

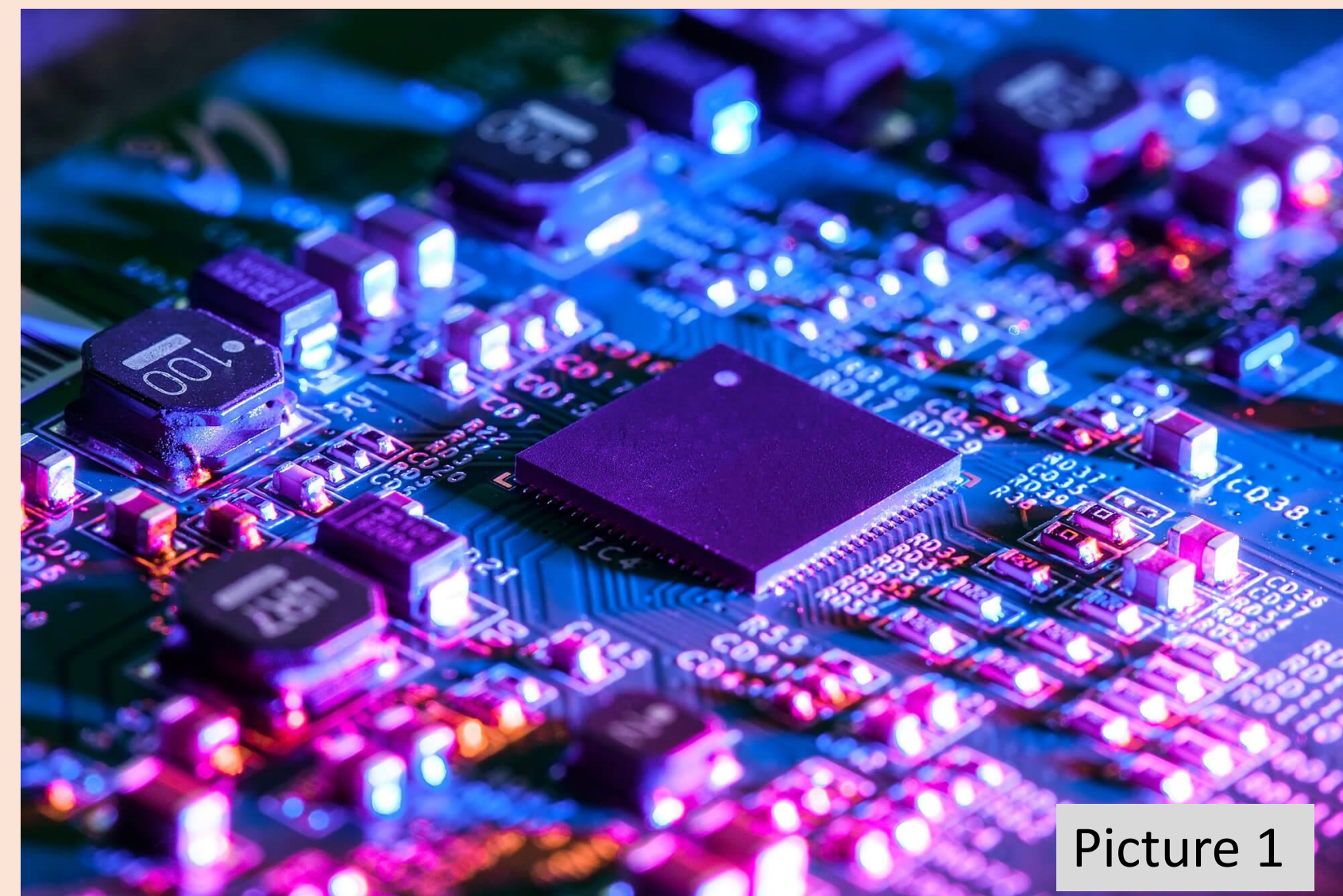
Outgassing rate measurements made traceable for the semiconductor industry

