COST EFFECTIVE GROWTH OF SILICON MONO INGOTS BY THE APPLICATION OF A MOBILE RECHARGE SYSTEM

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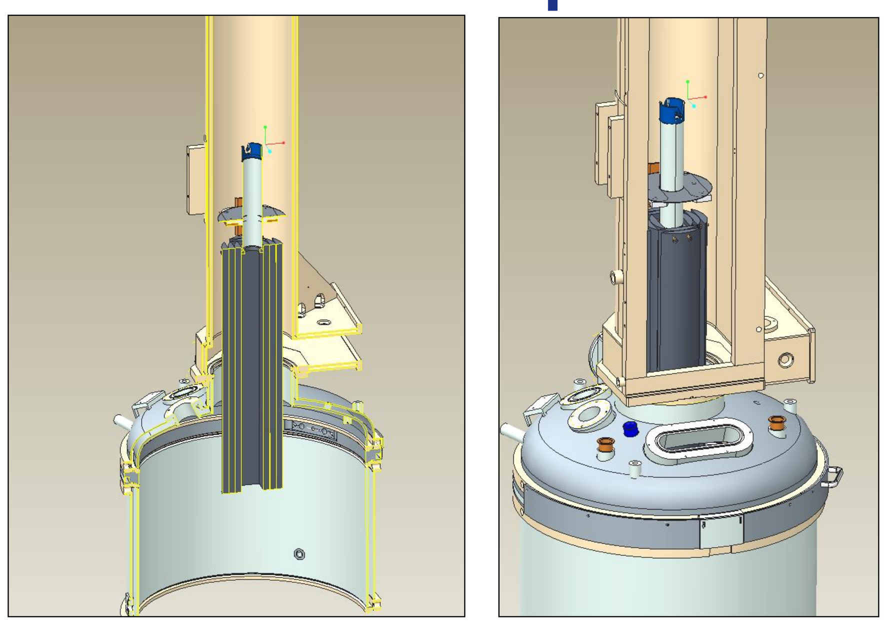
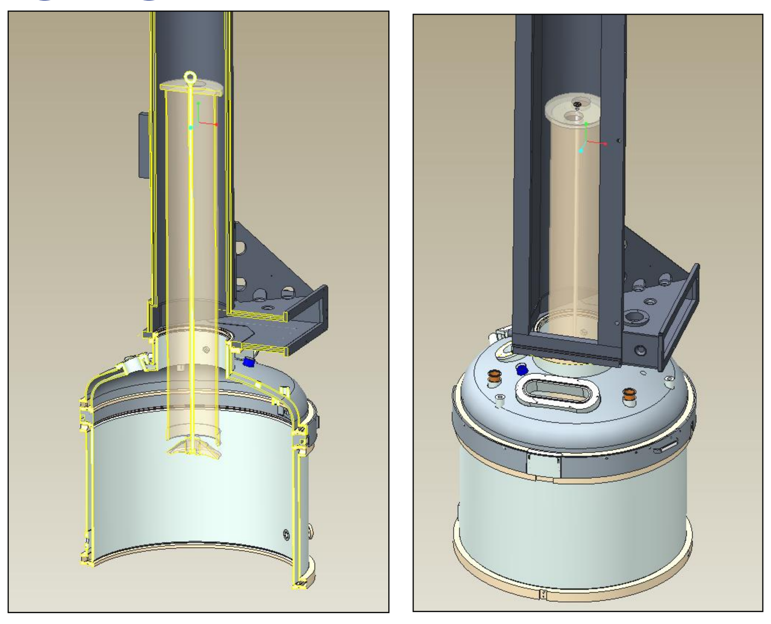
Multipulling of Silicon Monocrystals

At present, silicon monocrystals are still produced mostly according to the standard Cz-batch process. In order to reduce the production costs, in particular the crucible costs, and to economize the Cz-process by saving unproductive down times during the heat-up and cool-down cycles, multiple batch recharging is a favorable track. This multiple batch recharging is also called "multipulling Czochralski" (MPCz) and is defined here as the growing of several ingots in one crucible with melt replenishment after each growth process

