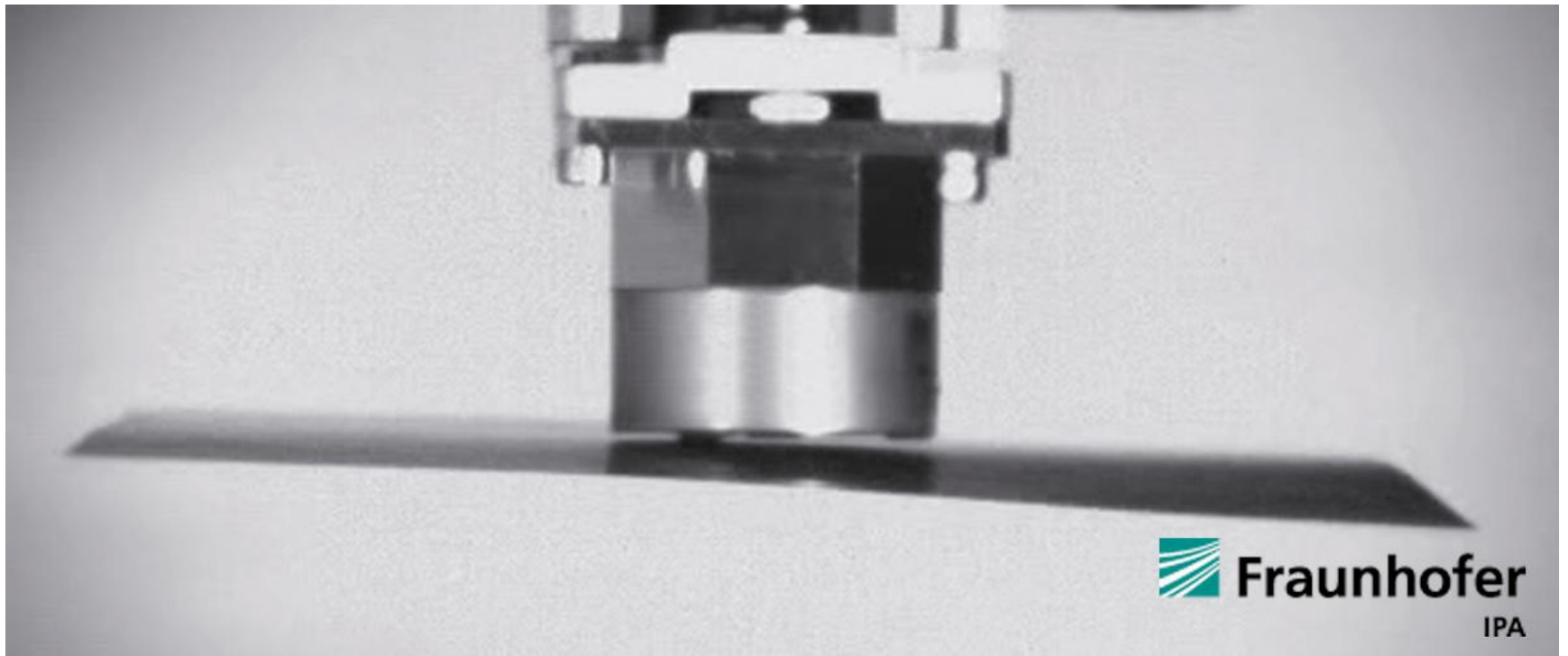

EUPVSEC PV Production Forum 2011

Optimized Handling and Automation in Wafer and Cell Mass Manufacturing

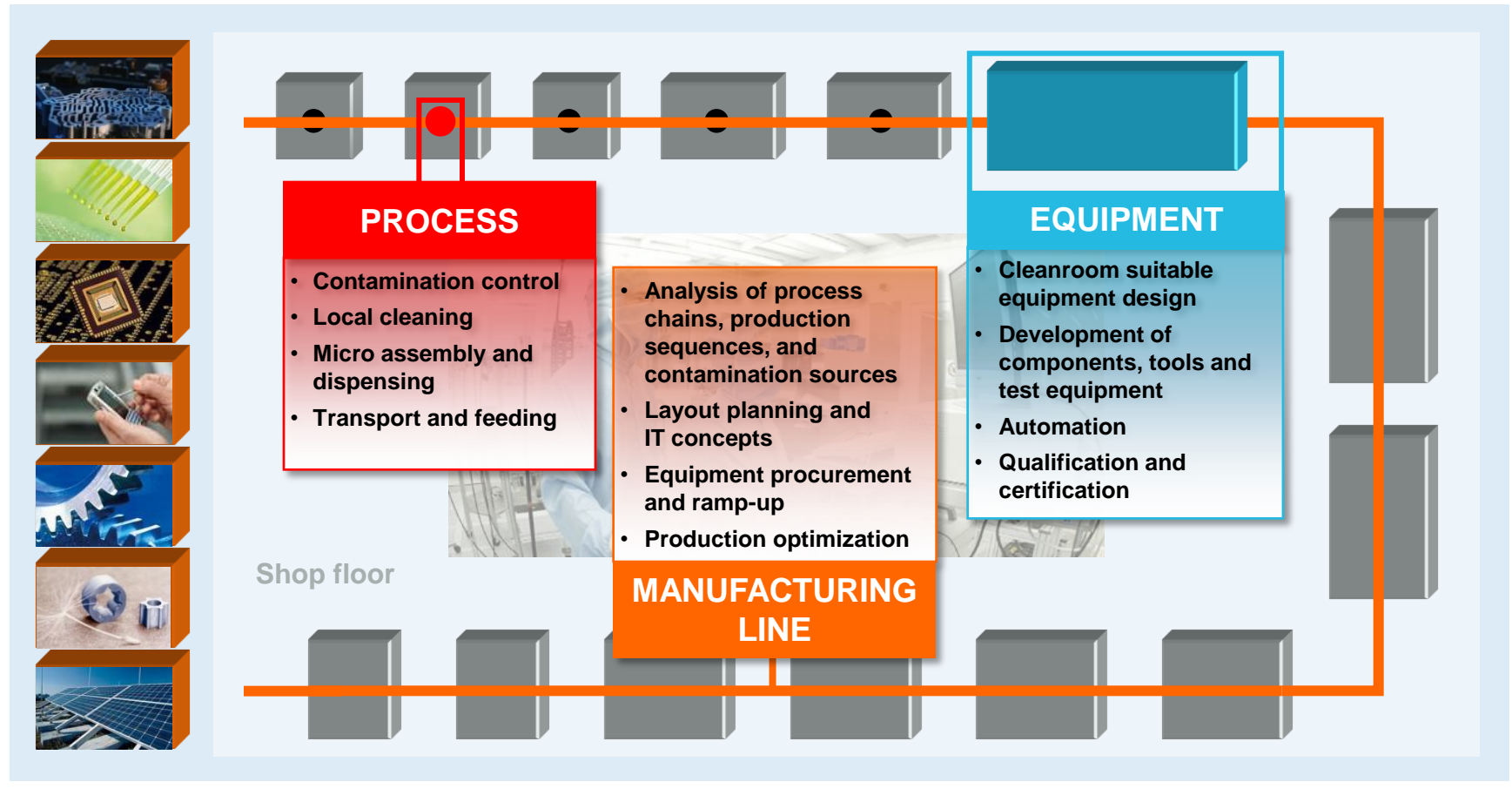


Fraunhofer IPA – Ultraclean Technology and Micromanufacturing at a glance

- Applied research and development in cleanroom manufacturing
- More than 25 years of experience and know-how
- 45 scientists and 30 students (assistants, interns, technicians)
- Average turnover Ø 5,1 Mio. € :
 - Institutional funding: Ø 12 %
 - Publicly-funded revenues: Ø 39 %
 - Industry revenues: Ø 49 %
- More than 40 patents and patent applications in the past 25 years

