Amorphous selenium (a-Se) for optoelectronic applications.

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Amorphous selenium (a-Se) is a photoconducting material with a set of unique properties many of which do not fit into the conventional notions of amorphous materials. This applies both to charge transport in high electric fields, and to the mechanisms of photo-generation and recombination. Indeed, it was found empirically, and demonstrated theoretically, that a-Se is the only amorphous photoconductor where charge, while drifting in high electric field, can avoid energy dissipation and hence can acquire enough energy to initiate impact ionization and secondary charge creation. We have shown that avalanche a-Se photosensors are capable of multiplication gain of up to 10^3. Combination of high avalanche multiplication gain with the extremely high quantum efficiency for charge photo-generation (~ 95% for blue light) makes avalanche a-Se photosensors a potentially superior alternative to silicon avalanche photodiodes and vacuum photomultipliers tubes.

Although high quantum efficiency is exploited in practical a-Se photosensors, its dependence on electric field and photon energy as well as the mechanism of the free charge photogeneration and recombination remained unclear despite intensive studies since 70s. Clarification of the recombination-dissociation mechanisms requires experiments on quantum efficiency over a much broader range of electric fields than it is possible with plain a-Se layers due to the technical complications associated with operating a-Se at electric fields higher than 30 V/µm. Here we use modified a-Se HARP (High-gain Avalanche Rushing Photoconductor) structure with pixel electrodes that allows us to apply high electric fields at which the avalanche multiplication occurs and to study the dependencies of the free-carrier photogeneration quantum efficiency in broad range of electric fields (10 - 100 V/µm) and wavelengths of excitation.

Our experimental data confirms previous findings that it is geminate pairs recombination that governs optical quantum efficiency in a-Se. Our results allow us to expand our knowledge on geminate recombination which previously was explained by Onsager dissociation theory. We show that for comparatively low photon energies Onsager theory fails to explain our results, provide the reason for this failure and suggest an alternative theoretical model which allows us to account for all observed experimental data.