Standard Concepts of Recharging

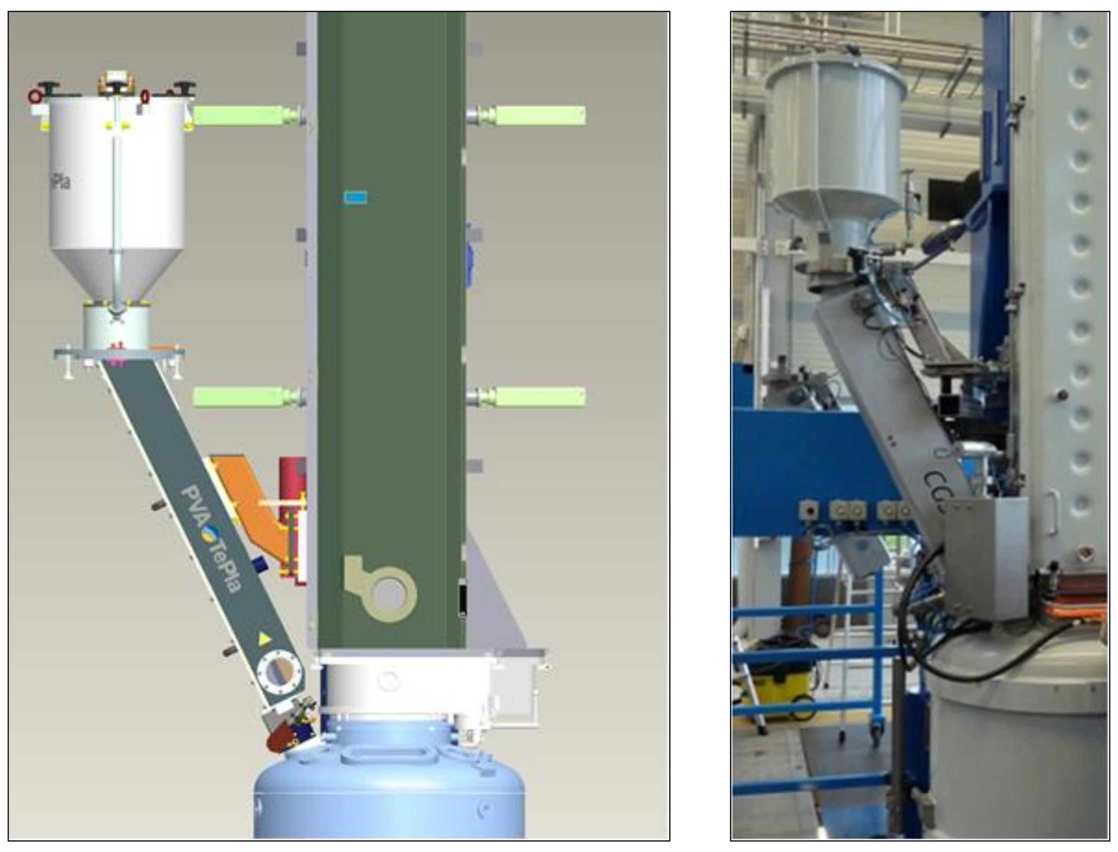


"Slab-Feeder" from PVA Crystal Growing Systems GmbH



"Central Feeder"

Simple, but effective recharge systems are the "slab-feeder", where the side slabs of squared ingots are attached to the central pulling drive and are slowly lowered into the hot crucible, or the "central feeder", where a quartz tube filled with silicon chunks also attached to the central pulling device is lowered into the crucible and emptied into the restmelt. The disadvantage of both systems is that the previous ingot had to be cooled down and taken out of the gate before starting the feeding process.



Stationary Feeding Unit from PVA Crystal Growing Systems GmbH

The stationary feeder is permanently mounted to the puller. The storage vessel (hopper) is removable for charging with silicon feedstock material up to a chip size of 10mm. Inside the connection piece between the hopper and the furnace vessel a system of movable quartz tubes is installed, which can be moved back and forth, depending whether the feeder is in operation for feeding or separated from the growth chamber by means of a gate valve for refilling the hopper.

Mobile Recharge System MRS

Mobile Recharge System from PVA Crystal Growing Systems GmbH

The great advantage of both systems (stationary feeding unit and mobile recharge system) is that the replenishment of the crucible can be executed during the cool down of the ingot in the gate chamber.

