



工業技術研究院

Industrial Technology
Research Institute

**New opportunities for NMI to
contribute to national QI**

**Revision of SI and its
Possible Contributions to
Environmental Impact and
Economic Growth**

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CMS-ITRI, Chinese Taipei
Oct. 18, 2019

Outline

- Awareness and Demand for Air Quality
- National Quality Infrastructure of PM 2.5 & LNG
- Particle Metrology and Revision of SI
- Quality Control for Industry (IC, LNG)

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Why Measuring AQI/Particulates

- Particulates are the most harmful form of **air pollution** due to their ability to penetrate deep into the lungs and blood streams unfiltered, causing **heart attacks, respiratory disease, and premature death**
- The smaller $PM_{2.5}$ were particularly deadly, with a **36% increase in lung cancer per $10 \mu\text{g}/\text{m}^3$** as it can penetrate deeper into the lungs.
- Worldwide exposure to **$PM_{2.5}$ contributed to 4.1 million deaths** from heart disease and stroke, lung cancer, chronic lung disease, and respiratory infections **in 2016**

Air Quality Index

- AQI is an index for reporting daily air quality, telling **how clean or unhealthy the air is**, and what associated health effects might be a concern.
- AQI is calculated for four major air **pollutants** regulated by the Clean Air Act: **ground level ozone (O₃)**, **particle pollution (PM_{2.5} & PM₁₀)**, **carbon monoxide (CO)**, and **sulfur dioxide (SO₂)**



AQI means

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
<i>When the AQI is in this range:</i>	<i>...air quality conditions are:</i>	<i>...as symbolized by this color:</i>
0 - 50	Good	Green
51 - 100	Moderate	Yellow
101 - 150	Unhealthy for Sensitive Groups	Orange
151 - 200	Unhealthy	Red
201 - 300	Very Unhealthy	Purple
301 - 500	Hazardous	Maroon

Air Quality & Gas Metrology

Air Quality Monitoring Network QA/QC program

- PM₁₀
- PM_{2.5}
- SO₂
- NO₂
- O₃

On-gong project: traceability of gaseous analyzers

- SO₂ (~ppm CRM)
- NO (~ppm CRM)
- O₃ (~SRP)

Low-cost Sensor QC program:

- PM_{2.5}
- O₃



Practice of collocation comparison of PM_{2.5} automatic monitors

- Beta ray(5)
- Microbalance(1)
- Light scattering(1)

