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Optical effects of laser-reduced graphene oxide layers in tandem perovskite/CIGS solar cells studied by numerical simulations

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Objectives and Methods

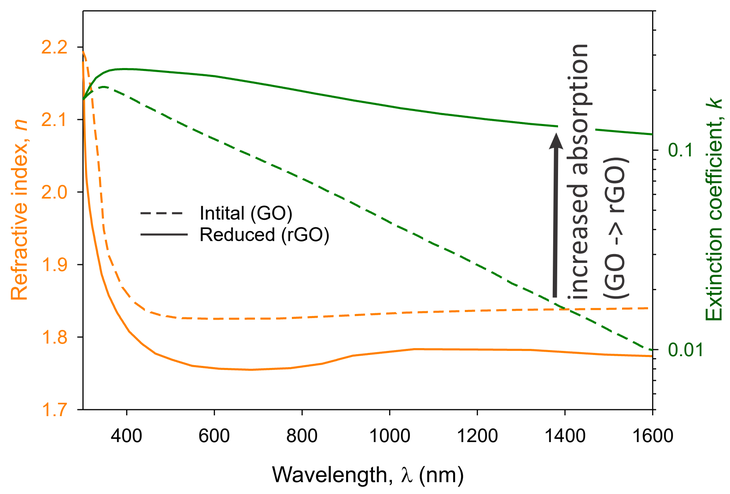
- Objective: To determine and present optical properties of the novel reduced graphene oxide (rGO)
- Objective: To evaluate and optimize optical properties of the PK/CIGS tandems with rGO as interlayer
- Objective: To give directions for further optimization of rGOs towards high efficiency PK/CIGS tandems
- Methods: Advanced optical modelling and simulations supported by experimental work
  [Kovacic et. all; Front. Photonics, vol. 3, 2022; doi.org/10.3389/fphot.2022.888486]

Motivation

- **Problem:** Current transparent electrode interlayers present a limiting factor in tandems (unstable conductive polymers)
- **Solution:** Introduction of novel graphene related materials – **rGO**:
  - tunable electrical and optical properties
  - laser treatment enables exact energy matching of rGO with adjacent layers
  - PK shielding layer against moisture
  - PV industry applicable (large area, fast)
- **Aim:** determination of rGO optical properties & its effect on photocurrent