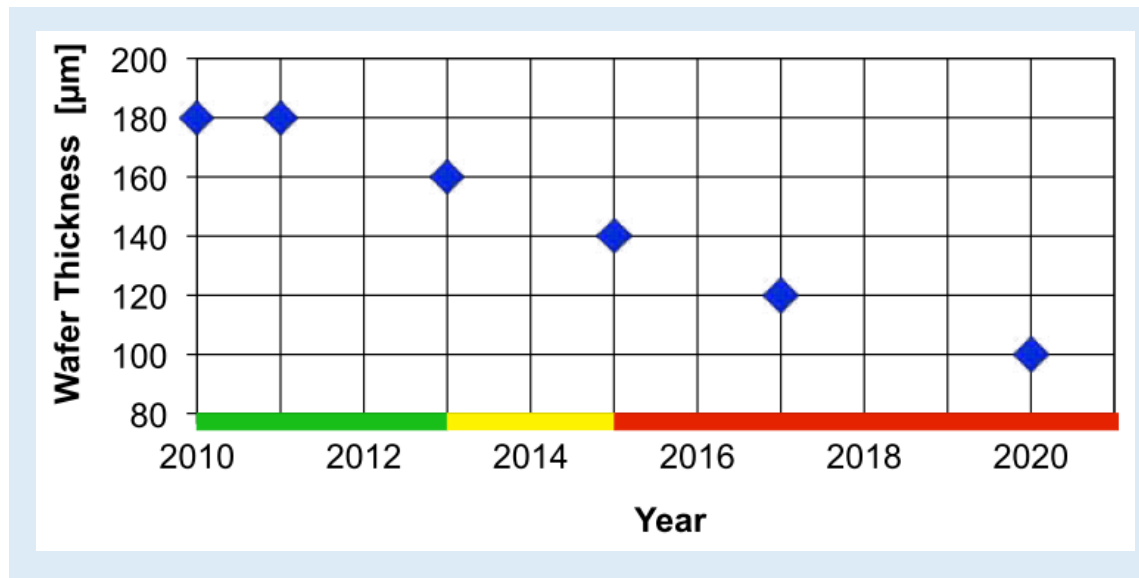


Our Services



International Technology Roadmap for Photovoltaics Results 2010

■ Wafer thickness:



**Wafer thickness in
mass manufacturing**

source:

ITRPV 2010 Results
2nd Edition March 2011

- The thickness of future substrates (wafers) will decrease, although not that dramatically as it has been forecasted earlier

International Technology Roadmap for Photovoltaics Results 2010

■ Throughput:

Year	Front end [wafer/h] (chemical + thermal)	Single line back end [wafer/h] (metallization + classification)
2011-2012	3600	3000
2013	5000	3600
2015	6400	5400
2020	7200	7200

Throughput front-end / back-end

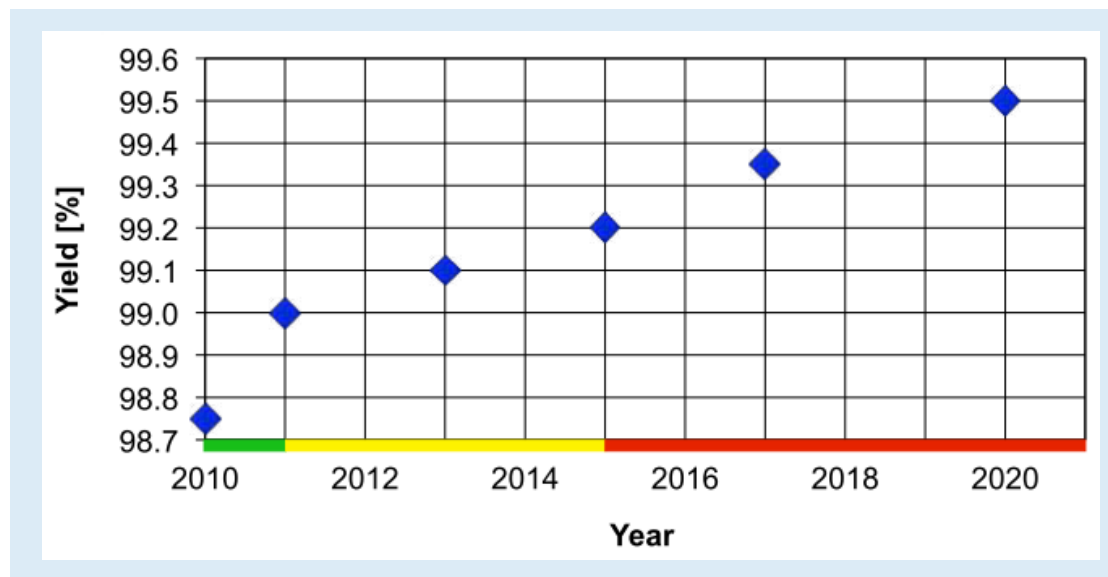
source:

