Soutenance de thèse

Fabrication and investigation of III-V quantum structured solar cells with Fabry-Pérot cavity and nanophotonics in order to explore high-efficiency photovoltaic concepts

Benoît Behaghel

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Amphi Friedel, Chimie ParisTech

In the past decade, photovoltaics (PV) has become a key player for the future of worldwide energy generation. Innovation in PV is likely to rely on high efficiency PV with flexible and lightweight thin films to enable PV deployement for mobile applications. In the framework of the Japanese-French laboratory "NextPV", this thesis investigates the development of III-V quantum structured solar cells to explore high-efficiency photovoltaic concepts especially intermediate band solar cells (IBSC). Quantum structured IBSC have proven to be limited by thermal escape at room temperature and by low subbandgap light absorption. Following a consistent approach, we evaluate the topology, thermal escape mechanism, quantum structure and optical absorption of In(Ga)As quantum dots in a wide gap $Al_{0.2}GaAs$ host material. We also characterize quantitatively the device operation and improve the optical design. For a high irradiation, we evidence a hot carrier population in the quantum dots. At the same time, sequential two-photon absorption (S-TPA) is demonstrated both optically and electrically. We also show that S-TPA for both sub-bandgap transitions can be enhanced by a factor x5-10 with light management techniques, for example by implementation of Fabry-Perot cavities with the different epitaxial transfer methods that we developed. More advanced periodical nanostructures were also fabricated in the case of multi-quantum well solar cells using nanoimprint lithography techniques. Overall we discuss the possibility of realizing intermediate-band-assisted hot-carrier solar cells with light management to open the path for high-efficiency quantum structured IBSC.

Jury member :

Christian SEASSAL	Directeur de Recherche (INL, Lyon)	Rapporteur
Guilhem ALMUNEAU	Chargé de Recherche (LAAS, Toulouse)	Rapporteur
Christophe SAUVAN	Chargé de Recherche (LCF, Paris-Saclay)	Examinateur
Alexandra FRAGOLA	Maître de conférences (UPMC, Paris)	Examinateur
Yoshitaka OKADA	Professeur (RCAST, Tokyo)	Examinateur
Stéphane COLLIN	Chargé de Recherche (C2N, Paris-Saclay)	Directeur de thèse
Jean-François GUILLEMOLES	Directeur de Recherche (IPVF, Paris-Saclay)	Directeur de thèse