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Motivation

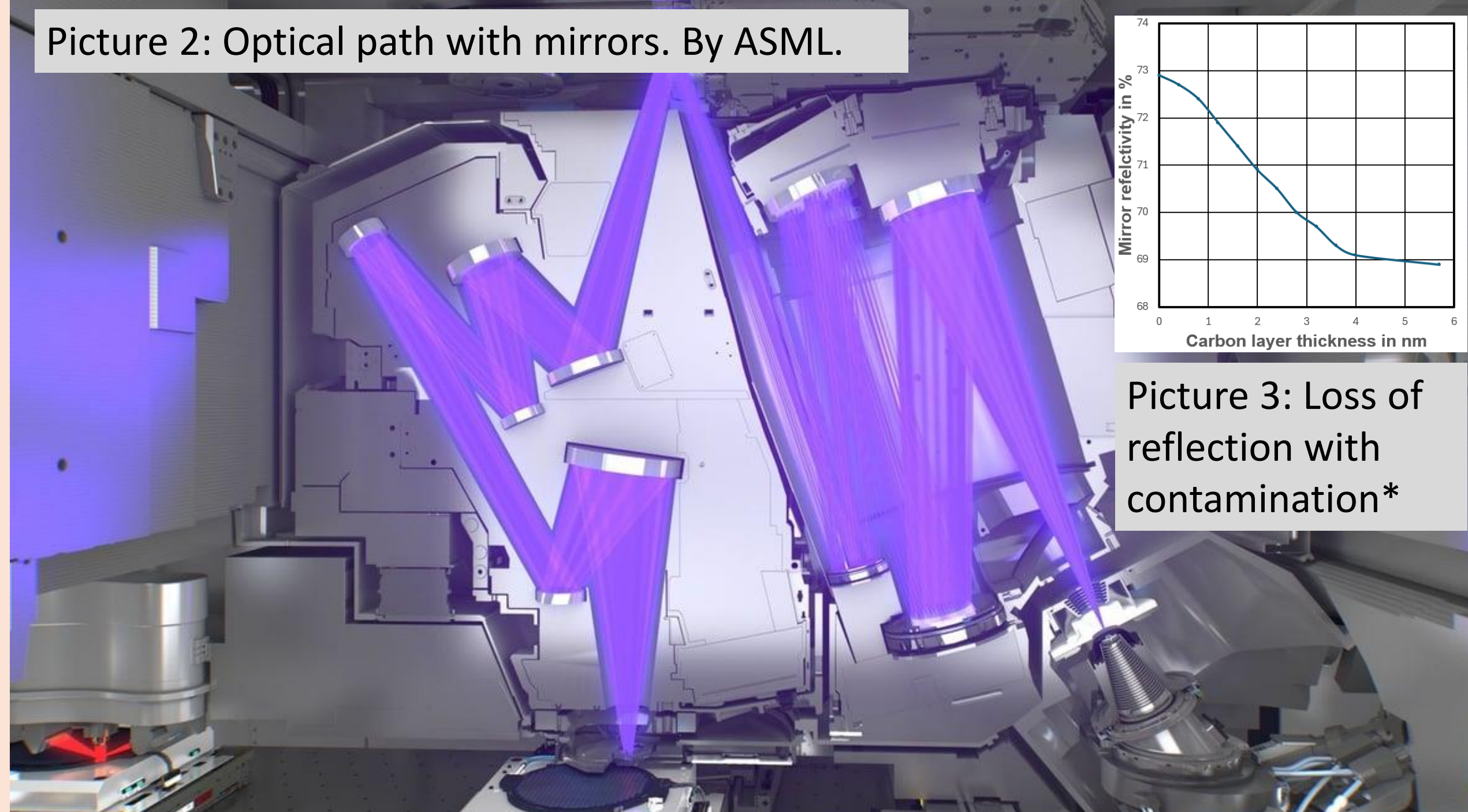
The most advanced integrated circuits manufactured in the semiconductor industry are nowadays produced by means of EUV light under vacuum conditions.



Picture 1

Mirrors reflecting the EUV-light for illumination are very sensitive to impurities of water and hydrocarbon molecules.

