x)\frac{\mathrm{d}T_{\mathrm{el}}(x)}{\mathrm{d}x}\mathrm{d}x$$

$$\text{Photocurrent: } I_{\mathrm{PTE}} = V_{\mathrm{PTE}}/R$$

$$\text{Noise-equivalent power: } \mathrm{NEP} = \frac{\sqrt{4k_{\mathrm{B}}TR}}{V_{\mathrm{PTE}}/P_{\mathrm{in}}}$$

## Summary

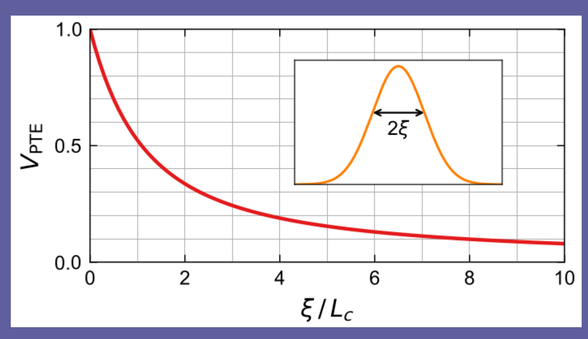
- Optimal parameters depend on performance metric
- ***Performance saturates with graphene quality***
- In high-quality detectors, Peltier cooling should not be ignored

## Reference

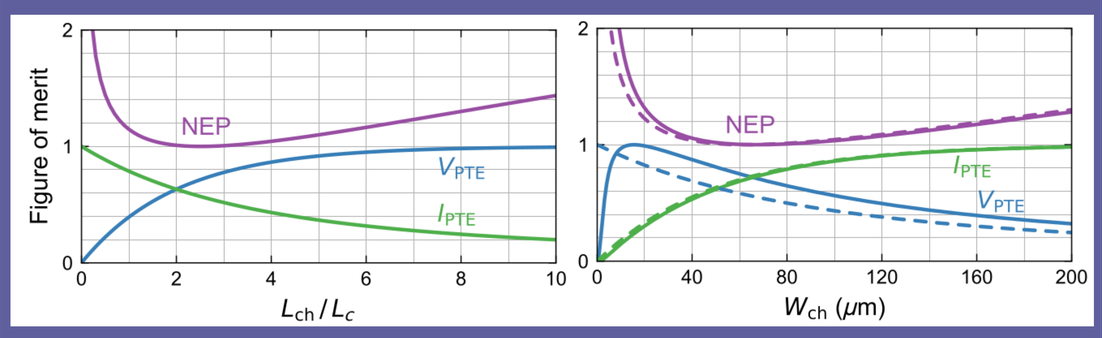
A Antidormi and AW Cummings, "Optimizing the photothermoelectric effect in graphene," *Phys Rev Appl* **15**, 054049 (2021)

## Results

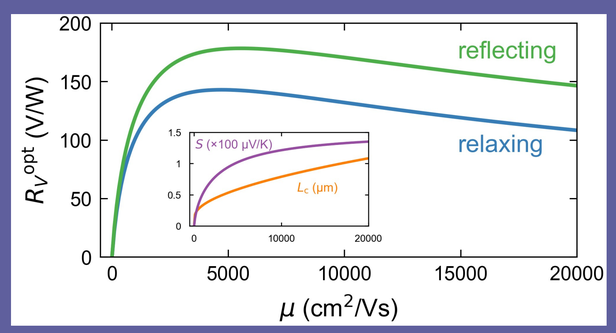
### Light spot size

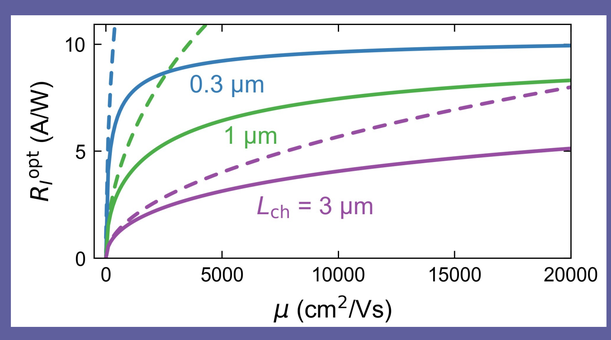



### Channel length / width




### Graphene quality




BOARD OF PATRONS:

Generalitat de Catalunya Departament d'Economia i Coneixement

CSIC Consejo Superior de Investigaciones Científicas

UAB Universitat Autònoma de Barcelona

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825272 (ULISSES)

Member of: BIST Barcelona Institute of Science and Technology; Institució CERCA Centres de Recerca de Catalunya

With the support of: ICREA; Gobierno de España Ministerio de Economía, Industria y Competitividad; Unión Europea Fondo Europeo de Desarrollo Regional; ACCIÓ; Generalitat de Catalunya