Photonic solutions to fight climate change

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The mitigation of climate change requires major transformations in the ways we generate energy and operate technologies that release CO_2. Photonic concepts and novel light-driven technologies provide many opportunities to mitigate CO_2 emissions, transforming our current modes of energy use into more effective and sustainable ones. In this presentation I will review several of these concepts that in the early stage of scientific discovery, with at the same time great technological potential.[1]

In photovoltaics, nanophotonic light scattering geometries can make solar cells more efficient or aesthetically appealing. Light-driven chemical reactions can serve as efficient alternatives for bulk chemical processes that are driven by fossil fuels and light-driven processing can serve as alternative in thermochemical and heat-intense processes. Many photonics opportunities also lie in the reduction of energy use. For example, all-optical computing using optical metasurfaces can make data processing more efficient and nanostructured surfaces can enhance passive radiative cooling for building infrastructure and industrial processes.

As an example of our own research I will present an integrated near field/far-field multiple scattering formalism to control the absorption of light in multijunction solar cells. We design and fabricate a metallodielectric metasurface back contact for an ultra-high efficiency III-V/Si multi-junction solar cell and enhance the light trapping inside the silicon bottom cell by multiple scattering, creating a record photovoltaic energy conversion efficiency for silicon-based multijunction solar cells of 36.1%.[3]

I will also present the Dutch national research, innovation and industrial development program SolarNL, in which universities, research institutes, TNO and Dutch companies work together to develop photovoltaics technology and industry to help create a fully sustainable energy generation system in our society by 2040.[3]

References

1) *Photonic solutions to fight climate change*, G. Tagliabue, H.A. Atwater, A. Polman, and E. Cortes, Nature Photon. (2024), in press. See here for a preprint of this article.
2) *Wafer-bonded two-terminal III-V//Si triple-junction solar cell with power conversion efficiency of 36.1 % at AM1.5g,* P. Schygulla, R. Müller, O. Höhn, M. Schachtner, D. Chojniak, A. Cordaro, S. Tabernig, B. Bläsi, A. Polman, G. Siefer, D. Lackner, and F. Dimroth, Progr. Photovolt. **32**, 1-9 (2023); *Nano-patterned back-reflector with engineered near-field/far-field light scattering for enhanced light trapping in silicon-based multi-junction solar cells*, A. Cordaro, R. Müller, S. Tabernig, N. Tucher, P. Schygulla, O. Höhn, B. Bläsi, and A. Polman, ACS Photon. **10**, 4061 (2023)
3) SolarNL: www.solarnl.eu