Particle detection in the barrier layer production

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Structure

- Introduction
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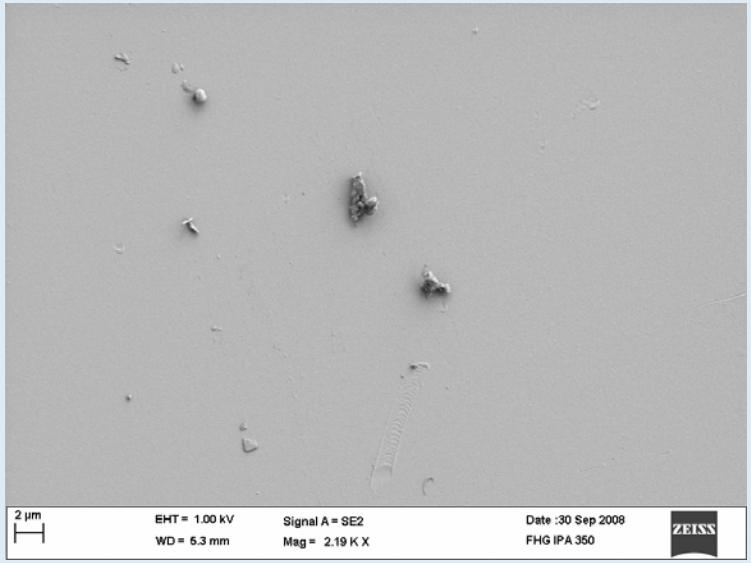
- Particle sources
- Design of a clean production environment in general
- Example: clean-retrofit of a conventional coating machine
- Detection of sediment particles on PV substrates
- Cleaning of substrates
- Selection of clean production equipment

Introduction

- Thin film based industries require very dense layers
  - OLED
  - Organic photovoltaic
  - CIS-thin film photovoltaic
- Impermeability of thin layers:
  - oxygen (cm3/m2 x d x bar) 10^{-5} up to 10^{-6}
  - water vapor (g/m2x day x bar) 10^{-5} up to 10^{-6}
- Layer thickness: < 500 nm
- Application substrates: foils
- Investigations showed that besides process parameters also contaminations have an impact on the barrier of a layer

Contamination risks

- Main contamination risk: particles on substrates
  - Thin layers < 500 nm
  - Layer penetration by particles
  - Particle size & number relevant
  - Risk start @ 50 % of layer thickness
- Airborne molecular contamination (AMC)
  - Caused e.g. by out-gassing of materials
  - Accidental film deposition on substrates



