New recycling process of Kerf-Loss Silicon Powder from Diamond-Wire Cutting Process without any chemical treatment

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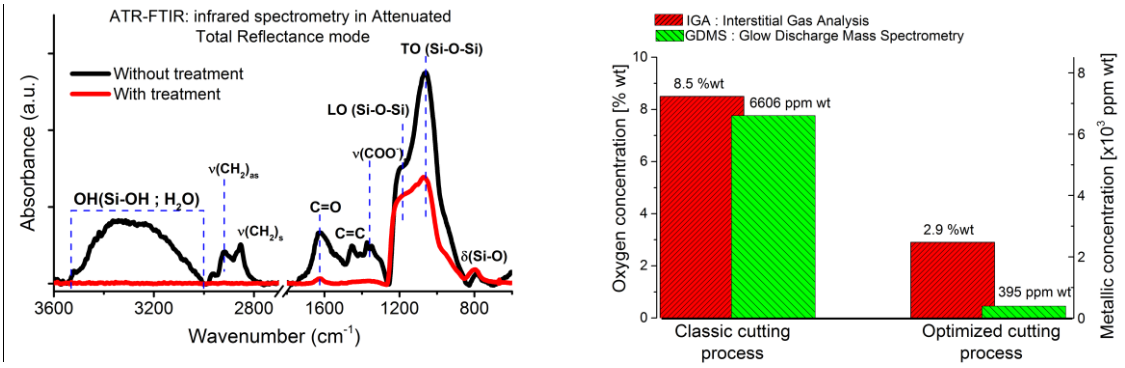
ABSTRACT

In the photovoltaic (PV) industry silicon shaping, the use of diamond wires with water based coolant still causes more than 40% of the valuable Si material to be lost during the squaring and wafering steps in a powder form. The recycling of the kerf-loss Si powder for PV or other applications shows both significant and achievable economic and environmental benefits. Currently, the main Si kerf-loss treatments are based on chemical etching using HF for the Si oxide removal and HCl for the metallic impurities dissolution. HF is dangerous for the users and the environment and expensive from the recycling point of view. The present work shows an optimization of the cutting process and an understanding of oxidation and organic contamination mechanism. This results allowed us to implement a new recycling process of this powder without any chemical step.

A fine characterization of the chemical bonds at the surface of the Si particles by ATR-FTIR spectrometry (Figure 1 (a)), XPS spectroscopy and Raman spectroscopy, has helped understanding the mechanisms of oxidation and organic contamination of the powder [1]. A detailed study of different cutting conditions allowed us to identify the origin of each metallic elements and propose a possible solution to avoid or eliminate it. This understanding has enabled setting up an efficient treatment without any use of chemical etching. This optimization of the cutting process has allowed a significant reduction of the oxygen concentration by a factor of 3 and of the metallic content by a factor higher than 15 (Figure 1 (b)). Thanks to this optimization, purity of the powder was improved from a 2N grade to a 3N grade. The main metallic elements present in this powder are aluminum, sulfur and nickel.



(a) (b)

Figure 1: (a) ATR-FTIR spectra of the silicon powder with and without treatment, (b) oxygen and metallic concentration for the classical cutting process and the optimized one.

The reduction of oxygen concentration and the efficient treatment allowed the melting of the recycled powder without any chemical treatment (Figure 2). This result open the way for the purification of the kerf-loss silicon powder by a thermal segregation process.

Figure 2: picture of an ingot obtained after melting of kerf-loss Si powder.

[1] A. Benayad, H. Hajjaji, F. Coustier, M. Benmansour and A. Chabli "Surface Chemical-Bonds Analysis of Silicon Particles from Diamond-Wire Cutting of Crystalline Silicon", submitted to Journal of Applied Physics, August 2016.

This work has received support from the French National Program «Investment for the future» in the frame of the INES2 project bearing the reference ANR-10-ITE-0003.