ITRPV 2010 Results
2nd Edition March 2011

- The throughput of lines has to double in 7 years

International Technology Roadmap for Photovoltaics Results 2010

■ Yield:



**Yield in module
production**

source:

ITRPV 2010 Results
2nd Edition March 2011

- The yield of a production line is one of its major KPIs and therewith in focus of optimization efforts

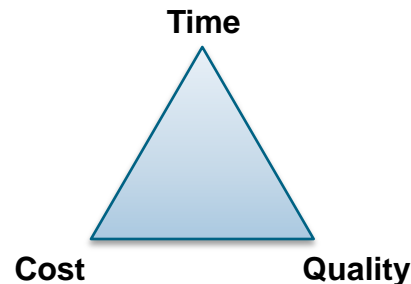
Summary of future demands

Wish list

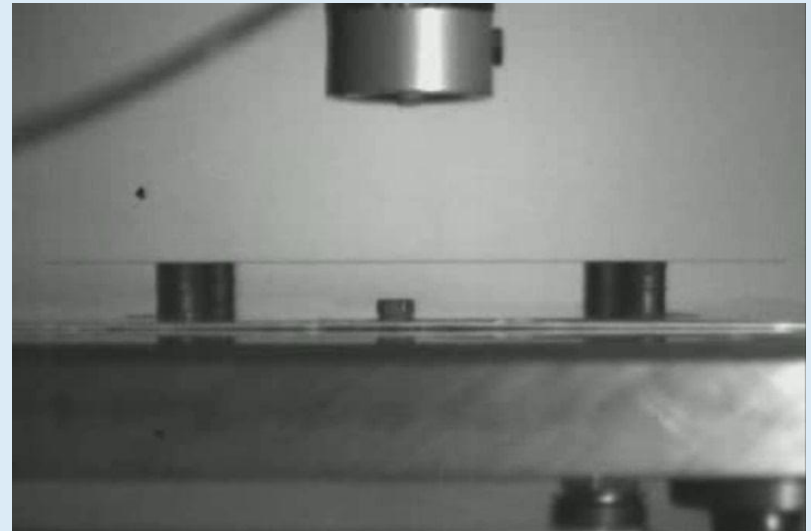
■ Conclusions:

- The handling has to be adapted to changing boundary conditions to avoid breakage
- To achieve higher throughputs, the handling and transportation has to be speed up
- Simulation-based material flow planning helps determine possible bottle necks in production

■ Triple constraint:

