

# Nano-processing and Nano-risks for Future Innovation

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Sustainability of human beings in the 21st century requires development of renewable energy systems based on technology innovation. Nano-processing plays a key role in promoting technology innovation relating to environmental and energy systems. An example of the key devices expected in the future is a combination of solar cells and Li-ion batteries, in which the indispensable materials are silicon and carbon. The shape and nanostructure of materials must be controlled to fabricate highly efficient devices at a low cost.

Silicon synthesized by Zinc reduction method from  $\text{SiCl}_4$  source had variety shapes from nano-wires to powders, which depends on processing conditions. Some of them are good for solar grade silicon having 6N purity. We show an innovative route to fabricate a spherical silicon solar cells (SSSC) shown in Fig.1 with a semi-concentration reflector system from silicon powders (see Fig.2). SSSC is not an ultimate device, but shows essential features such as less silicon usage, low cost, durability and flexibility. In the future, the current efficiency about 11% will be improved up to 18%. First, the production cost of SSSC can be reduced to much lower than that of SSC. The amount of silicon used for SSSC is reduced to 1/5 to 1/7 due to the concentration of solar rays by the reflective mirrors. The cost of solar grade silicon can be dramatically reduced by changing the current process, the Siemens method ( $\text{SiHCl}_3 + \text{H}_2 \rightarrow \text{Si} + 3\text{HCl}$ ), to a new process, the DuPont method as an example (see Fig. 2). The Siemens method, whose reactor is a kind of CVD reactor, produces polycrystalline silicon for the conventional pulling process, the Czochralski process. On the other hand, the DuPont method ( $\text{SiCl}_4 + 2\text{Zn} \rightarrow \text{Si} + 2\text{ZnCl}_2$ ), whose reactor is a kind of furnace that produces granular and needle-like silicon, is not good for the pulling process. SSSC can use powdered silicon to produce a silicon ball. The amount and the cost of silicon used for SSSC are much lower and this results in low cost.

Material recycling, high-efficiency energy and renewable energy required for the 22nd century must be achieved by reducing the number of chemical elements. Silicon and carbon are key materials. Controlling the shape and the nanostructure of materials can enable highly-efficient devices. Nano-processing can realize highly-efficient processes and

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low-cost mass production by developing new reaction engineering that design material structures with reactions<sup>(1)</sup>.

Nano-hazard data strongly depend on nano-processing. We are developing a structuring knowledge system<sup>(2)</sup> for nano-risk assessment shown in Fig.3. Both nano-processing and nano-risks are crucial for developing future materials and devices.

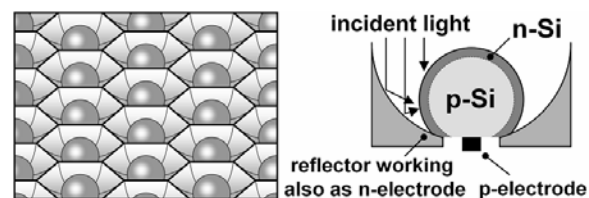


Fig 1. Schematic features of SSSC.

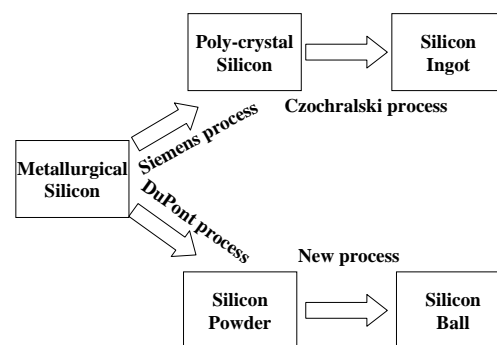


Fig.2. New route of silicon ball production through powdered silicon

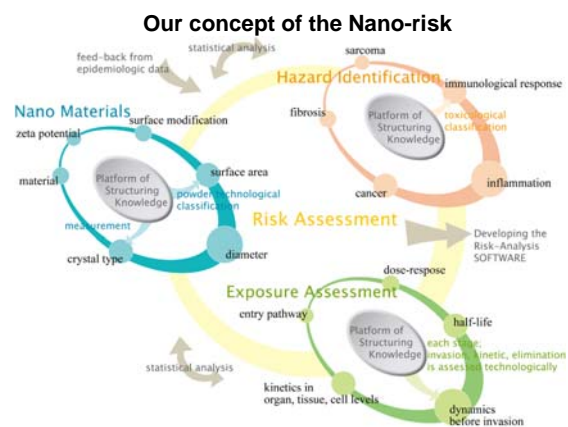


Fig.3 Structuring knowledge on nano-risks.

## References

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