Producing novel energy saving porous ceramics using waste solar cell silicon wafer slicing sludge

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Solar power, a renewable energy generated by solar cells to convert energy from the sun, grows rapidly in the past decade. Solar cells are usually made of monocrystalline or polycrystalline silicon [1]. The silicon solar cell base, silicon wafer, is sliced from silicon ingot by sawing wire during slicing process. Cutting oil (polyethylene glycol (PEG), diethylene glycol (DEG), or mineral oil) with the functions of cooling and lubrication and silicon carbide (SiC) powder as the abrasive are added for accelerating cutting efficiency [1]. Thereafter, silicon wafer slicing slurry containing cutting oil, Si, SiC and few metallic components (Fe, Cu, and Zn etc.) from sawing wire is generated. Normally, cutting oil can be recovered by centrifugation and metallic components can be further dissolved by strong acid, but the advanced separation of Si and SiC particles is still an unachievable goal except abandoning the valuable Si particles using strong NaOH to dissolve Si [2]. Thus, wafer slicing (WS) sludge containing Si, SiC particles and metallic components after centrifugation are usually dumped.

Since SiC and Si have the characteristics of high strength, high thermal conductivity, and high specific heat capacity, and SiC and Si particles will partially gasify during high temperature, so that the feasibility of producing energy saving porous ceramics using WS sludge as the raw material was studied in this research. Silicon WS slurry was sampled from a solar cell manufactory located at north of Taiwan. WS slurry was pretreated by centrifugation and the sludge was further dried at 105 °C to remove the residual cutting oil (mineral oil). Thereafter, dry WS sludge was ground and past ASTM sieve # 18. WS slurry was then mixed with a ceramic raw material taken from a kiln roller manufactory at different mixing ratios of 0, 10, 20, 30, and 40%, respectively. The mixed raw material was further processed by a series of processes including ball milling, dry, grinding, pelletizing, and mould press to fabricate green ceramic bodies. The green ceramic bodies were finally fired at a wide range of temperatures (1,100–1,450 °C) to fabricate energy-saving porous ceramics. The characteristics of energy-saving porous ceramics, including shrinkage, bulk density, porosity, and thermal coefficients, were finally detected.

The shrinkage, bulk density, and porosity of produced energy-saving porous ceramics were shown in Figure 1–3, respectively. Stable shrinkages of 30 and 40% WS sludge ceramics were found (Fig. 1) among the temperature ranges of 1200–1400 °C and 1100–1350 °C, respectively. The bulk density and porosity (Fig. 2–3) show that the ceramics of 30 and 40% WS sludge have lower bulk density and obvious high porosity than others. In conclusion, the experimental results show that: (1) WS sludge can be used for producing energy-saving porous ceramics and the optimal mixing ratios were 30 and 40%; (2) the wide firing temperature range (200 °C or more) giving a very easy and stable production confirms excellent ceramics products; (3) energy-saving porous ceramics should resist heat variation and the ceramics of 30 and 40% WS sludge could resist temperature variation below 1,400 and 1,350 °C respectively and had coefficients of thermal expansion of 15–20 x 10⁻⁶/°C. Finally, this novel method using waste WS sludge to produce high-valued energy saving porous ceramics was achieved and more advanced thermal measurements will be done in the near future.
Figure 1. The shrinkage of produced energy-saving porous ceramics using wafer slicing (WS) sludge.

Figure 2. The bulk density of produced energy-saving porous ceramics using wafer slicing (WS) sludge.

Figure 3. The porosity of produced energy-saving porous ceramics using wafer slicing (WS) sludge.

References