# Structural characterization of microcrystalline-amorphous hydrogenated silicon samples prepared by PECVD method

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## ABSTRACT

Microcrystalline-amorphous doped hydrogenated silicon ($\mu$c $n^+$ a-Si:H) samples were prepared by using plasma enhanced chemical vapor deposition (PECVD) method. The samples were deposited on corning substrates at 270 °C and then were annealed at 250 °C during several hours. Raman scattering spectroscopy was employed to study the amorphous-microcrystalline ($\mu$c/a) phase transition and the subsequent microcrystallization process as a function of the annealing time. It was found that the conductivity of the material is closely related to the normalized Raman intensity of the LO mode. In this work, such relation is explained in terms of the impurities activation and by the hydrogen effusion, which takes place during the annealing process. Samples morphology was characterized by atomic force microscopy (AFM). Crystallized silicon islands were observed with an average diameter depending on the annealing time.

**Keywords:** Amorphous silicon, PECVD, Raman scattering, Atomic force microscopy.

## 1. INTRODUCTION

Hydrogenated microcrystalline silicon ($\mu$c-Si:H) has a recognized technological importance because of its significant device applications for instance as a window layer and top contact layer in hydrogenated amorphous silicon (a-Si:H) based solar cells. This kind of material also has interesting properties as high doping efficiency [1] and different optical properties from amorphous silicon. In particular, p and n doped $\mu$c-Si:H films [2] have received considerable attention because of their high conductivity and low activation energy of conductivity. Heavily phosphorous-doped $\mu$c-Si:H films are widely used as ohmic contact layers in thin film transistors (TFTs). Plasma enhanced chemical vapor deposition (PECVD) method is one of the most popular technique utilized to prepare $\mu$c-Si:H films. However the structural properties of these films have been shown to be dependent on preparation conditions, such as rf power, chamber pressure, substrate temperature and the $SiH_4$ concentration in $H_2$ [3] among other things. In addition, impurity doping is one of the significant factors that determines the film properties. $\mu$c-Si:H films consist of microcrystallites less than a few tens of nanometers in sized embedded in an amorphous matrix [4]. The crystallite size and the crystalline volume fraction ratio both significantly affect the $\mu$c-Si:H film properties.

On other hand, it is well known that the deposition of metals onto the a-Si:H films and their subsequent annealing induces microcrystallization [5]. During the microcrystallization process it has been observed the formation of c-Si islands with considerable island growth when noble metals are present [6]. Within these islands of micrometric dimensions, the internal structure change from the amorphous to the microcrystalline phase resulting in a metal-induced a/$\mu$c phase transition. This a/$\mu$c phase transition has been investigated by some researchers using metals such as Au [5], Cr [7], Ni [8] and Al [9] in order to to decrease the crystallization temperature of a-Si:H at a much lower temperature as compared to its normal crystallization temperature of pure Si of about 873 K [10]. Hence, the study of such



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