REACTIVE DUSTY PLASMAS: FROM CUSTOM-DESIGNED NANOCLUSTERS TO NEXT-GENERATION RENEWABLE ENERGY

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Reactive plasmas have long been known to be prone of dust that forms in the ionized gas phase. Such plasmas have been widely used to produce a variety of nanostructured materials, with the most prominent examples being polymorphous or nanocrystalline silicon which is primarily aimed for solar cell applications. However, despite years of research, there still remain a very large number of critical questions such as (i) how to control the structures and sizes of nanoclusters, which are among the primary building units of such films? (ii) how to control the nanocrystal nucleation sites and sizes of critical clusters? (iii) how to minimize the use of the seemingly unavoidable heavy hydrogen dilution which in turn adversely affects the silicon functional layer performance in applications? (iv) is it possible to control the crystallographic growth directions by tailoring the Si nanocluster formation, both in the gas phase and on the surface? (v) what are the physical mechanisms that can enable the most effective control of the presence of the nanostructured phase? (vi) is it possible to arrange the nanocrystalline quantum dots in a custom-designed three-dimensional stack within the functional layers to optimize the performance of the third-generation photovoltaics? And perhaps the most important issue is our very limited understanding of the specific dusty plasma-related processes and effects involved in these and relevant processes. This presentation focuses on such issues and highlights the exciting possibilities of using high-density inductively coupled reactive dusty plasmas to produce advanced silicon-based nanomaterials for the next-generation photovoltaic devices. Specific physics-based approaches to the solution of the above mentioned issues are discussed and illustrated by the recent experimental, theoretical, and computational results obtained through large-scale international collaborative activities on plasma nanoscience and plasma-based nanotechnology.