Nanocrystalline Si films to cut cost of optoelectronics

High bulk silicon material costs and environmental risks associated to tellurides and selenides might be the final obstacles to full development of photovoltaics in the years to come. The use of thin nanocrystalline silicon (nc-Si) films would provide an answer to this problem, if their full potentialities in terms of low cost technology and high conversion efficiency could be demonstrated.

As nc-Si is a distribution of silicon nanocrystals in an amorphous silicon matrix, quantum confining effects might also be present, leading to additional applications in optoelectronics. However, the deposition of nc-Si films having an appropriate content of amorphous and crystalline phases in the right nanocrystal size range is a very difficult task, depending on a large number of independent variables.

Computational tools under development

In its bid to respond to this challenge, the NANOPHOTO project aims to develop computational tools capable of assisting the design and the operation of a new nc-Si growth process. The work covers four main areas:

- deposition of nc-Si thin films using a plasma-enhanced, low energy chemical vapour deposition (LEPECVD) reactor;
- computer modelling of a 2D and 3D low energy (LEPECVD) reactor, of the kinetics of surface reactions and of the 2D growth of nc-Si films;
- structural, electrical and optoelectronic characterisation of undoped and doped films;
- preparation of prototypes of solar cells and light-emitting devices

Among anticipated breakthroughs is industrial adoption of the LEPECVD technique, bringing the advantage of high quality and very high throughput. In addition, the use of nc-Si can be foreseen as an alternative to α-Si in industrial applications such solar cells and flat displays, as well as the development of LEDs operating over a wide range of energies.

Project successes

Progress in modelling. At the half-way project stage, development of a 2D model of the deposition reactor has been completed, fitting well with the analysis of the plasma distribution and composition on the median part of the reactor. Modelling of the silicon nanocrystal growth also closely matches the transmission electron microscope images. (Figure)

Homogeneous films produced. Deposition of microscopically homogeneous films, consisting of a distribution of Si dots, few nm in size in an amorphous silicon matrix, meets the requirements for both photovoltaic and optoelectronic applications

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Coordinator: Prof. Sergio Pizzini, University of Milano-Bicocca, Milan, Italy