**“Novel” Semiconductors and Nanostructures for Enhanced Optoelectronic**

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Due to excellent optoelectronic performance inexpensive perovskite hybrid semiconductors has potential to replace “classical” III-V and II-VI compound in many applications. For example, sub-nanosecond radiative decay time was first observed for weakly bound excitons in bulk GaAs semiconductors and was understood in terms of the phenomenon known as giant oscillator strength (GOS).1 GOS is a quantum phenomenon connected with coherent excitation of excitons over the entire volume of exciton localization, and is counterintuitive because the radiative decay time is inversely proportional to this volume. Consequently, it was predicted theoretically2 that an exciton weakly confined in a nanocrystal (NC), with radius *a* much larger than the exciton radius *a*ex, is characterized by GOS with magnitude *f*NC = *f*0(*a*/*a*ex)3 >> *f*0, where *f*0 is the exciton oscillator strength. Indeed ~100 ps radiative decay times were observed in large-size CsPbX3 (X = Cl, Br, I) perovskite NCs.3

The development of organic-inorganic perovskite photovoltaics (PV) and radiation detectors (RD) has been particularly impressive. In the past 10 years, perovskite-based PV cells have reached a certified efficiency of 25.2% and perovskite-based RDs have demonstrated comparable progress by combining remarkable defect tolerance, large mobility-lifetime products, tunable band gaps, crystal growth from low-cost solution processes, and strong stopping power from Pb. We connect this progress with suppressed recombination in this material. Our analysis of the best PV cells, including perovskites, shows that their efficiencies are very close to ultimate PV limits in the absence of carrier recombination.4 The recent data on perovskite RDs5 also indicate, from our point of view, the advent of ultimate collection efficiency. For such RDs, we provide a theory that describes current collection efficiency in the absence of the carrier recombination.5

Finally, I will discuss photoluminescence properties of nanoplatelets, which have a chance to become the best colloidal fluorophores, due to its size dependent tunability, high optical stability, fast picosecond decay time and narrow PL line.

1 E. I. Rashba and G. E. Gurgenishvili, Edge absorption theory in semiconductors. *Sov. Phys. Solid State,* **4**, 759-760 (1962).

2 Al. L Efros and A. L. Efros, Interband absorption of light in a semiconductor sphere, *Sov. Phys.*

3 M. A. Becker*, et al.* “Bright triplet excitons in caesium lead halide perovskites,” *Nature*, **553**, 189-193 (2018).

4Al. L. Efros and V. G. Karpov “Electric power and current collection in semiconductor devices with suppressed electron−hole recombination”, ACS Energy Lett. 2022, **7**, 3557−3563

5 M. Kovalenko, et al. Stable Near-to-Ideal Performance of a Solution grown Single-Crystal Perovskite X-Ray Detector. 2022, https://doi.org/10.21203/rs.3.rs-1117933/v1