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Semi Quantitative Analysis of Oxygen to Silicon Ratio and Oxygen Content Determination in Thermally Sprayed pc-Si Sheet for Solar Cells Substrate

I. A. S. Carvalho(1,3)*, R. L. Ribeiro (2,3), E. P. Muniz(4), J. R. T. Branco(1)

(1) Fundação Centro Tecnológico de Minas Gerais (CETEC)/SDT, Av. José Candido da Silveira 2000, Belo Horizonte, CEP 31.170.000 - MG. igor.carvalho@cetec.br; jose.branco@cetec.br
(2) Centro Federal de Educação Tecnológica (CEFET), Rua Monte Santo, 319 – Divinópolis – CEP 35.5200.36 – MG ricardo@div.cefetmg.br
(3) Rede temática em Engenharia de Materiais (REDEMAT)/ Praça Tiradentes, 20, Ouro Preto - CEP 35.400.000 – MG
(4) Centro Universitário do Norte do Espírito Santo (CEUNES)/ Rua Humberto de Almeida Franklin 257, São Mateus, CEP 29.933.480 – ES eduardo.muniz@hotmail.com
* Corresponding author.

Abstract - Silicon is considered an essential input for hi-tech industries [1] in which high purity silicon is used with consequent high production cost. Therefore, the polycrystalline silicon (pc-Si) still guarantees its application on solar cells as important market product until year 2050 [2]. Furthermore, 90% of solar modules between 1998 and 2005 were made with solar cells of crystalline silicon [3]. An increasing in the production of silicon for the photovoltaic industry is expected and technologies to produce low-cost silicon with appropriate impurity levels will be needed [4]. There have been interests in developing thick silicon films through plasma spraying technology, which has been practiced for many and still remains an effective and economical method of making high performance coatings. The Atmospheric Plasma Thermal Spray (APTS) process proved to be an efficient process to pc-Si silicon sheet deposition [5-8] due to metallurgical grade silicon low-cost, which is marketed in the range of 98 to 99% of purity and due to APTS advantages such as swiftness and low-cost in layers processing [9]. Fourier Transform Infrared Spectroscopy (FTIR) is a powerful technique to analyse materials microstructure. It can be done at room temperature, in air, without contacts and it is indicated for being a non destructive technique [11-13]. The aim of this work is to characterize APTS silicon sheet by FTIR to get the Oxygen to Silicon ratio to determinate the [O]/[Si] bonding geometry and to get a semi quantitative analysis of oxygen concentration. So far, there is no such analysis for APTS silicon sheets. The [O]/[Si] bonding geometry promotes shifting on IR absorption frequencies that are singular for each case [14,15]. The Oxygen content promotes stretching and rocking vibrations that leads to the existence of characteristics IR absorption frequencies on materials lattice [14-19]. Also, the 635cm^{-1} and 790cm^{-1} bands substitution to 876cm^{-1} is an indicative of more Ogygen content on the material bulk [14-19]. The results showed that we have an asymmetric stretching vibration of oxygen atom in its twofold-coordinated bridging bonding site and its presence can indicate a least a 0,5% atomic bonded-oxygen concentration. We also found the Si-O-Si stretching which is usually observed in thermally grown SiO_2 [16] or at least, in silicon samples with oxygen concentration values higher than 5% [14]. For [O]/[Si] bonding geometry results, we found that we have a [O]/[Si] ratio over 2.0 in a H-SiO_3 configuration for APTS sheet, with IR frequency being dependent to Oxygen content by the time of the sheet deposition.

Table 1: The plasma thermally sprayed silicon sheet deposition parameters

Primary gas/Ar (sccm)	Secondary gas/ (sccm)	Power (kVa)	Carried gas (sccm)	Spray distance (mm)	Power feed rate (g/min)
100	10	1.8	60	180mm	5-10

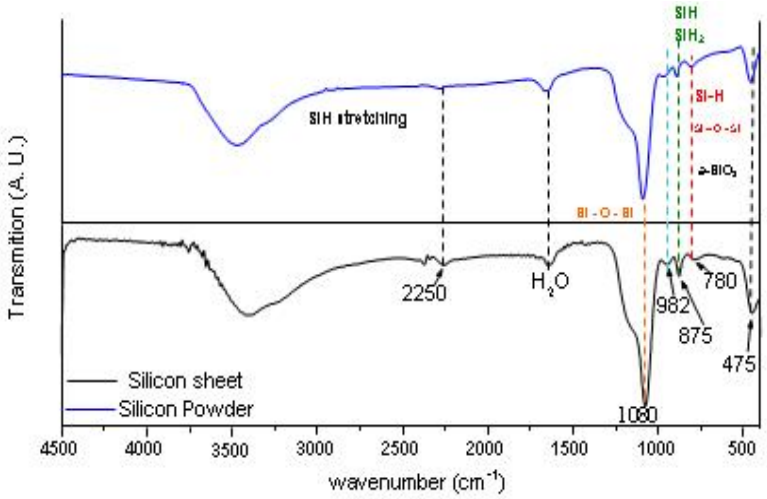

Figure 4: FTIR spectrum of silicon powder and atmospheric plasma thermally sprayed silicon sheet. They are poly-crystalline silicon spectra. It possible to see the Si–H, Si–O–Si and the SiH_2 frequency related to its vibration mode.

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