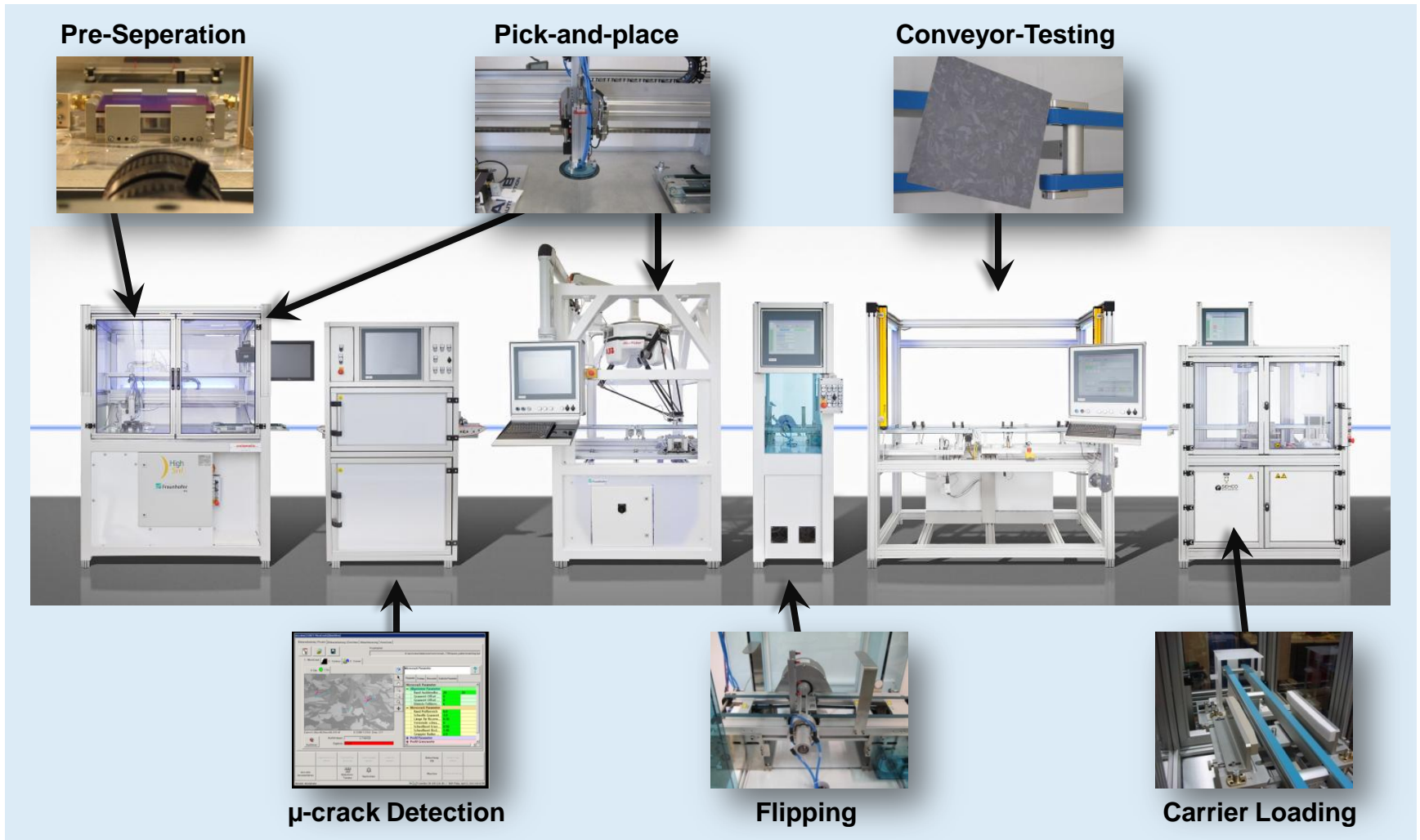


Handling in Slow Motion



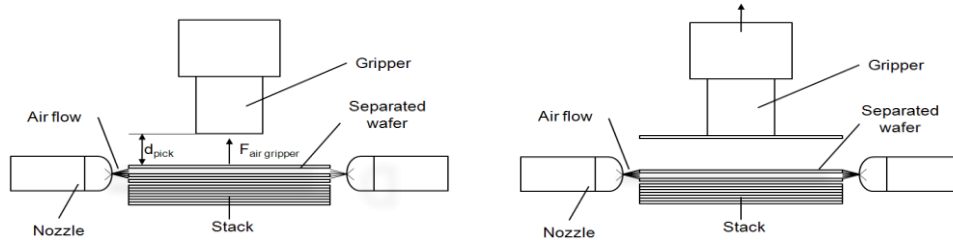
- Save handling is very much conditioned by the set of parameter and boundary conditions
- There is no overall „Best in Class“ Gripper available, each system has its pros and cons, related to the dedicated needs

PV – Lab at Fraunhofer IPA

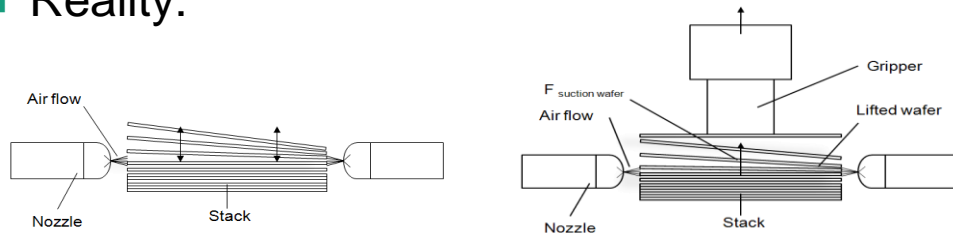


Handling and Automation in PV: Pre-Separation

- Enormous potential of harming the substrate
- Pre-Separation as it should look like:

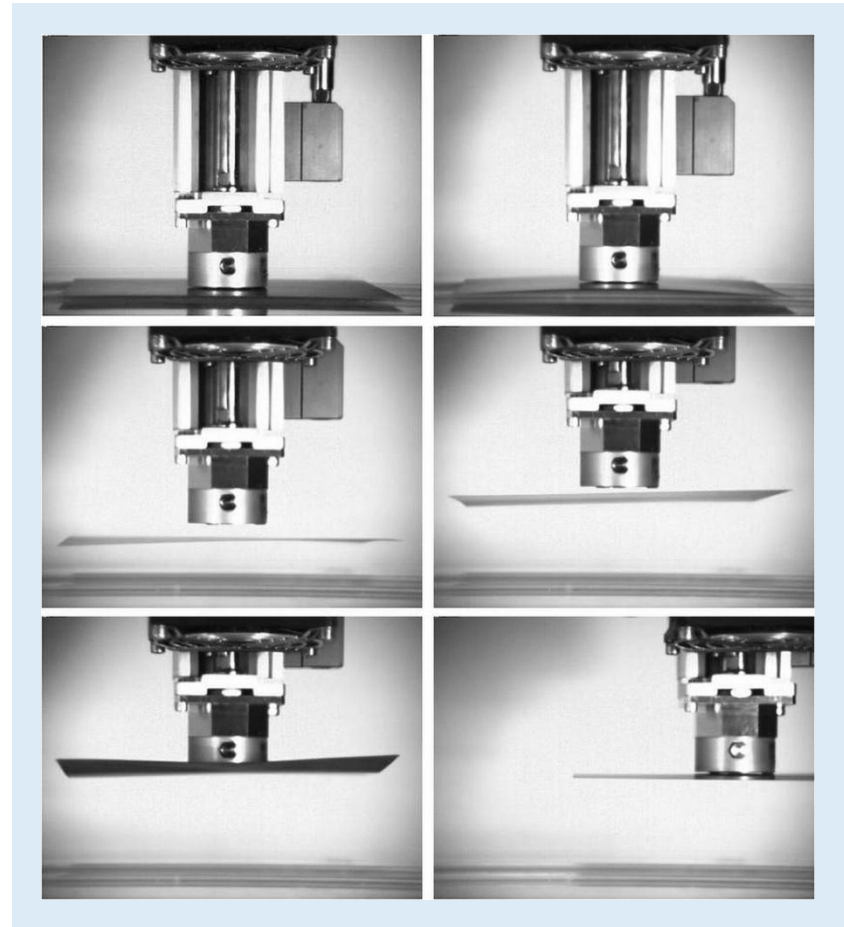


- Reality:



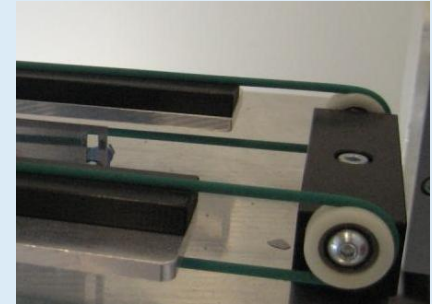
Handling and Automation in PV: Pick-n-Place via gripping

- Multi-Variant case studies
 - Acceleration (pos./neg.)
 - Air pressure
 - Pick-up / Placing height
 - Dwell period
 - ...
- Measured KPIs:
 - Sucking forces
 - Accuracy of positioning
 - Damaging
 - ...



Handling and Automation in PV: Conveyor belt transportation

- Commonly used method of transportation
- KPIs, determined by experiments:
 - Accuracy of positioning
 - Slip
 - Combination of materials
 - ...
- Aims:
 - Minimal transportation times, because they are no value adding
 - Minimal effort of installation / maintenance
 - ...



