

Industrial TCO Coating for Thin Film Photovoltaics

With the surge of photovoltaics (PV) in the world today, thin film solar cell manufacturers are looking for better and more economical coating solutions for their production lines. Beneq, with its in-house nAERO[®] aerosol-assisted deposition method, presents a technically superior, economical and independent coating method for in-line and off-line coated products. nAERO is capable of producing low-haze and high-haze transparent conductive oxide (TCO) coatings, which allows the cell manufacturer to optimize the coating to suit his specific needs and thus maximize the efficiency of the thin film cell.



Adjustable pyrolytic hard coating

The TCO coating produced by nAERO is a pyrolytic hard coating consisting of fluorine-doped tin oxide ($\text{SnO}_2\text{:F}$). Coating parameters can easily be adjusted and optimized to yield best results. Design of coating properties can be carried out according to priority on haze, conductivity or transmittance. A valuable degree of freedom in designing TCO made by

nAERO is given by the flexibility and wide range of obtainable haze. Haze can be as low as < 1% or as high as 20%, including the range between the two extremes. nAERO TCO by Beneq is fully temperable and can be laser-scribed or wet-etched. In addition, the pyrolytic hard coating has very good adhesion to sealing materials.

Coating specifications¹

Type	transparent conductive oxide (TCO) coating	
Chemical composition	based on fluorine-doped tin oxide $\text{SnO}_2\text{:F}$	
Subgroup (based on haze)	low haze	medium to high haze
Haze, D65/10 [%]	1	12 (example)
Transmittance ² , average 400–1000 nm [%]	> 83	> 83
Sheet resistance ³ [Ω/\square]	12	10
Thickness [nm]	400	750
Uniformity, sheet resistance [deviation]	< 2.0 Ω/\square	
Uniformity, transmission [deviation]	< 1%	
Temperable	yes	

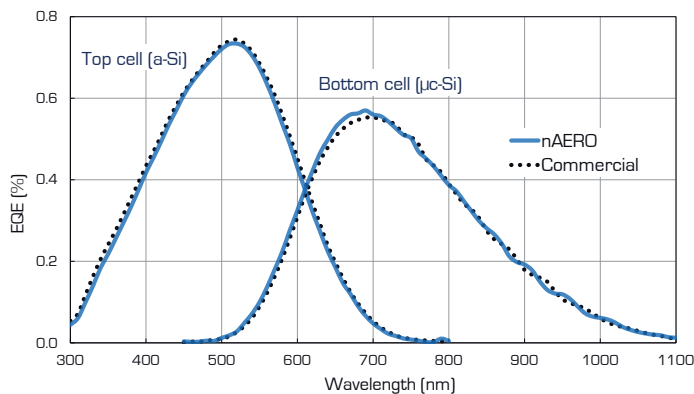
¹ All properties are nominal and solely applicable to specimens under specific testing conditions. The information is not intended to and does not create any warranties.

² Transmission measured with index matching liquid CH_2I_2 [haze compensation] on 4 mm low-iron glass.

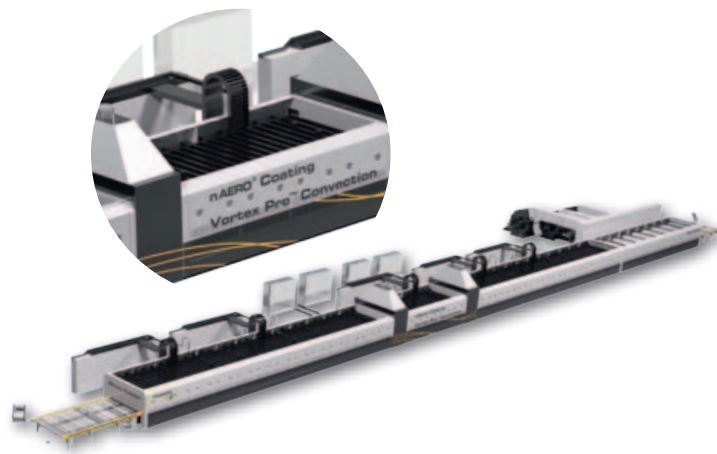
³ Measured by 4-point method.