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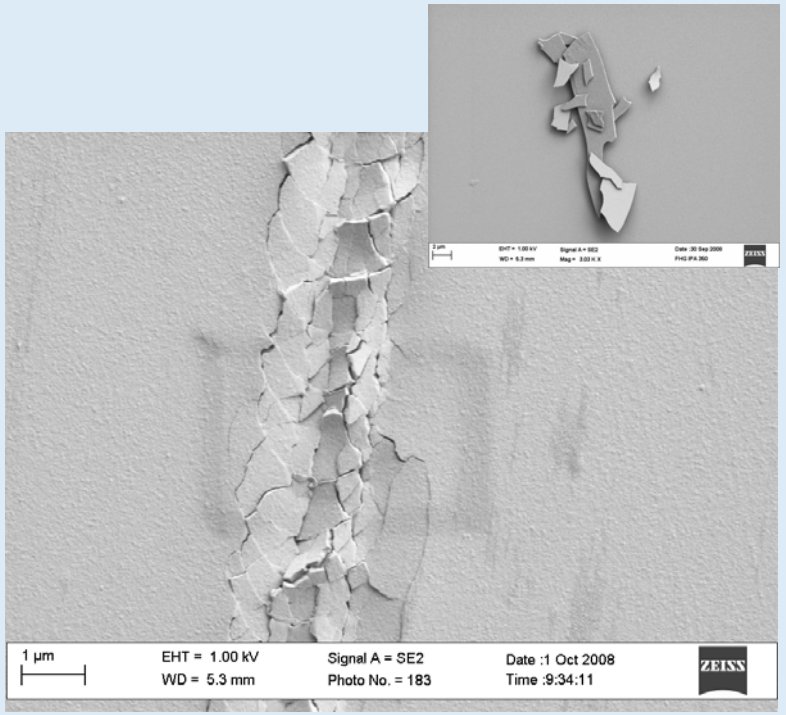
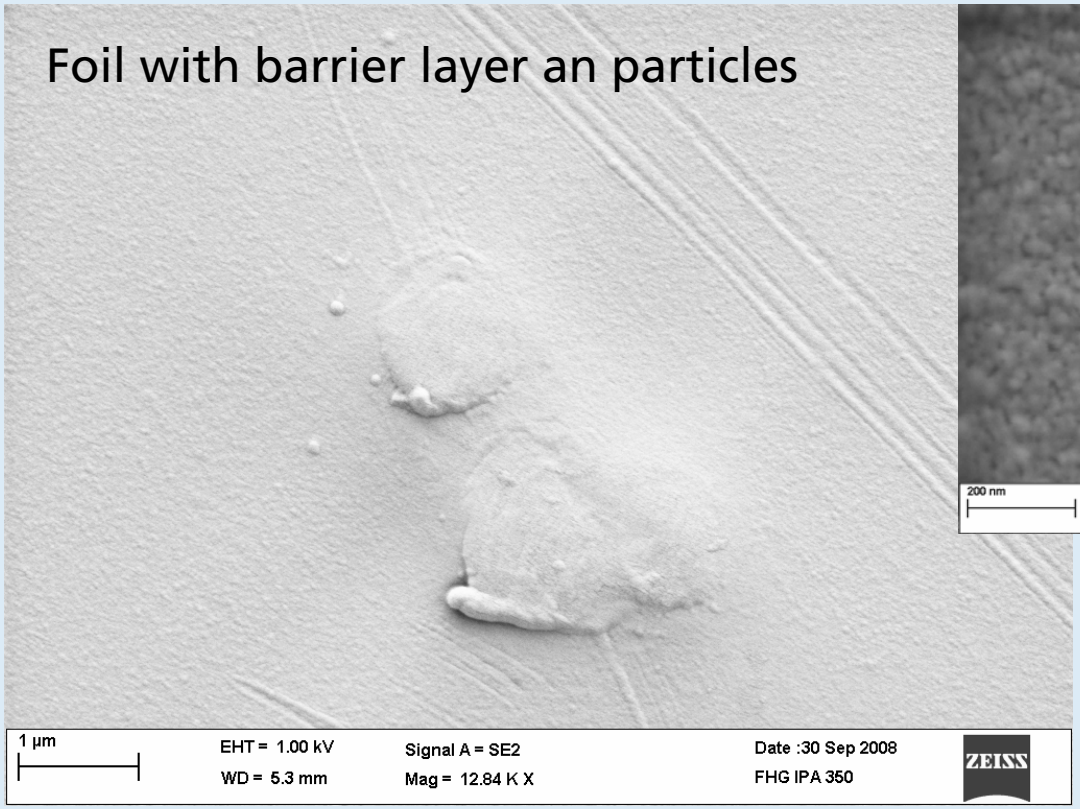
Particle sources

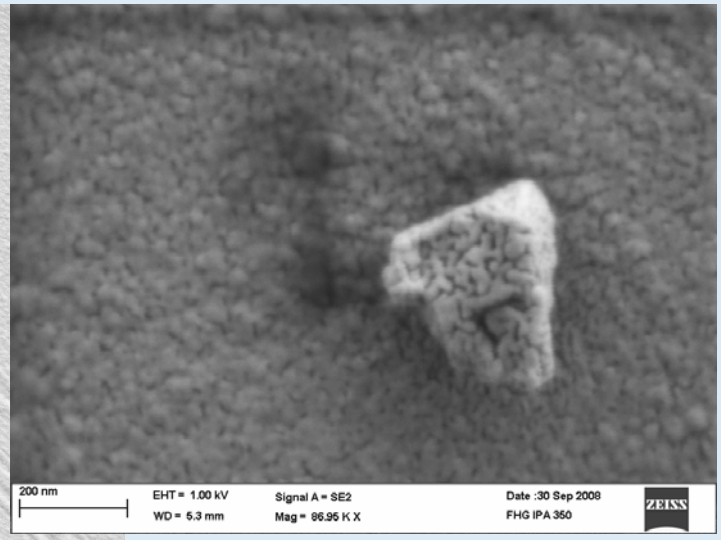
- Contaminated substrates
  -> initial particle load on foils
  -> caused during production
- Environmental air
  -> huge concentrations of relevant particle sizes are in usual production environments
- process and automation equipment
  -> particle generation by mechanical friction
  -> Electro static effects increases contamination by attraction of particles

