THE SMALLER, THE GREATER

Silicon particles – conditioning and cleaning The quality of the silicon used in their production significantly affects the lifetime of solar cells. Furthermore, silicon is a valuable material. Thus cleaning and recycling of silicon granules and wafer scrap should be a profitable undertaking. However, such cleaning is easier said than done. The small silicon particles are often more contaminated on the surface than silicon chunks as a result of crushing.

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Fig.1: Removal of impurities from silicon granules with a granule size distribution between 100 µm and 4 mm is a challenge

The greatest challenge in etching silicon is presented by small particles or granules. A possible solution to this problem is to use a sophisticated granule etching tool which permits cleaning of small sized silicon granules (> 0.1 mm) and wafer scrap.

A major issue is to determine the feasibility of acid wet chemical cleaning for improving the surface quality of granular silicon such as wafer scrap. The tools used for producing such clean surfaces are a band filter and conventional cleaning equipment using baskets or barrels.

Removal of impurities from silicon granules with a granule size distribution between 100 µm and 4 mm is a challenge. Companies are currently focusing their attention on wet chemical treatment of the surfaces of silicon granules and wafer scrap in order to produce a higher efficiency, high throughput, cost effective industrial process.

A variety of contaminations

The problem of cleaning silicon surfaces is complex, particularly in view of the wide variety of possible contamination, particle size, and surface structures. Organic residues containing sodium or even fingerprints can be found as well as metallic residues (e.g. iron) resulting from crushing and transport processes. Also the very large surface area which has to be cleaned, due to the particle size with a minimum starting at 100 µm, poses a challenge.

All contamination has to be removed completely down to the demanded level, which often lies in the ppbw zone.

Wet chemical cleaning can be an appropriate instrument for economic removal of contamination from silicon surfaces. As an example, a functional approach to the cleaning of wafer breakage from production, is presented. Based on the use of mainly conventional HF/HNO_3 acid mixtures, the feasibility in the par-

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ticular process application is examined critically. Currently the average surface quality demanded in approved specifications for prime grade polysilicon granules stipulates a value lower than 50 ppbw for metals like iron.

Impurities impair cell lifetime

It is known that metallic impurities essentially reduce the lifetime of solar cells. Recombination-active impurities like Fe, Cu, Cr, and Ti contribute to a drop in solar cell efficiency. Bulk contaminations (subsurface contaminations) are caused by:

- Diffusion – Fast diffusion metal atoms like Ni or Cu go into the bulk at "room temperature"
- Cracks (open- and closed cracks) – Cracks are caused by mechanical treatment and impurities (particles) generated by the mechanical treatment fill and close cracks

The operating efficiency reported for solar cells produced with polysilicon granules depends on the purity of the silicon. The conventional process sequence uses barrels or carriers to clean silicon granules, which lowers production throughput.

Valuable waste

Cleaning silicon granules by means of a band filter offers higher average efficiencies due to the clean surface while simultaneously presenting a more compact, cost effective option for production. The efficiency levels of today's solar cells are seriously limited by the quality of the materials used in their production, i.e. by the purity of silicon. Silicon granules with a high surface purity are demanded by the market. Due to the increasing quality requirements the surface quality of silicon granules must be excellent. Silicon material in different forms (powder, granular, chunks, wafers. etc.) is produced as waste or scrap at different stages of the overall solar wafer production process. This valuable "scrap material" can be re-used in the production of silicon ingots, which reduces manufacturing costs. A granule etching tool enables producers as well as users of solar silicon to clean and recycle this valuable raw material from various stages of the fabrication process.■

Clean silicon surfaces of utmost importance

- The problem of cleaning silicon surfaces is complex, particularly in view of the wide variety of possible contamination, particle size, and surface structures.
- Currently, the average surface quality demanded in approved specifications for prime grade polysilicon granules stipulates a value lower than 50 ppbw for metals like iron.
- Cleaning silicon granules by means of a band filter offers higher average efficiencies due to the clean surface while simultaneously presenting a more compact, cost effective option for production.

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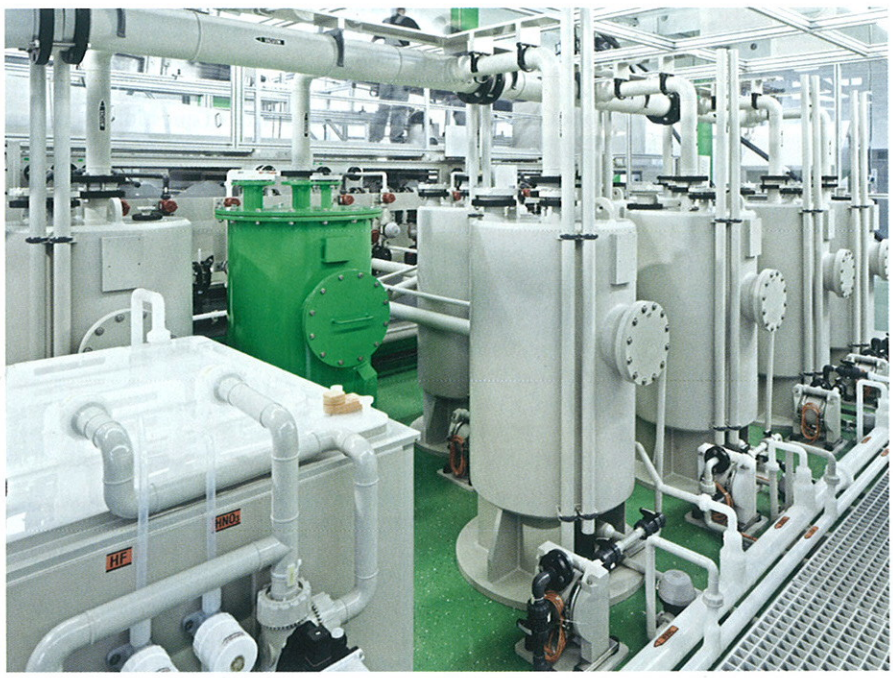

Fig.2: Silicon granules and wafer loss can be cleaned by a new etching process