Raw material usage efficiency

nAERO is a novel coating technology, which benefits from the advantages of both spray pyrolysis and conventional CVD. nAERO deposition is based on sub-micron sized droplets that are directed to the glass substrate. This enables a high growth rate and good material economics, with a raw material (precursor) yield of 20% or better. nAERO is a flexible coating method that allows manufacturers to reach their specific balance between transmission, haze and conductivity.



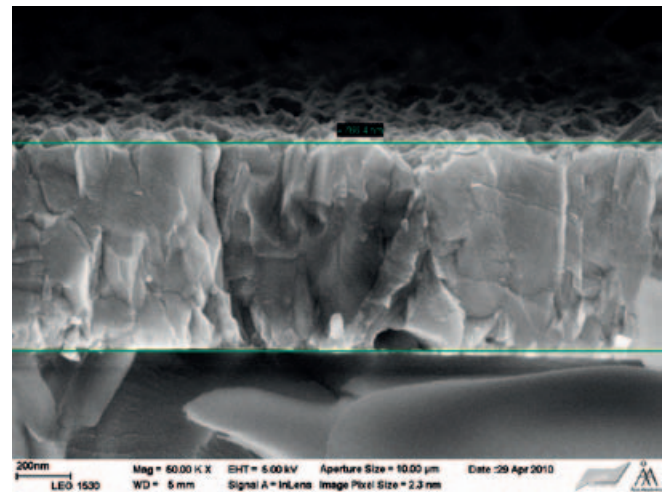
Comparison of external quantum efficiency (EQE) between a-Si/ μ c-Si tandem solar cells manufactured using nAERO[®]-coated and another commercially available TCO glass. Study performed and results reported by Helmholtz-Zentrum Berlin, Germany.



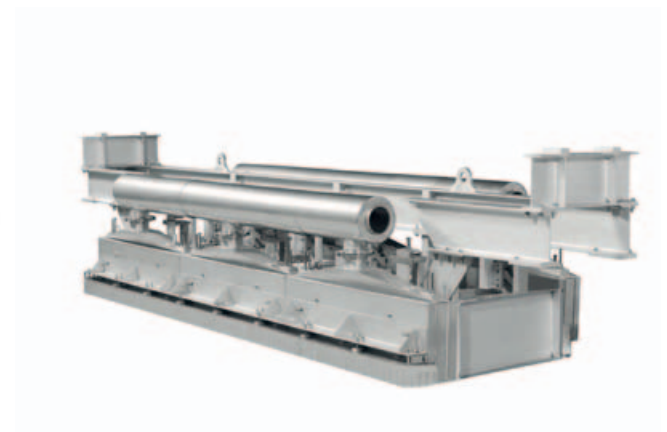
The Beneq-Glaston TFC2000[™] Thin Film Coating system for continuous off-line production of TCO coated glass. This equipment is offered in collaboration with Glaston.

Underlayer

If needed, such as in Low-e glass manufacturing, an underlayer consisting of SiO_x , SiO_2 or TiO_2 can be added between the electrically active TCO layer and the glass substrate. This underlayer is produced in a process step prior to nAERO coating. The underlayer serves as a barrier layer against sodium diffusion and eliminates iridescence in reflected light.



Scanning electron microscope image of a TCO coating (example) deposited by nAERO on soda-lime-silicate flat glass. Cross-section of the coating (between green lines). Coating thickness \approx 750 nm, sample haze level 10%.



Beneq Functional Coating System FCS 4000F main coating beam for in-line coating of flat glass substrates on a continuous basis.

Main Office:

Beneq Oy
P.O. Box 262
FI - 01511 Vantaa
Finland

Tel. +358 9 7599 530
info@beneq.com
www.beneq.com

Sales and Service Offices:

Beneq China
Beneq Germany
Beneq USA