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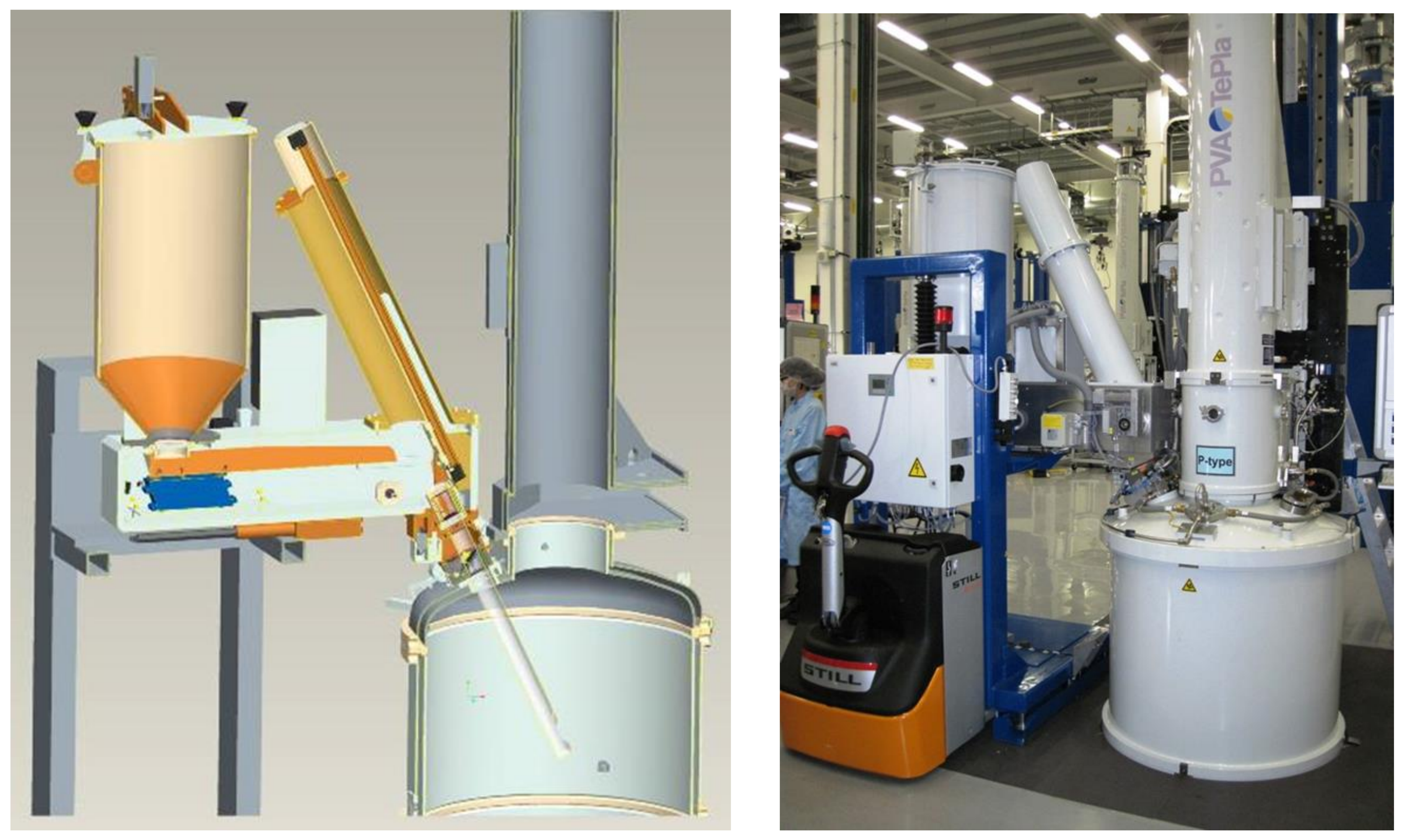
Principle of the Mobile Recharge System MRS



