New solar energy technologies: Impacts on R&D activities in CRTEn (Tunisia)

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The energy balance of Tunisia reached a deficit beyond 2000. To overcome this deficit, Tunisia developed a strategy based on integrating renewable energy (RE) in the balance, aiming to constitute 30% of the total national energy production around 2030. Industrial integration, development of RE and then creation of employment and added value need capacities strengthening while focusing on research and development (R&D), innovation and technology Transfer. The ambitious energetic strategy of Tunisia needs the development of skills in RE technologies.
Solar thermal activities address low and mid temperature starting with interest to the material, the component and complete systems. The objective is to master technologies that support local industries and achieve a technology survey. The main applications targeted are Solar Domestic Hot Water production, which is the main successful solar application in the country, solar agricultural applications, solar cooling, solar drying and solar desalination. Efforts are focused the last three years on CSP (Concentrated Solar Power), which could have an important impact as some power plants are planned using this concept in the near future.
Tunisia (CRTEn) was the first Arab and African country who produces silicon solar cells at a pilot level in 1990 with a yield of about 11%. Technological progress led in 1993 to an average efficiency of 12-13%. Thanks to nanoscience and nanotechnology, the photovoltaic laboratory of CRTEn (Tunisia) experienced new breakthroughs and perspectives in crystalline silicon solar cells processing. Various nanostructured silicon surfaces were developed to improve the quality of crystalline silicon (Si) wafers and then the efficiency of related solar cells. Our aim is to increase the efficiency of silicon solar cells and reduce their manufacturing costs via the "top – down" approach, by using engineered nanostructured silicon surfaces via Porous Silicon (PS) and/or silicon nanowires (SiNWs).
PS-based Si nanostructures were prepared via electrochemical etching (EE) in HF solutions and via stain etching (SE) of Si wafers in ($HF/HNO_3/H_2O$) solutions as well as throughout HF/HNO_3 vapor etching (VE) of Si wafers. The first method (EE) was essentially used in the formation of silicon nanostructures that can be used as antireflection coating or as a sacrificial layer to getter impurities from both mono and multicrystalline silicon wafers. The SE method is generally employed to form a PS sacrificial layer, and is not well indicated to form well defined nanostructures with precise geometrical and morphological parameters. The third method (VE) is a rather complex controlled chemical reaction in presence of a mixture of HF/HNO_3. VE may lead to the formation of PS as well as to another ionic phase ($(NH_4)_2SiF_6$) (soluble in water and ethanol) that may be used to achieve "top – down" micrometric grooves having various geometries. One more way to reduce surface reflectivity is to form SiNWs – based layer commonly called "black silicon" via a "top - down" approach using silver (Ag) or gold (Au) assisted metal dissolved in HF/H_2O_2 aqueous solution. We succeeded demonstrating that the formation of nanostructured silicon in the "top – down" approach can deeply reduce surface reflectivity and improve surface passivation of crystalline Si solar cells using "top-down" chemical/electrochemical approaches. Silicon nanostructures enable achieving cheap grooves that may have several applications. They may also be used as precursors to purify the base material, and improve the electrical and optoelectronic properties of related Si solar cells. However, while black silicon (SiNWs) reduces reflectivity to less than 3 %, surface recombination has long been the bottleneck of related solar cells and has so far limited the cell efficiencies to only modest values.