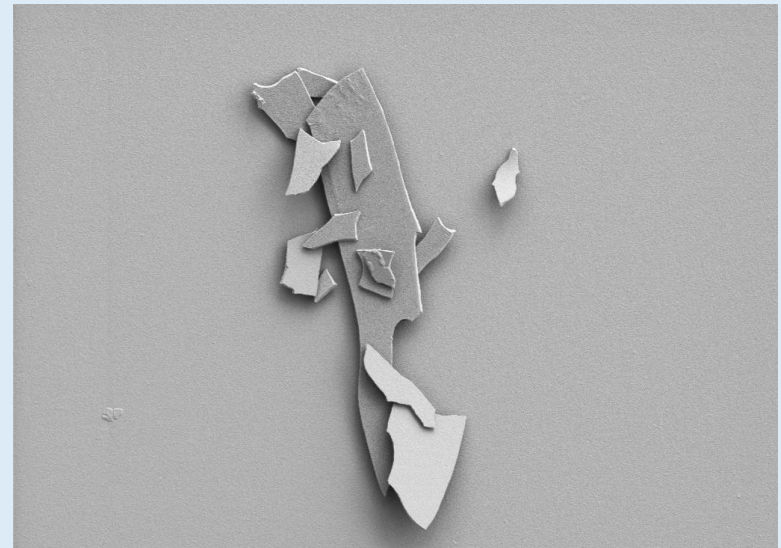
Contamination Control

- Due to thinner functional layers, tiny little particles can have big influences on the overall effectiveness of substrates



1 μm EHT = 1.00 kV Signal A = SE2 Date :30 Sep 2008
WD = 5.3 mm Mag = 12.84 K X FHG IPA 350 ZEISS

SEM-photos

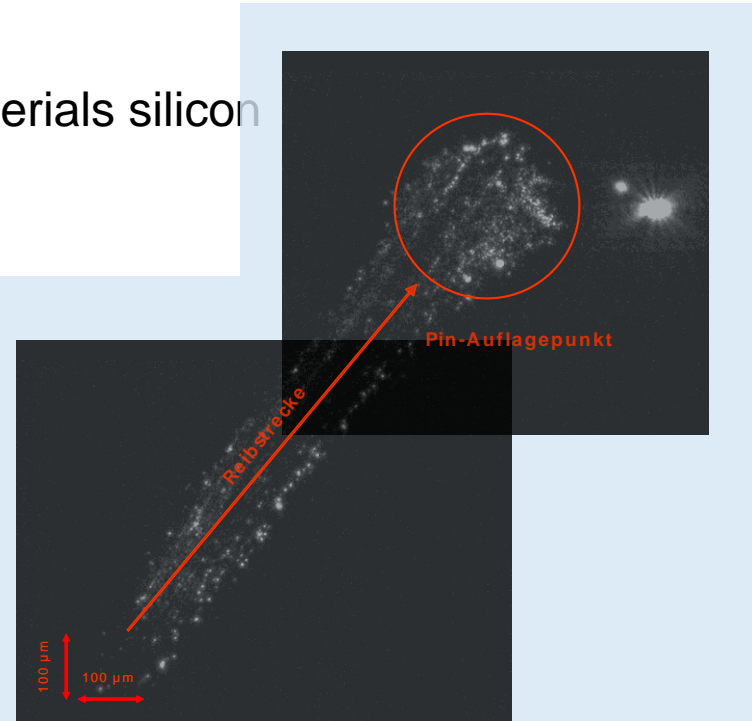
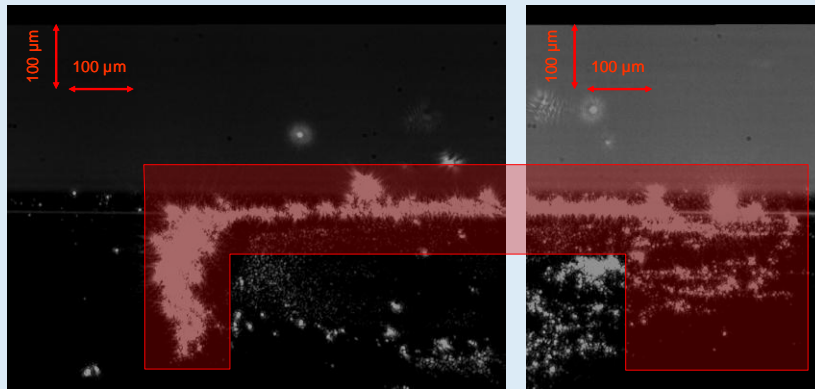


2 μm EHT = 1.00 kV Signal A = SE2 Date :30 Sep 2008
WD = 5.3 mm Mag = 3.03 K X FHG IPA 350 ZEISS

source: Fraunhofer IPA, Ultraclean Technology and Micromanufacturing

Cross-contaminations

- Cross-contamination due to handling
 - Case studies with glass sheets illustrated the effect of emission of particles due to friction
 - Similar experiments with the set of materials silicon - rubber are equivalent



Thank you for your attention

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