comparison report of PM_{2.5} monitors

- precision
- MDL, Method detection limit
- Measurement uncertainty



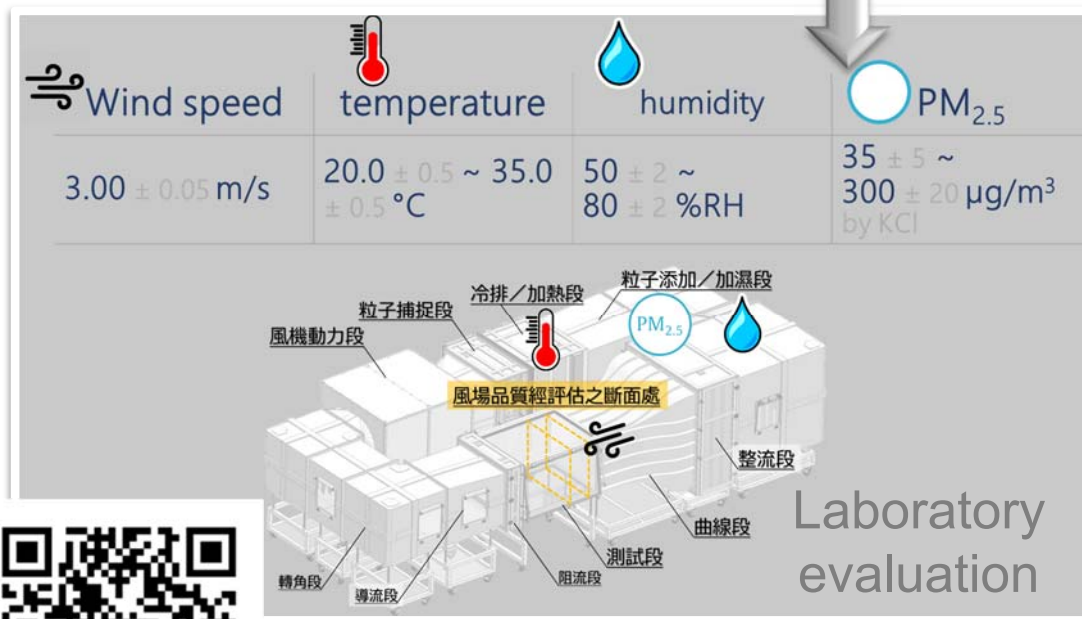
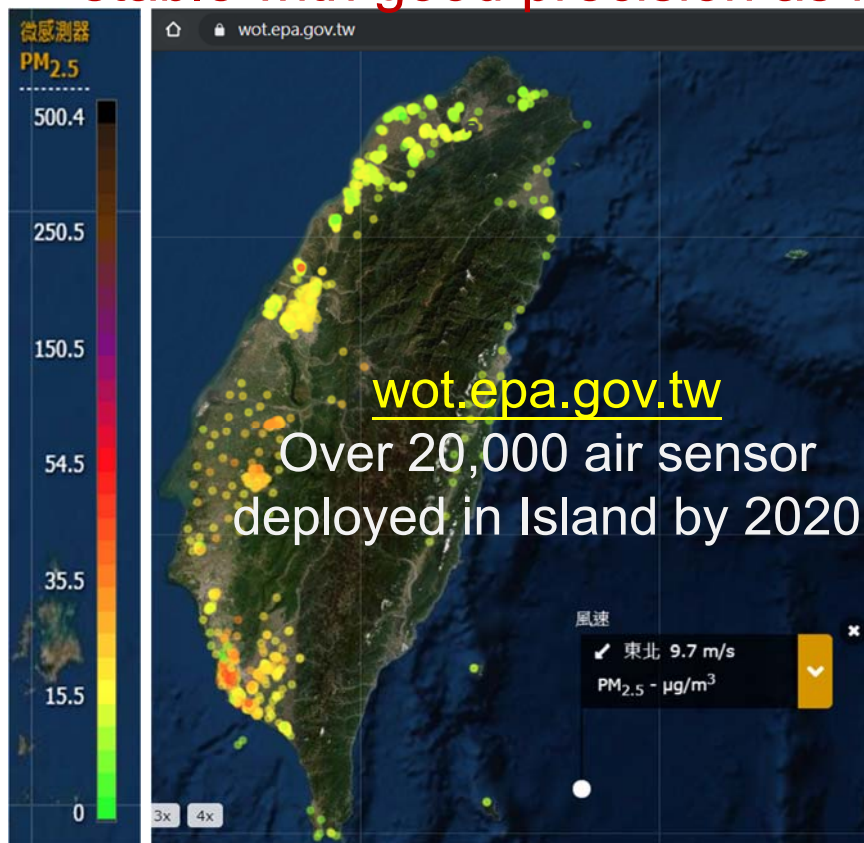
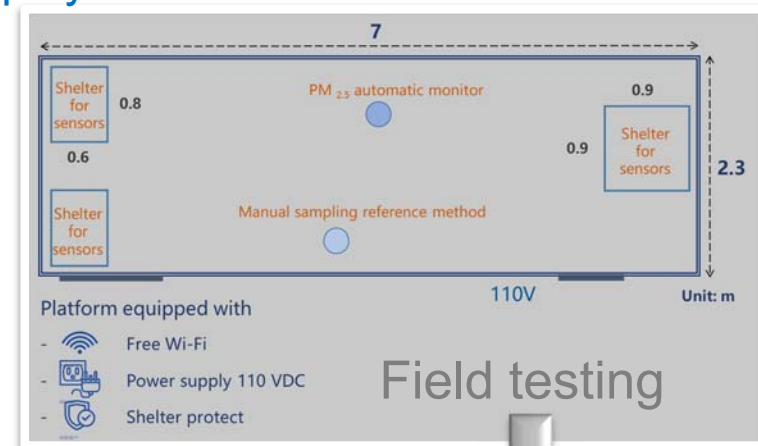
- **Specifications** required for new-deployed PM_{2.5} monitors
- **QA program** to maintain traceability

Low-cost Sensor Testing and QC Programs

We do

- Type testing of newly developed sensor intended to deploy in field
- Start from field testing followed lab evaluation with wind tunnel system
- Not necessary to discuss TYPE APPROVAL or CERTIFICATION due to its varied applications
- Uncertainty might be over 200%
- Fit in purpose is more important....

