Processing of Metallurgical Silicon by Powder Metallurgy

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Abstract. Silicon is the most important semiconductor material in electronics and electrotechnics and also the most frequently studied substance in solid state physics and chemistry. Dominant approaches focus on purifying or upgrading widely available metallurgical silicon to reduce photovoltaic costs. Based on these new possibilities, the present work shows composition, particle sizes and porosity of sintered metallurgical silicon by means of X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM).

Key-words: Powder Metallurgy; Silicon; Electron Microscopy, Photovoltaics.

1. Introduction

Silicon is one of the semiconductor substrates utilized in the manufacturing of transistors, diodes, rectifiers, and integrated circuits [Fonseca & Onmori, 2007], as well as of solar cells. Researches in porous silicon have a big profit due to its electrical and optical properties, as photoluminescence, photoconductivity and absorption [Fontana et al., 2006]. Porous silicon substrates can be prepared electrochemically by anodization from silicon crystalline wafers [Bin. 2000]. High-energy ball-milling with further consolidation stages allow the obtainment of porous silicon of good quality [Jacubowicz, 2004]. The porous silicon is also an examples of inorganic component used in hybrid photovoltaic cells [Tokranova et al. 2005].

Manufacturing of compact parts from low-cost silicon and without binding agent may avoid inclusion of native oxides (proceeding from wet cleaning and high-temperature processing). Silicon powders can be conditioned to produce particulates with a hydrogen-terminated surface before compaction [Barraclough, 2007]. The present work aims to characterize metallurgical silicon powders and compacts by XRD and SEM.

2. Methodology

Metallurgical silicon used in this work was kindly donated by the Globe *Metais* Brazilian Company, branch of Globe Speciality Metals Incorporation. Silicon was furnished as granules and powders with maximum particle size of 3.4 mm and purity of 99.0 w.-%. Such material was pounded at a steel pestle punner and processed at SPEX Mill to allow its cold pressing. PVAL agglomerant was used in some samples and the as-milled powders were processed for 5 and 15 minutes. The powders were cold uniaxially (90 MPa) and cold isostatically (300 MPa) pressed during 90 seconds. The as-milled powders were consolidated at temperature of 1200^{o}C and by pressureless sintering (titanium crucible in high vacuum) and uniaxial hot pressing (graphite die in argon), respectively. Microstructural investigation was performed by XRD (Cu Kα radiation) and SEM with an energy-dispersive spectrometry (EDS).

3. Results e Discussion

XRD experiments show that manual milling modifies the preferred orientation of the pristine granules. Otherwise, SPEX milling increases the number of planes of the silicon crystal lattice. Sintering keeps the higher number of planes observed after SPEX milling. SEM illustrates the morphology modification on silicon powders after milling processes. This technique also shows that hot pressing produces porous silicone compacts and the pores are well distributed and homogeneous (Figure 1).

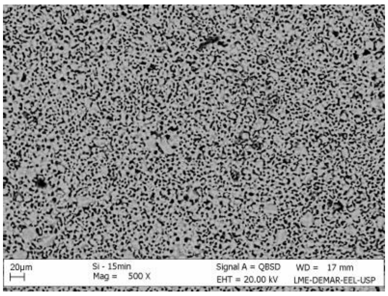

Figure 1 – SEM of porous silicon compact.

4. Conclusion

Powder metallurgy can be used to produce porous silicon compacts from metallurgical silicone feedstock with good quality. Further studies must be performed to verify the electrical and photoluminescence properties of these compacts.

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