Relationship between interstitial oxygen, substitutional carbon, resistivity and minority carrier lifetime in metallurgical multicrystalline silicon

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Abstract. In this study we try to indentify relation between carrier lifetime, resistivity and two mains impurities concentration in a p-type upgrade metallurgical multicrystalline (UMG) silicon ingot. Thanks to this relation, we could prevent the Light Induced Degradation (LID) phenomenon and the SiC particles formation which are, respectively, at the origin of Voc losses and shunts in solar cells. So these 2 parameters are important for photovoltaic panels' efficiency. Lifetime measurements are achieved by means of the Microwave Photoconductivity Decay "μw-PCD" technique, and concentration measurements are determined by FTIR. We demonstrate that resistivity variations depend on oxygen's concentration but carbon analyses must be continued.

Key words

Metallurgical multicrystalline silicon, low-cost, minority carrier lifetime, interstitial oxygen, substitutional carbon.

Objectives and interests

Silicon based Photovoltaics is a way to convert solar light to electricity. It represents more than 80 % of photovoltaic installation. Its full development involves a drop of module's price and an increase of the raw materials cost.
This induces studies of low cost silicon substrates simultaneously with cells processes optimizations.
In this paper, the upgrade metallurgical silicon is analyzed (UMG). It's a purification of the cheapest silicon, called metallurgical silicon (MG), which has an excess of metallic impurities. This UMG is a good compromise between the raw material and the electronic grade [1]. But in solar cells based on UMG, the light induced degradation is more important [2]. It might be linked to the presence of both boron and interstitial oxygen Oi.
Our aim in this work is to establish relations between oxygen Oi, minority carrier lifetime (τ) and resistivity (ρ) in UMG wafers before the LID phenomenon to prevent it. Thus we have performed concentration measurements by FTIR.
In this material, carbon could form SiC particles during crystallization. It seems to be at origin of shunting in solar cells [3]. Moreover, an excess of oxygen with carbon saturation can be expressed by a coprecipitation which will creates recombination centers. This could be an efficiency limitation of solar cells [4].
Therefore substitutional carbon, [Cs], analyzes have been also performed by FTIR.
For these tests, wafers have been sawed vertically along the brick to compare the crystallization progress, electrical properties and concentrations parameters.

Main contributions

Two samples have been chosen and sawed along one UMG ingot. One is placed at 5,5 cm near the crucible, the second is placed closer (at 2 cm near the crucible) to study crucible effects on to the ingot. Concentration measurements by FTIR require thick and polished samples: 1cm thick wafers have been chosen.

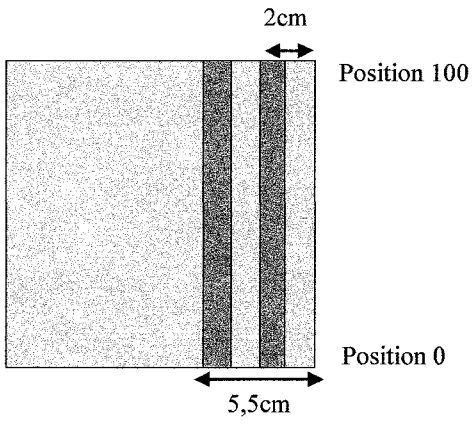

Figure 1: samples in the brick