THE PV SOLAR VALUE CHAIN

STARTING WITH CHEMICAL PROCESSES AND ENDING WITH MICROELECTRONIC TECHNIQUES, THE PHOTOVOLTAIC (PV) VALUE CHAIN COMBINES A GREAT VARIETY OF EXPERTISE. CONNEXION TAKES YOU THROUGH THE KEY STEPS, FROM THE SILICON RAW MATERIAL TO THE SOLAR MODULE.

1. MANUFACTURING SOLAR GRADE SILICON
   - **Metalurgical grade silicon**
     - From quartz: Silicon is found only in combined form in nature. Using an electrometallurgical process, it is produced from a mixture of quartz (SiO₂), coal, and wood in a very high temperature furnace.
   - **Metallurgical silicon**: Metallurgical silicon is about 99% pure. Further purification is required for the PV solar industry; solar grade silicon must be more than 99.99999% pure.
   - **Purification of metallurgical silicon**: Cracking of the trichlorosilane at high temperatures (1100°C) in a reactor. The silicon is deposited and obtained in the form of purified nuggets called "chunks".

2. MANUFACTURING WAFERS
   - **Wafer production**: The wafers are treated in different ways to clean off the debris from previous processes. A first selection is made to remove defective wafers.
   - **Slicing wafers from ingots**: The ingots are sliced in wafer using wire saws. A high-precision cutting is necessary for minimum waste. No more than 0.18 mm thick, the wafers can easily crack.
   - **Shaping of the monocrystalline ingots**: The square shape obtained (step 3) allows the optimization of the space in the modules fabrication.
   - **Tailing, cylindrical grinding and cutting of the ingots**: The extremes of the ingot, rich in impurities and flaws, and the external surface corrugations are eliminated.

3. MANUFACTURING PV CELLS
   - **Crystallization of the silicon in ingots**: Monocrystalline is obtained through growth or pulling of a cylindrical ingot from a monocrystal through the Czochralski process. The melting point is reached at 1414°C.
   - **Slicing wafers from ingots**: The wafers are placed in a bath to remove the surface damaged by sawing and to texture their surface. This texture enhances the absorption of sunlight.
   - **Cells encapsulation**: After strings of cells being interconnected, they are assembled with a sheet of glass, two foils for EVA resin and a impermeable film (the "backsheet"). Using a vacuum lamination process, the system is heated and pressed: it is now a photovoltaic laminate.
   - **Connecting cells**: The cells are assembled and welded together to form multi-cell strings.
   - **Doping by diffusion**: To obtain a semiconductor junction, the wafers are doped in surface with phosphorus or boron by thermal diffusion, in a furnace heated to 800°C.
   - **Métallisation**: An electrical circuit is screen-printed into the front or rear surface of the wafer, to carry the collected current. This coating also gives solar cells their blue color.
   - **Testing**: The modules are tested in calibrated artificial light to measure their electrical characteristics.

4. MANUFACTURING PV MODULES
   - **PV solar modules**: The PV solar modules are now ready to generate direct current. The size of the modules depends on the application.
   - **Cells encapsulation**: The modules are tested in calibrated artificial light to measure their electrical characteristics.
   - **Finishing and mounting the modules**: The PV solar module is framed and equipped with a junction box for power connection.

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