Optical Spectroscopy of Semiconductor Nanowires: Tailoring Light Harvesting and Emission at the Nanoscale

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Dielectric and semiconductor nanostructures are becoming increasingly important as components in nanoscale integrated circuits and optoelectronic devices. Such resonant structures can exhibit complex interactions with light, controlling the wavelength, momentum and polarization of emission. Concretely, the directional/spectral optical response of nanowires (NWs) is a fundamental property that depends on the material, geometry and dimensions of the nanostructures and that needs to be considered in the design of NW optical devices [1, 2]. In this contribution, we investigate emission and absorption from finite semiconductor NWs, theoretically and experimentally (Fourier microscopy and cathodoluminescence polarimetry) demonstrating their behavior as optical absorbers [3, 4] and nanoantennas [5,6].

The description of light absorption at finite semiconductor NWs based on Mie (theory) resonances prevails over a wide angular range, however failing at grazing incidences where leaky/guided modes begin to play a relevant role [3]. Conversely, we have also demonstrated that directional emission of polarized light is governed by the Fabry-Perot-like guided/leaky mode resonances that mediate the emission process [5,6]. Our results show that semiconductor NWs can efficiently emit and absorb electromagnetic radiation in defined direction/polarization/frequency, providing a solid theoretical framework to tailor the NW response to electromagnetic radiation, relevant to the design of: broad band and broad angle nanowire-based solar cells and photodetectors; and lighting devices such as LEDs, nanolasers, or single-photon source.

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References

[1] L. Cao, J. S. White, J. S. Park, J. A. Schuller, B. M. Clemens, and M. L. Brongersma, *Nat. Mater.*, **8**, 643 (2009).

[2] J. Claudon, N. Gregersen, P. Lalanne, and J-M. Gérard, *Chem. Phys. Chem.*, **14**, 2393 (2013).

[3] G. Grzela, R. Paniagua-Domínguez, T. Barten, D. Van Dam, J. A. Sánchez-Gil, and J. Gómez Rivas, *Nano Lett.*, **14**, 3227 (2014).

[4] D. R. Abujetas, R. Paniagua-Domínguez, and J. A. Sánchez-Gil, *ACS Photonics*, **2**, 921 (2015).

[5] D. Van Dam, D. R. Abujetas, R. Paniagua-Domínguez, J. A. Sánchez-Gil, Erik P. A. M. Bakkers, Jos E. M. Haverkort, and J. Gómez Rivas, *Nano Lett.*, **15**, 4557 (2015).

[6] B. J. M. Brenny, D. R. Abujetas, D. Van Dam, J. A. Sánchez-Gil, J. Gómez Rivas and A. Polman, submitted.