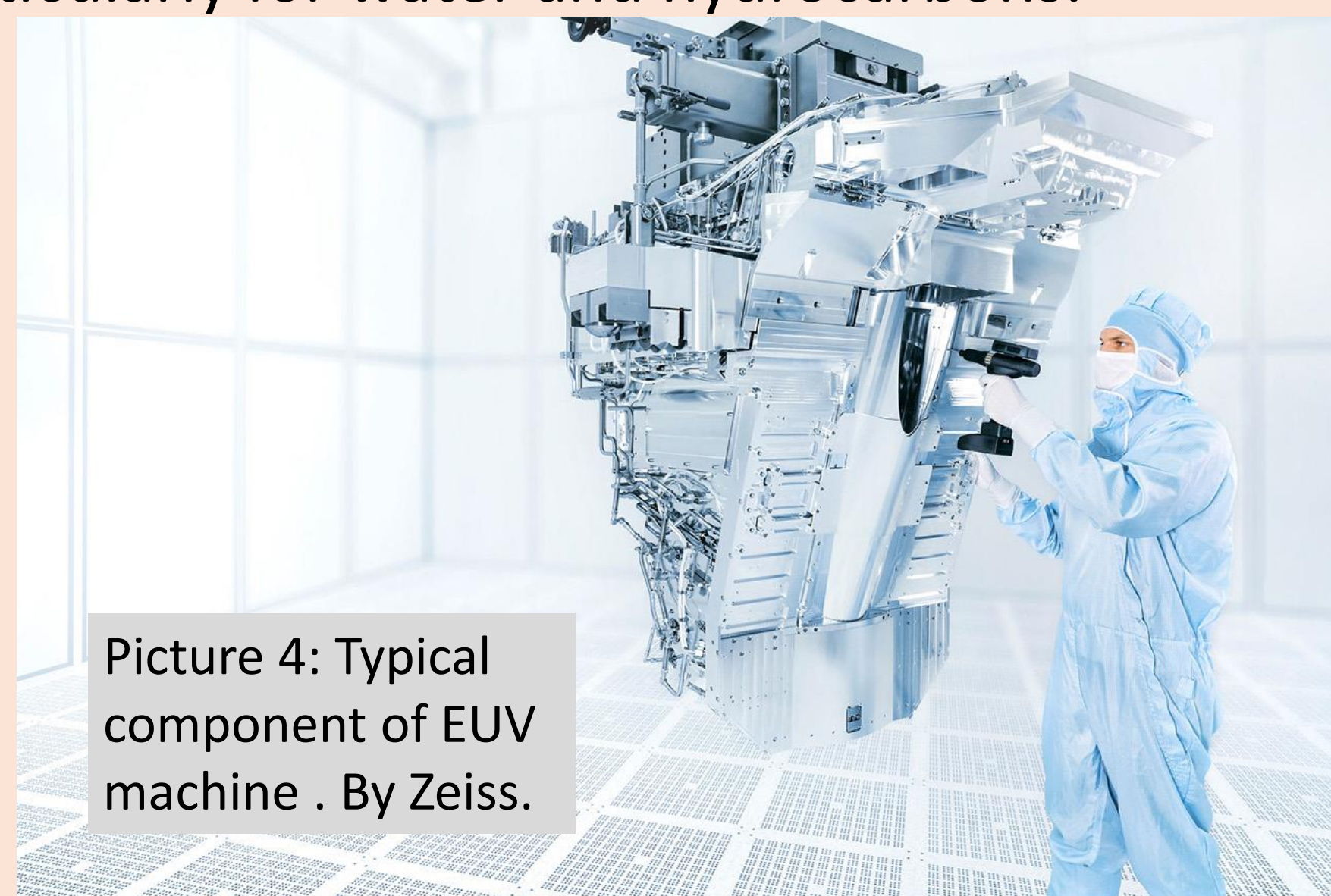
Picture 2: Optical path with mirrors. By ASML.



Picture 3: Loss of reflection with contamination*

The vacuum environment must be very clean: “Ultra clean vacuum” (UCV).

The outgassing rate of the components installed in the EUV vacuum chamber must be measured and be below a certain limit, particularly for water and hydrocarbons.



Picture 4: Typical component of EUV machine . By Zeiss.

The challenge

Until 2014 the results of outgassing rate measurements were neither comparable nor traceable to the SI.

