
## Workshop »Coatings for Energy Technologies«

# Comparing Thin Film and Silicon Solar Mass Production Equipment

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Two main concepts are present in today's solar mass market. Crystalline silicon (c-Si) with a 95% market share, thin film solar (a-Si, CdTe, C(G)IS) – coated directly onto glass or other substrates and minor applications such as crystalline GaAs. State of the art mass production tools can treat easily over 1M square meter per year or depending on technology over 600 MW PV peak power. Certain steps such as laser cutting, screen printing and batch cleaning are not so cost-relevant for the final product, so this presentation will focus on vacuum deposition tools.

SINGULUS provides - besides others – inline machines for core technology coatings in both thin film and c-Si solar cells. That contains PVD-coating tools for front and rear contacts (metals and TCOs), PECVD tools for doped and undoped dielectric films (oxides, nitrides, a-Si:X, poly-Si:X) and evaporators and furnaces for formation of absorbers in thin film technology (Coevaporation, Selenization).

Now the question for the machine builders is, can these technologies benefit from each other? As usual the answer is yes and no: Some aspects are fundamentally different, such as substrate transport of wafers in a carrier and sheet glass which can roll directly on rollers. Also, the thermal stability is a hard criterion which sets boundaries for glass compared to silicon. Other aspects can be transferred between the technologies such as the heating and cooling rates of the substrates which scales with thermal mass and emission properties, or process uniformity; Some technological aspects are almost equal and help to scale up vacuum coaters such as the vacuum generation or deposition technology.

If we look on the detailed processes for both technologies, we see that the front contacts in single junction PV have fairly similar requirements for bandgap and lowest absorption at decent conductivity. The same applies for rear contacts: TCOs or metals for thin-film (Mo, Al, Cr). So these PVD technologies can benefit strongly from each other. A major difference from c-Si to thin film is the glass substrate that is heated quite to the limit. SINGULUS furnaces run the glass to or above the softening point to form decent absorber material. This gives extra constraints on the machine chambers and transport system and diffusion of impurities. In any case both PV branches can and had learn from each other: That is true on the process side but also on the machine and component side.