

Case Study at the 3rd European DOE User Meeting in Lucerne „Applying DoE to the Deposition of Amorphous and Microcrystalline Silicon films by Hot-Wire CVD“

(06.02.2010 – 11:35 by Markus Höfer, Fraunhofer Inst.)

Markus Höfer, Artur Laukart und Lothar Schäfer

Fraunhofer Institute for Surface Engineering and Thin Films IST

Bienroder Weg 54E, 38108 Braunschweig, Germany

markus.hoefer@ist.fraunhofer.de

Abstract

Hot-Wire CVD (HWCVD) is a new promising deposition technique for photovoltaics and other fields of silicon technology. In comparison to plasma enhanced CVD it has several advantages concerning deposition rate, gas utilization, scalability, cost of ownership etc. Up to now, HWCVD processes have mostly been investigated in fundamental studies applying small-scale deposition systems far away from equipment used in industrial production facilities. For studying the performance of HWCVD under more industry-relevant conditions we have equipped two medium-scale inline deposition systems with HWCVD sources with deposition areas of up to 500 mm x 600 mm. The presented data comes from the commissioning of the first of the two inline deposition systems.

As factors SiH₄ gas flow $q(\text{SiH}_4)$, pressure p , wire temperature T_{fil} and substrate-filament distance d_{SF} were chosen. DoE was applied in a multi-stage process. In order to compare film properties at a constant thickness of approximately 450 nm at first the dependence of the deposition rate on the four factors was analyzed by means of a 2(4-1) factorial. Based on these results we were able to find good estimates for the deposition times for the subsequent preparation of 32 depositions forming a complete CCD extended by 8 center points. In each deposition run a set of substrates was coated, enabling subsequent analysis of the prepared silicon films by Raman spectroscopy, X-ray diffraction (XRD), electron probe microanalysis (EPMA), quantitative secondary ion mass spectrometry (SIMS), Fourier transform infrared spectroscopy (FTIR), photo and dark conductivity measurements and other methods.

For low-cost techniques like Raman and FTIR spectroscopy all 32 samples of the complete CCD were analyzed instantly. On the contrary, for more costly and time-consuming methods of measurement like XRD and SIMS only subsets of samples representing full (24) or fractional (2(4-1)) factorial designs extended by a number of centre points were analyzed.

A remarkable result is that for most of the approx. 30 response variables – in agreement with theory – already the (fractional) factorial subsets of the data provides impressively good information of the basic influences of all factors. Moreover, in agreement with recommendations of DoE textbooks, adding 5 to 6 center points to a fractional factorial drastically increases the explanatory power of the design even if there is no indication for curvature.

3rd European DOE User Meeting
06.01. - 06.02.2010
Lucerne

June 1st to June 2nd 2010 in Lucern / Switzerland

The registration fee is 420,- Euro excl. of VAT

All lectures are given in English

For more information please have a look at the conference page (english / german)

http://www.statcon.de/dxusermeeting_63_en.html