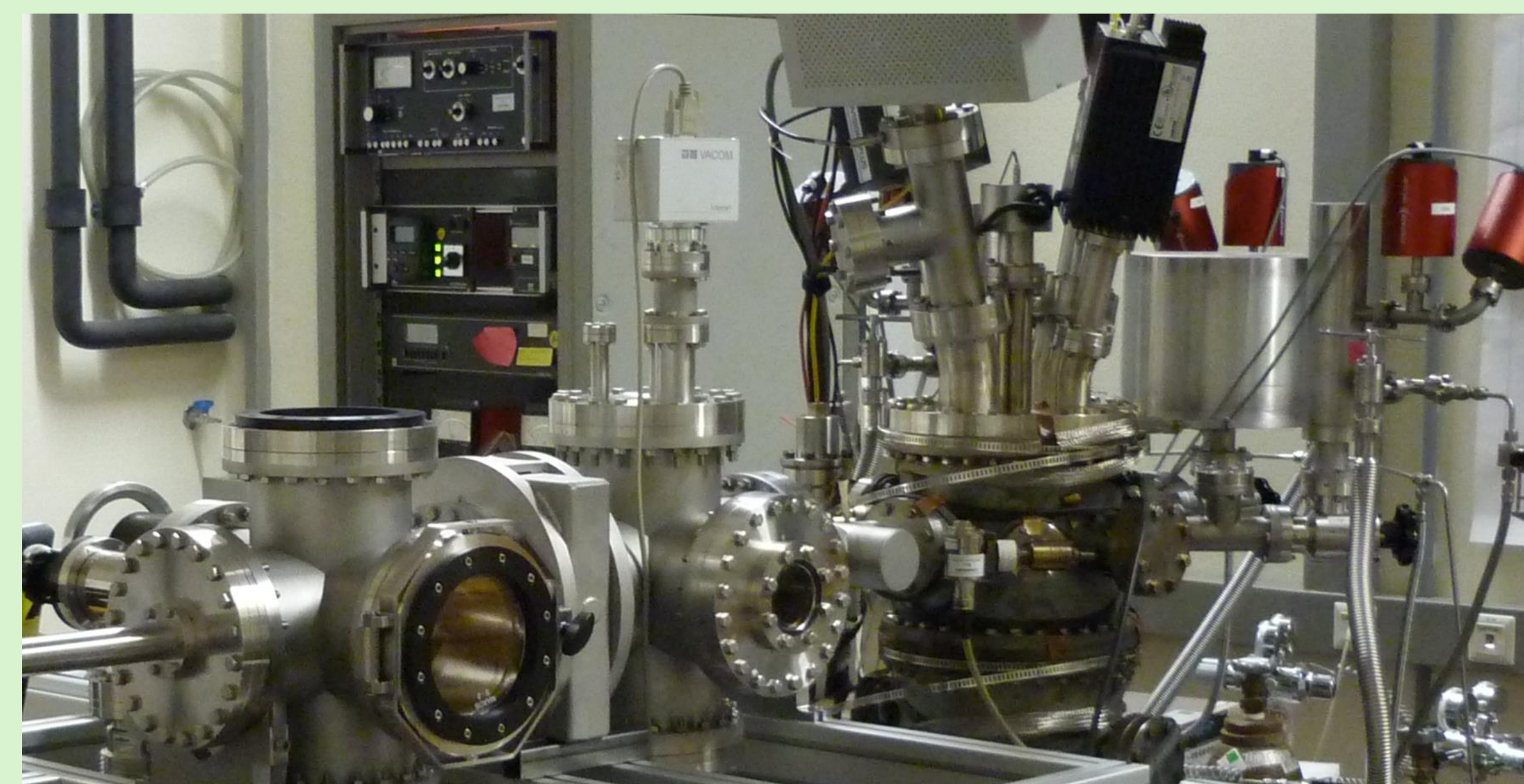
So, how to set reliable limits of outgassing rate?

How to set standards for the suppliers of vacuum components and EUV equipment?



The solution

Step 1: Establish a **primary standard** for outgassing rates in vacuum environment: Outgassing rates are now traceable.



Picture 5: PTB's primary system for outgassing rate measurements

Step 2: Standardise measurement systems for outgassing rates with the help of ISO TC 112. Quadrupole mass spectrometers are needed for outgassing rate measurements: Standardise the characterisation of quadrupole mass spectrometers for this purpose.