Scanning electron microscope



Particle sources





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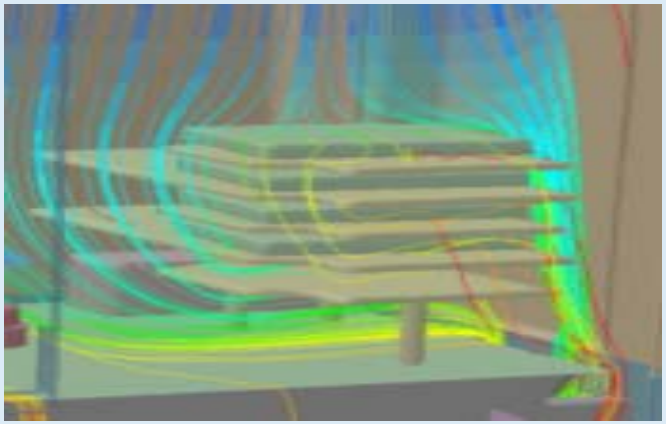
Design of a clean production environment in general

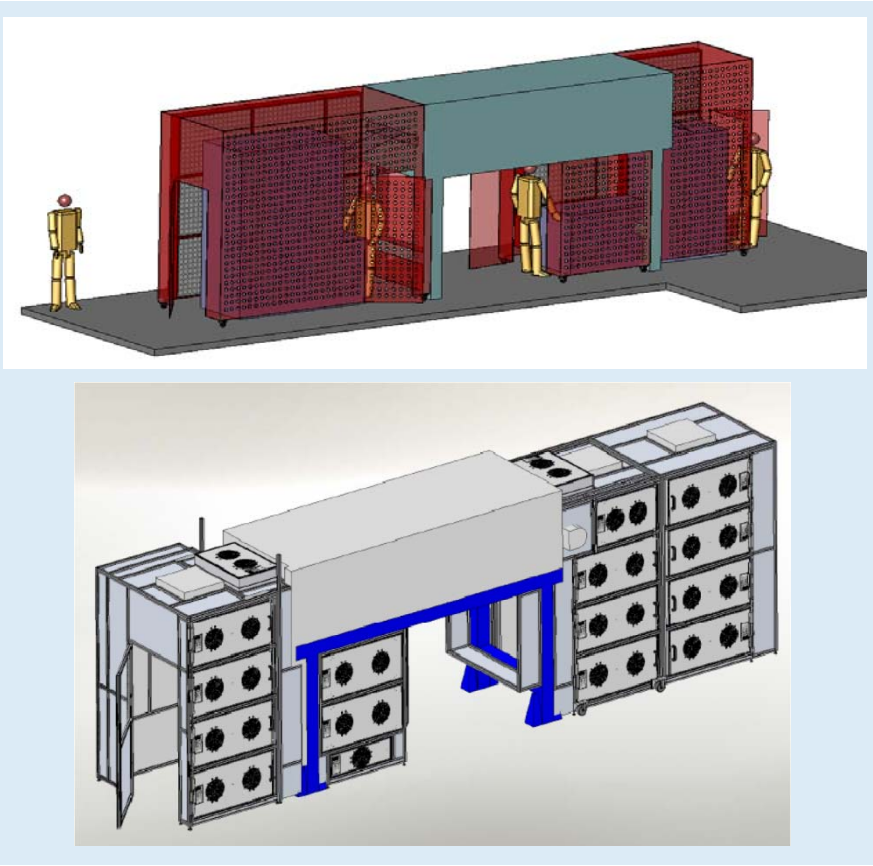
- Clean production equipment minimizes particle emission
  - Low mechanical friction, material selection, encapsulating of particle sources
- Airflow design of equipments can help to
  - Provide a clean environment, steady removal of airborne contaminations, e.g. particles, molecular contaminations



Air flow simulation
Example automation equipment:
pathlines describe the **path of air**

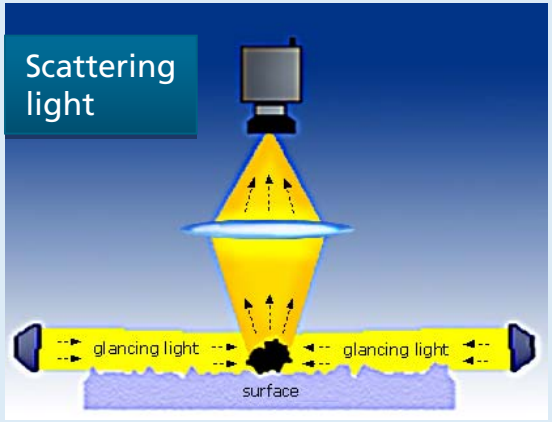
Example: clean-retrofit of a conventional coating machine

- Cleanliness concept should be part in the early stage of the machine design
- The technical effort of a clean-retrofit is much higher
- Clean design concept:
  - Housing of the relevant equipment parts (ESD)
  - Encapsulation of particle sources
  - Airflow design with filtration (horizontal flow with particle sources downstream of product)



Detection of sediment particles on substrates

- Development of a new substrate scanner
- Measurement principle: Glancing system Grazing incidence illumination with laser beam -> particles cause scattering light
- smallest detectable particle size: ≥ 0.5 µm
- Applications for large scale substrates, e.g. PV glass substrates, foils, etc.