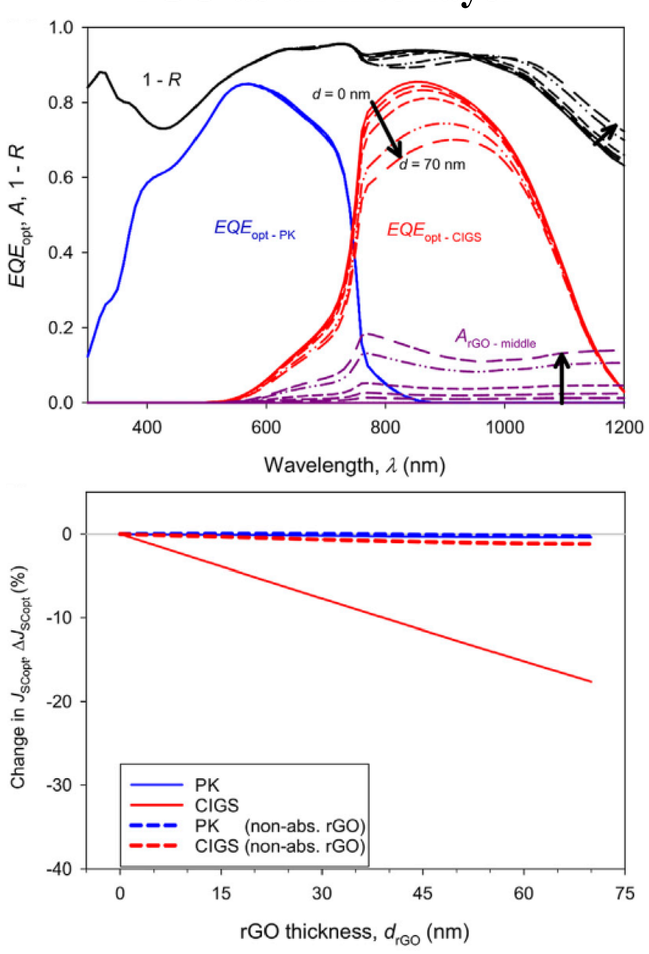
Experiment & Simulated structure

Complex refractive index determination



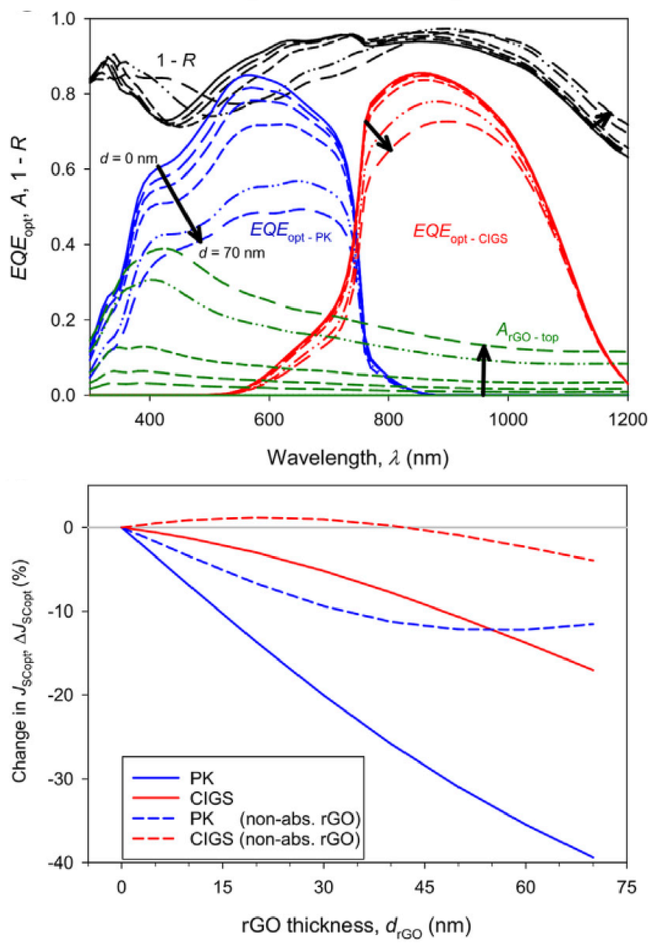
Simulation results

rGO as an interlayer



- thicker rGO -> higher parasitic abs. -> lower photocurrent of CIGS cell only

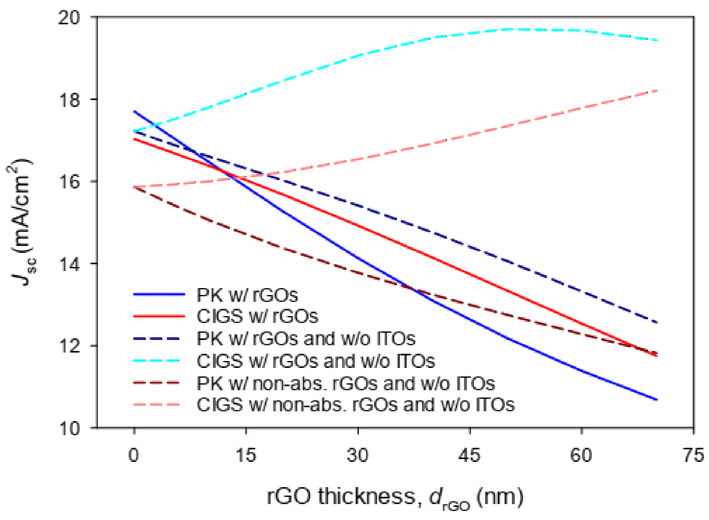
rGO as a top contact / protection



- thicker rGO -> higher parasitic abs. -> lower photocurrent of both subcells

Optimization

directions for further optimization



- **Usage of non (low) absorbing rGO**
  highly reduced parasitic absorption
- **Refractive index optimization**
  tuned interference effects
  resulting in higher *J*sc
- **Replacement of ITOs with rGOs**
  with non (low) absorbing rGO
  improvements in both *J*sc are possible above reference tandem
- **Patterning of rGO**
  smaller rGO area - lower parasitic abs.

Conclusion

- Optical properties of GO and rGO were determined
  - high absorption, scattering
- Thin or low absorbing rGO layers show potential for tandems
  - only small *J*sc loss;
  - can be compensated by increased *V*oc and/or *FF*
- Further optimization of optical properties of rGO by laser treatment
  - reduction of parasitic absorption; refractive index optimization
- Presened results show a guideline for needed electrical improvements (*V*oc, *FF*) due to introduced rGO
  - a balance between optical and electrical properties is needed

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