stable with good precision as indicators

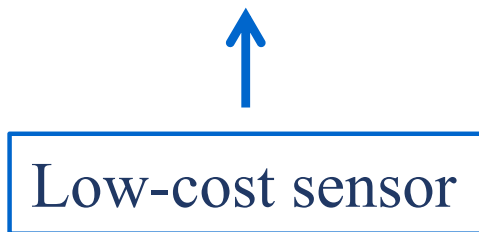
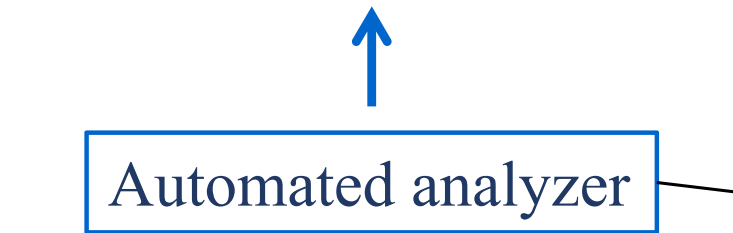
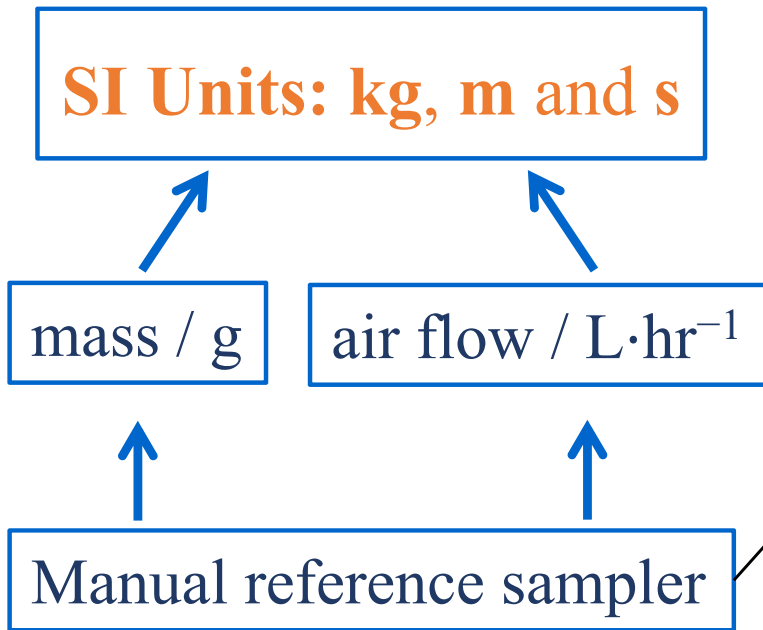


For details, please meet us
<https://airsensortest.blogspot.com/>
 or contact: tsaiyin@itri.org.tw

Metrological Traceability of PM_{2.5} Monitors & Low-Cost Sensors



PM_{2.5} analysis method
- TW EPA: NIEA A205.11C



Mass concentration of PM_{2.5} / $\mu\text{g}\cdot\text{m}^{-3}$



The role of traceability and uncertainty on PM_{2.5} mass concentration monitoring

Method detection limit and Measurement Uncertainty :

Measurement Principle	Brand / Type	MDL, $\mu\text{g}/\text{m}^3$	U, $\mu\text{g}/\text{m}^3$
Beta-ray	Met One BAM-1020	4	5
Beta-ray	Durag VEREWA F-701-2	5	5
Beta-ray	Environment S.A MP101M	6	8
Beta-ray	HORIBA APDA-375A	5	8
Beta-ray	Thermo Fisher Scientific Model 5014i	4	6
tapered element oscillating microbalance	Thermo Fisher Scientific TEOM 1405-F	4	8
Light scattering	Comde-Derenda APM-2	6	7

No PM_{2.5} CRM



Traceable to what?