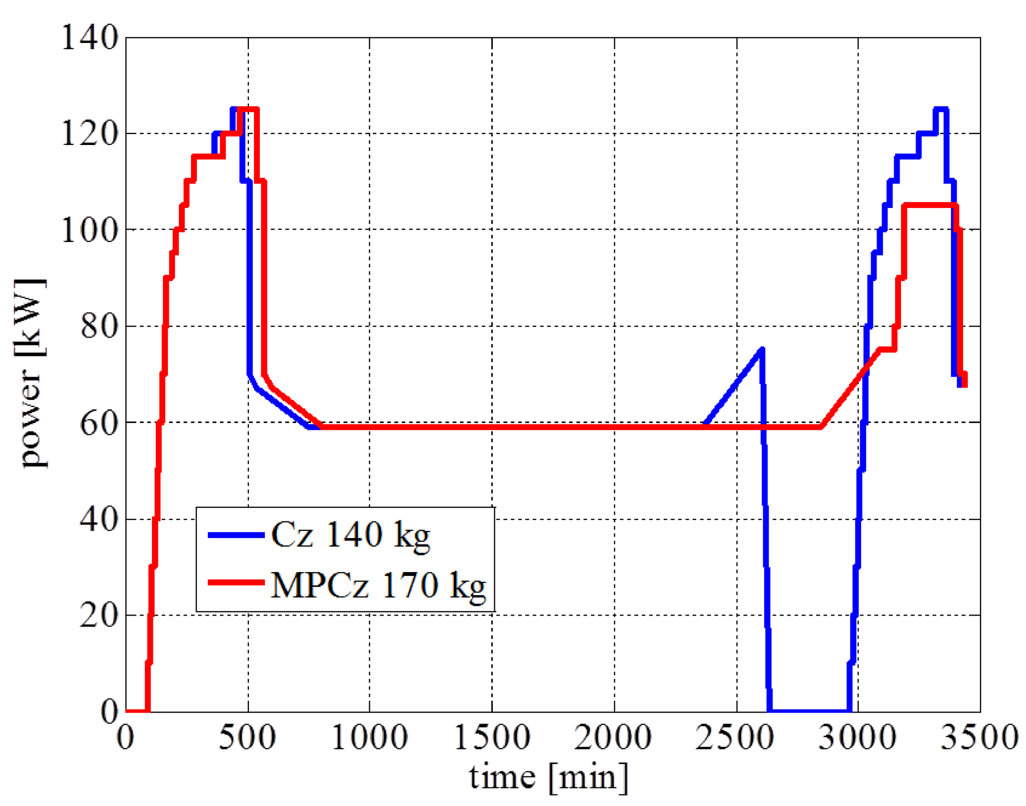
Mobile Recharge System MRS in process

The MRS-system can be docked in any phase of the growth process, for instance in the melting or in the endcone phase. The docking valve remains closed and after docking, the MRS-system is evacuated and leak tested. When the melting phase or the ingot growth is completed and the ingot is separated from the growth chamber, the feeding of the hot crucible can be initiated. Therefore the whole feeding system is pressurized to the growth chamber condition. The docking valve is opened and the quartz tube is lowered to its feeding position in the hot crucible. Feeding can be executed under argon gas flow.

The MRS-system is controlled by the PLC of the puller, which is the case for Cz-pullers from PVA CGS Gmbh. For other manufactures it is also possible to control the mobile feeder by its own PLC, assuming a flange for the docking valve is available.

ECONOMIC ANALYSIS OF THE MULTIPULLING Cz-PROCESS

The main economic potentials are the cost-saving of crucible consumption and the reduction of the down-time between the standard batch processes, resulting in a considerably increased output.



Power consumption of the heater versus process time for a standard Cz- (blue curve) and a recharge MPCz-process (red curve).

process stage	time [h] Cz	time [h] MPCz
pump down (incl. leak test)	1.5	1.5
melting to diptemperature	7.5	8.5
stabilization, neck, crown	3.5	3.5
body	27	33
endcone	4	4
time to next diptemperature	13.5	6

***Table I:** comparison of a standard Cz-process with a MPCz-process.*

The curves were derived from real crystal growth experiments performed at the crystal growth department of PVA CGS GmbH. The results are summarized in table I. The standard charge weight is 140 kg for an 8 inch ingot with a body length of 1600 mm. The blue curve represents a complete standard process followed by the cool down and heat-up sequence for the second ingot ending at the dipping point. The red curve shows the course of the heater power for the crystal growth with a optimized fillevel of 170 kg and the subsequent refill process of the hot crucible, also ending at the dipping point.

The longer duration of the body growth due to the topping up of the crucible is compensated by reducing the downtime (see fig.). An increase of productivity of 25 % (25 ingots/year) and an economization of 67 % of the crucible cost should be possible using the MRS system. One MRS-system should serve for 5-7 pullers.

Conclusions

High quality crystals can be grown by the application of the MPCz-technique. With this MRS-system capital costs can be minimized. It is shown that the additional investment for the recharge system is quickly amortized by the economization of crucibles and other operation costs.

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