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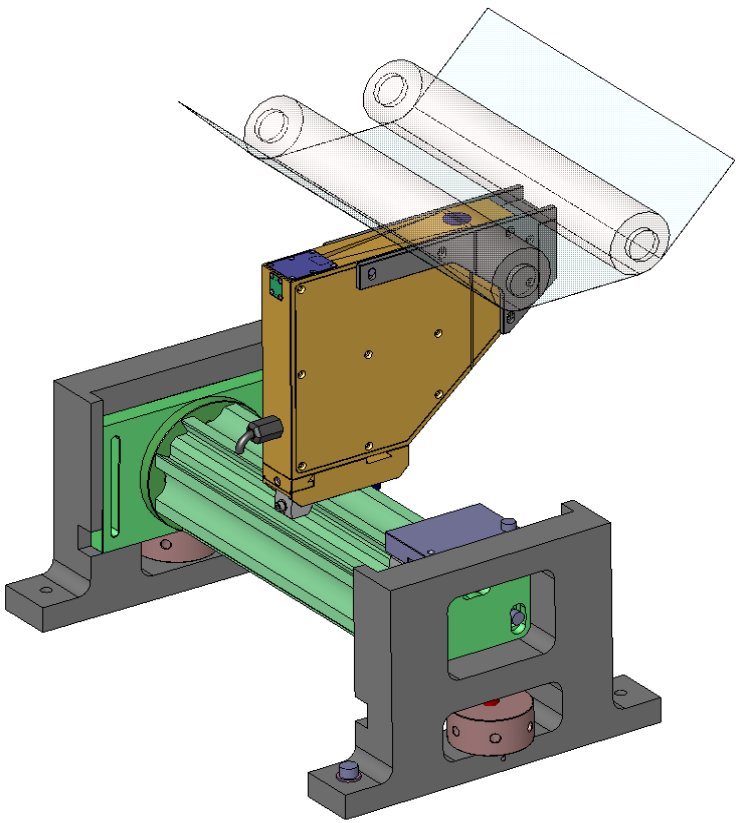
Detection of sediment particles on foils

- Inline measurement, speed 0.5 m/s
- Scan range: 10 mm (can be increased)
- Sensor position is adjustable
- To scan the whole foil a corresponding number of sensors can be used

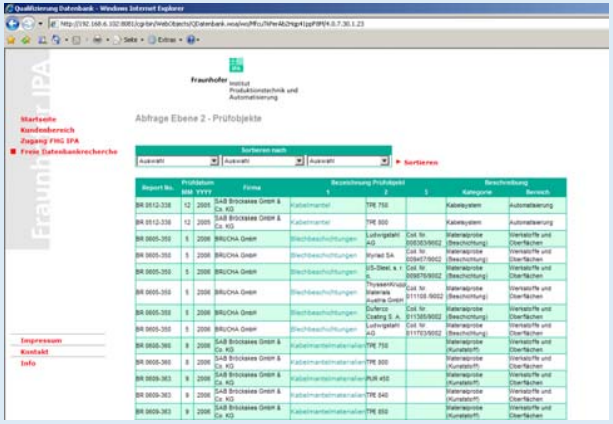


Cleaning of substrates

- Cleaning of small particles is a problem in general because of the strong adhesion
- Adhesion forces:
  - 20.000 x > weight
  - 50 x > elektrostatic
- Critical particles size for cleaning: < 1 (2) µm
- Preferred solution: avoidance strategy

Selection of clean production equipment

- First independent platform for cleanroom suitable products
  - Overview of all tested products and results
  - Worldwide availability via internet: www.tested-device.com
  - Two views: public information (released documents) and customer access



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Summary

- Even under ideal process conditions particles can cause weak barrier functionality through defects in the layers.
- Particles are generated during manufacturing and processing of substrate materials.
- Particle-free confectioning of substrate material would be ideal but is not available in the market presently. However, the knowledge for suitable equipment design is available.
- For relieable process control and quality assurance an effective detection of particles is necessary. This should also be possible in-line.
- A new particle scanner with high sensitivity and very short measurement time has been developed.

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