

# Raman studies of aluminum induced microcrystallization of $n^+$ Si:H films produced by PECVD

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## Abstract

We performed a Raman scattering study of aluminum induced microcrystallization of thin films of phosphorous-doped hydrogenated amorphous silicon ( $n^+$  a-Si:H). These thin films of heavily doped  $n^+$  a-Si:H were prepared by plasma enhanced chemical vapor deposition. Afterwards, aluminum was deposited and followed by an annealing process at 523 K in a nitrogen environment during several hours. Raman results reveal the formation of microcrystalline regions distributed in the amorphous matrix, induced by the film annealing in the presence of the aluminum. We have used the spatial correlation model to estimate from the Raman signal the microcrystallite size and its relation with the annealing time. The estimated crystallite size was found to be between 6.8 and 9.5 nm and the broadening and downshift of the signals are explained in terms of the crystallite size and lattice expansion effects due to the annealing process. Conductivity values of the samples as a function of the annealing time are explained in terms of the contributions from the amorphous and from the microcrystalline phases.

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## 1. Introduction

Amorphous (a-Si:H) and microcrystalline silicon ( $\mu$ c-Si:H) films are of great current technological interest due to the possibility to use them in large area integrated optoelectronic devices, such as thin film transistors (TFTs) [1], solar cells [2], diodes and bipolar transistors [3]. In particular, doped  $\mu$ c-Si:H films as p or n layers [4] have received considerable attention because of their high conductivity and low activation energy of conductivity. This kind of material also possesses interesting superior properties such as high stability and improved carrier mobility as compared to a-Si:H [5]. However, such properties depend strongly on the growth param-

eters as the substrate temperature and the chamber pressure whose effects can create defects in material and at the interfaces, which causes deterioration device performance. Therefore, for device applications, it is necessary to know better the microcrystallization process to obtain reproducible high optoelectronic grade  $\mu$ c-films [6].

The  $n^+$  a-Si:H films can be obtained from different deposition methods, such as chemical vapor deposition, sputtering and plasma enhanced chemical vapor deposition (PECVD). The PECVD is the most popular technique, since it supplies low defect density, high doping efficiency films at low process temperature [7]. It is well known that the deposition of a metal onto the a-Si:H film and its subsequent annealing induces microcrystallization [8]. In this microcrystallization process it has also been observed the formation of c-Si grains with considerable grain growth when noble metals are present

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