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Influence of Incorporated Light Elements on Refining Process for High-Purity Silica using Microchannel Device

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Demand of high-purity silica as a source of solar grade silicon (SOG-Si) has been continuously increasing, while the prospect and amount of high-grade silica ore, the feedstock for the conventional Siemens process, is limited. Hence, it is necessary to develop an alternative approach to supply high-purity source for SOG-Si in large quantities using less expensive method. Since 99.9999% (6N) or higher purity is required for SOG-Si, efficient way of refining is strongly required especially for the elimination of light elements such as boron and phosphorous due to its dopant activity.

Diatomaceous earth, an earth abundant silica resource, with aqueous chemical process is a candidate for the high-purity silica supply [1]. We have reported the elimination of boron from the diatomaceous earth using microchannel device, which has advantage for efficient reaction due to short diffusion distance and large interfacial area [2]. In the previous study, solvent extraction by 2-ethyl-1,3-hexanediol (EHD) toluene solution were carried out on a "model sample" consisting of purified silica spiked with trace amount of boric acid and a "real sample" consisting of preliminary refined diatomaceous earth, respectively. In both cases, residual boron content after the extraction using a microchannel device was lower than the case using a conventional separatory funnel although the contact reaction period was much shorter. However, the extraction efficiency on the real sample was lower than that on the model sample. Since incorporation of impurities strongly influences to the precipitation of silica network, the precipitation and separation are key processes for further efficient refining.

Here we report the elimination of light elements from silica solution focusing on silica precipitation and separation with scaling up of a microchannel device. Microchannel with horizontal water/organic interface, on which the interfacial area can be easily enlarged, was fabricated on a silicon and glass substrate using photolithography techniques (Fig. 1). As model solution sample, purified silica and impurities, such as boric acid, were dissolved into NaOH aqueous solution. Following the pH adjustment with HCl aqueous solution, the model solution sample and EHD toluene solution were injected into the microchannel at 3 mL min^{-1}, respectively. Composition of the sample after extraction was determined by inductively coupled argon plasma atomic emission spectrometry (ICP-AES).

As a result, the formation of parallel laminar flow was observed in the microchannel along with the horizontal axis on the substrate, and the model sample with precipitated silica was successfully separated. The extraction efficiency was comparable to the previous result on a narrower microchannel at 0.1 mL min^{-1} of the flow rate. This result indicated that the efficient elimination of light elements can be operated using the scaled-up microchannel device to produce high-purity silica for SOG-Si. The structural analysis of the refined silica and the influence of silica precipitation to elimination of impurities will be discussed.

References

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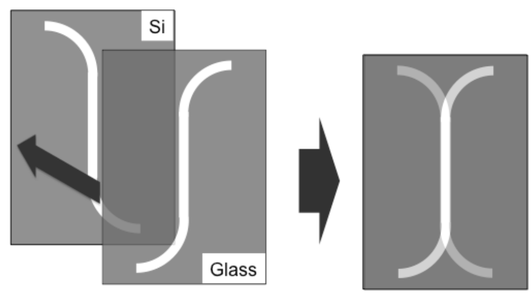

Figure 1.Schematic image of a microchannel combined with silicon and glass substrates