TECHNICAL SPECIFICATION ISO/TS 20177



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Vacuum technology — Vacuum gauges — Procedures to measure and report outgassing rates

Technique du vide — Manomètres à vide — Méthodes de mesurage et de rapport du taux de dégagement de gaz

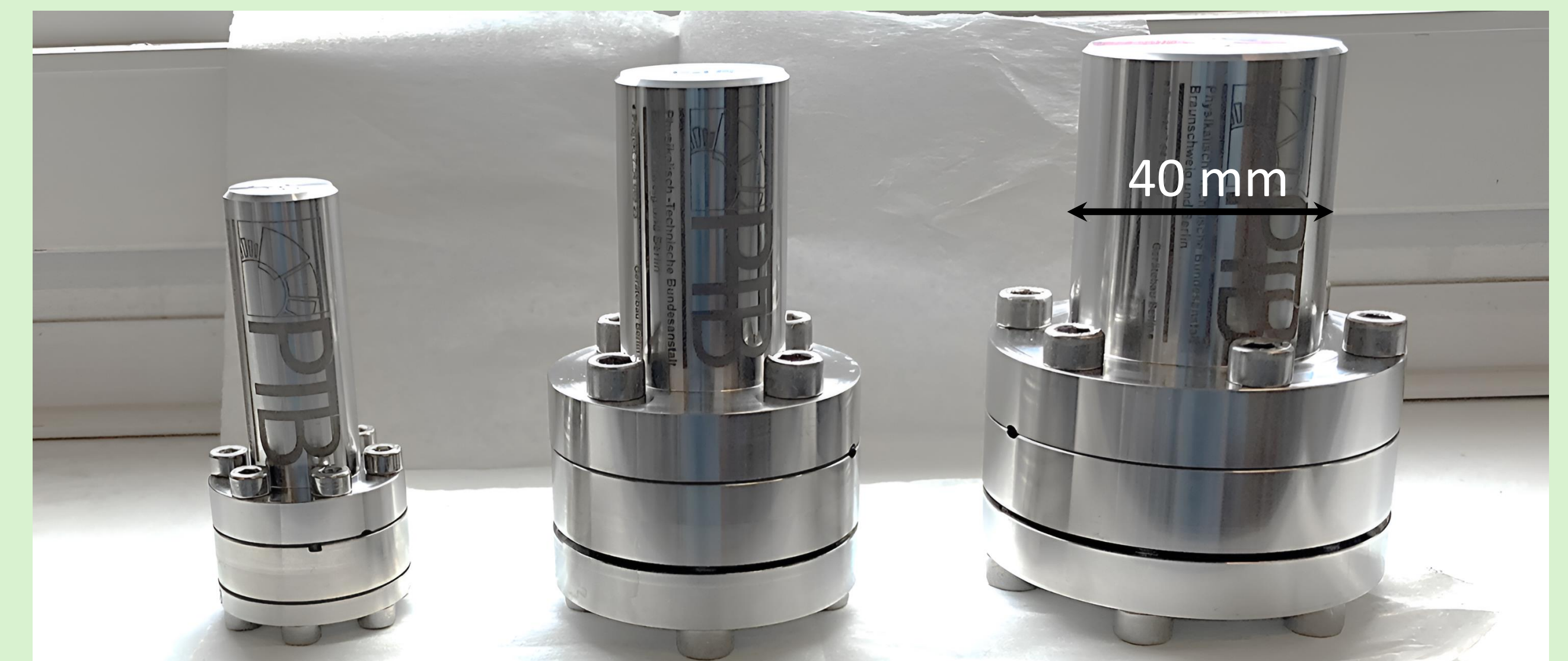
TECHNICAL SPECIFICATION ISO/TS 20175

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Vacuum technology — Vacuum gauges — Characterization of quadrupole mass spectrometers for partial pressure measurement

Technique du vide — Manomètres à vide — Description des spectromètres de masse quadrupolaires pour mesurage de la pression partielle

Step 3: How measurement systems for outgassing rates can be validated and compared? Transfer standards are needed! Establish **reference outgassing samples**.



Picture 6: Reference outgassing samples by PTB

These reference outgassing samples provide a known flux of either water or dodecane molecules. The latter represent the huge bunch of hydrocarbons which are affecting EUV mirrors. The samples are used as benchmark for outgassing rates.

Guidelines were developed how to calibrate such reference outgassing samples at a primary standard and against a secondary standard (master sample) and how to validate measurement systems for outgassing rates.

Outlook



The two industrial partners, Zeiss and ASML, manufacturers of EUV machines will now seek to commercialise the production and calibration of reference outgassing samples. Master samples will be calibrated by the primary standard at PTB.

With the help of the reference outgassing samples, suppliers of Zeiss and ASML can validate their measurement systems. Outgassing rates are now traceable to the SI. Reliable outgassing rate limits can be set for EUV lithography machines.

*Data taken from Chen et al., Proc. SPIE, 2014, DOI: 10.1117/12.824435

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