Low temperature plasma epitaxy. How does it work?

P. Roca i Cabarrocas$^{1,3}$, R. Leal$^{1,2}$, F. Haddad$^1$, W. Chen$^{1,3}$, I. Florea$^1$, J.-L. Maurice$^1$

$^1$LPICM-CNRS, Ecole Polytechnique, 91128 Palaiseau, Cedex, France
$^2$TOTAL – New Energies, 24 cours Michelet, 92078 Paris La Défense
$^3$Institut Photovoltaïque d'Ile-de-France (IPVF), 8 rue de la renaissance, 92160 Antony, France

Plasma Enhanced Chemical Vapor Deposition using a capacitively-coupled RF glow discharge has become the standard technique for the production of amorphous and microcrystalline silicon thin films. Over the past years we have been using the plasma synthesized silicon clusters and nanocrystals to improve the electronic properties of polymorphous and microcrystalline silicon while increasing their deposition rate [1]. Interestingly enough the same conditions which result in pm-Si:H on glass substrates lead to epitaxial growth on 100 oriented c-Si substrates [2].

Exploring these plasma conditions over the past ten years has resulted in exciting new results: i) epitaxial growth maintained up to several microns with an improvement of the epi-layer quality with thickness ii) fast relaxation of the strain at the interface, iii) successful heteroepitaxy of SiGe on Si as well as on III–V substrates, iv) ultrathin film crystalline silicon cells transferred onto foreign substrates, etc [3]. However the detailed epitaxial growth process remains elusive.

In this work we address the initial stages of epitaxial growth at ~200 °C by combining in-situ spectroscopic ellipsometry and transmission electron microscopy measurements, which point toward an island growth mode. The relative roles of silicon radicals, atomic hydrogen, and bombardment by silicon ions or by charged clusters will be discussed.

Figure 1. Cross sectional HRTEM image of the initial stage of epitaxial growth on (100) c-Si substrates by PECVD from silane-hydrogen gas mixtures at 200 °C.


This work was carried out in the framework of a project A from IPVF (Institut Photovoltaïque d'Ile-de-France) and has been supported by the French Government in the frame of the program of investment for the future (Programme d'Investissement d'Avenir – ANR-IEED-002-01).