



PhD THESIS DEFENSE: Environmentally friendly nanocrystals synthesized and processed in ambient conditions for solution-processed solar cells

MEHMET ZAFER AKGUL

February 11, 2021

11:00 to 14:00

Online (Teams) and ICFO Auditorium

Due to the continuously increasing energy demand and the environmental concerns about climate changes raised by international community, alternative energy resources have been put under intense investigation for the past decade. As a consequence, different technologies have been proposed, photovoltaics being a promising one among them. Till now, different structures and methods have been employed to fabricate photovoltaics for energy production. Traditionally, vacuum-based deposition methods have been used to form the stacks required for proper photovoltaic operation. Triggered by the advancements in

colloidal synthesis methods, thin films of colloidal semiconductor nanocrystals (CNCs) have gained tremendous attention as cheap substitutes for vacuum-deposited layers. Up to date, various colloidal synthesis methods have been developed to produce semiconductor nanocrystals for applications in photovoltaics. Thanks to the high degree of controllability and high material quality, hot injection methods have been the way-to-go for the past decades. However, the application of CNC films in large-scale photovoltaics has been delayed due to the synthesis constraints originating from hot injection methods itself. In this work, we demonstrate that it is possible to eliminate the need for air-free techniques by careful selection of the precursors and oxygen-aware design of reaction conditions. We use the semiconducting compound silver bismuth sulfide (AgBiS₂) as the prototype material to demonstrate the easiness and efficiency of the method. This semiconducting compound is selected as the prototype material thanks to its attractive optical properties for photovoltaics and the environmentally friendly nature of the constituent elements. Solar cells fabricated using CNCs synthesized at room temperature have yielded a power conversion efficiency of 5.5 %, demonstrating the promising potential of the method. The application of the method in the synthesis of AgBiS₂ CNCs results in a cost reduction of at least 60 % compared to the previous studies reporting similar photovoltaics-grade AgBiS₂ CNCs. Another important challenge in employing hot injection methods is the scalability. Due to the difficulties in maintaining the thermal fluctuations within the reaction volume low and in the maintenance of inert atmosphere inside the reaction vessel, hot injection methods impose an inherent scale constraint on the synthesis. On the other hand, with the elimination of scale constraint by the use of an ambient condition synthesis method, the requirement for high temperature reaction and chemically inert reaction environment is eliminated, enabling us to achieve large-scale volume production of CNCs. This, in turn, can lower the production cost of CNCs further, hence the cost of photovoltaics that are based on CNCs. In addition, we show that the ambient condition method can be adapted for the synthesis of another metal chalcogenide, namely silver bismuth selenide CNCs (AgBiSe₂) with an extended absorption spectrum further into the near infrared down to ~ 0.9 eV. The resulting AgBiSe₂ CNC solar cells achieved a preliminary efficiency up to 2.6 %. Also, thanks to the structural similarity of these two compounds, the two methods that are developed for the synthesis of AgBiS₂ and AgBiSe₂ CNCs are combined and optimized to obtain alloyed quaternary AgBiSSe CNCs as a facile means of bandgap tuning in silver bismuth chalcogenide semiconductor family. The formation of AgBiSSe CNCs are verified through optical and structural characterization methods to show the formation of quaternary phase and also the phase purity of the obtained product. Overall, it is shown that the proposed ambient condition synthesis method is capable of providing photovoltaics-grade RoHS-compliant materials at a lower cost and higher throughput compared to the hot-injection based methods, opening a novel way for low-cost environmentally friendly photovoltaics.

We strongly support Zafer on this important day of his professional career. Also, we wi

h him a very successful presentation.

Due to recommendations in place to contribute containing the spreading of COVID-19, the defence will be carried out semi presencial with a maximum of 66 Icfonians in the Auditorium, and partly remotely via MS Teams. This is the link to follow the Thesis Defence online [Click here to join the meeting](#)

If you are interested in attending in person, please address your request to mery.gil@icfo.eu by Monday February 8.

Hosted by: Prof Dr Gerasimos Konstantatos