Change of aerosol composition in real world

- Size distribution
- Speciation
- Humidity effect



Collocation comparison referred to reference method

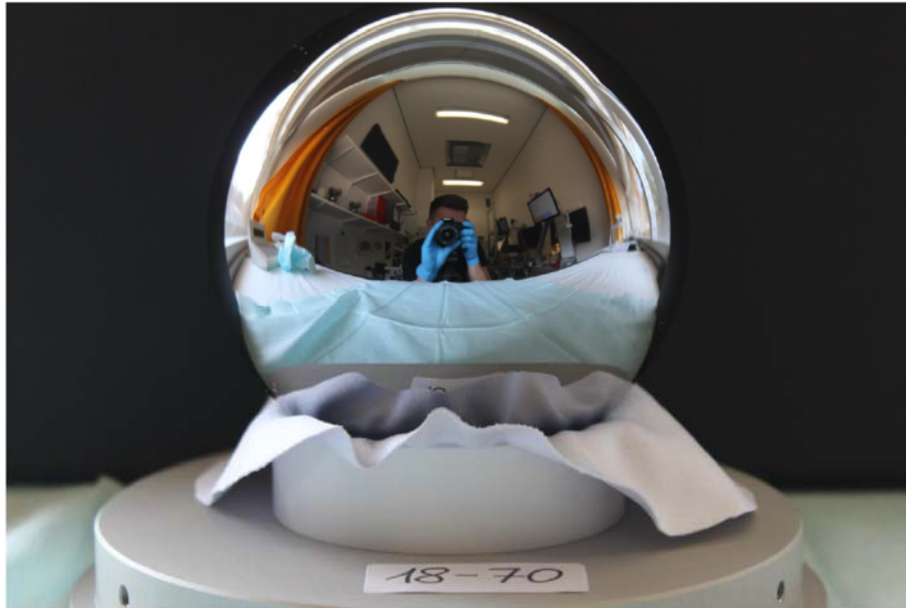


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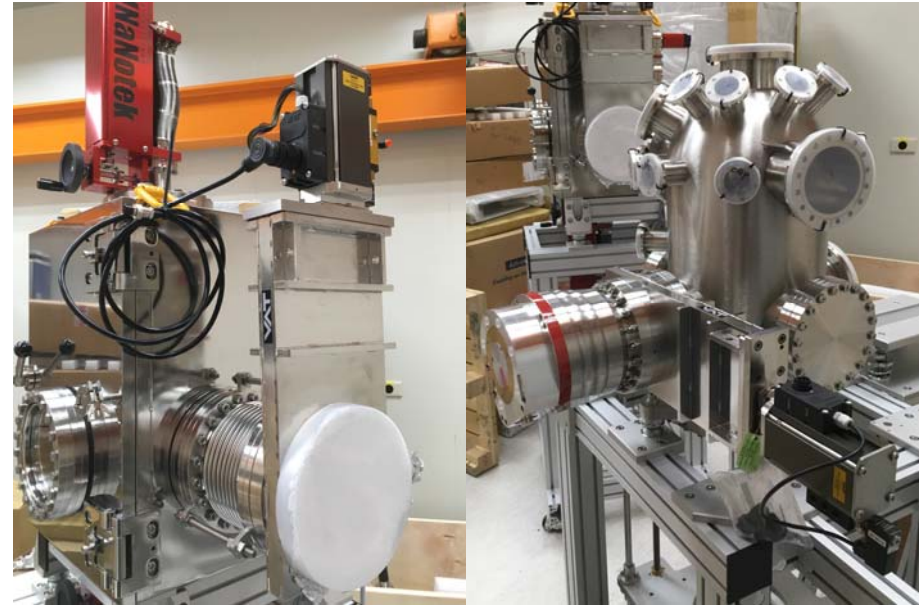
Si Sphere & XRCD kg Realization at CMS/ITRI

CMS/ITRI's Si-28 sphere:



^{28}Si isotopic fraction: 99.9985502(80) %
UnRoundness: 25.0 nm
Surface roughness: 0.196 nm

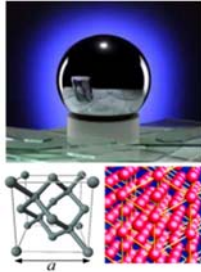
XRF XPS system:



Integration in progress

New kg Dissemination

Highly enriched Si-28 sphere



$$m_{sphere} = \frac{8V_{core} \sum_i x(^iSi) A_r(^iSi)}{a^3 A_r(e)} \frac{2R_{\infty}}{c\alpha^2} h - m_{deficit} + m_{SL}$$

Vacuum to air transfer

Secondary kg standard (air)



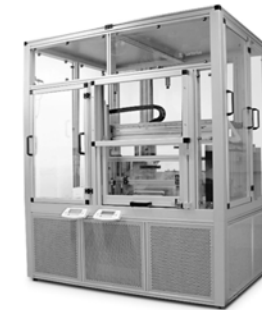
Dissemination



✓ Vacuum mass comparator (installed)



✓ Vacuum-air transfer and sorption effect measurement



✓ 10 g, 100 g and 1 kg full automation mass comparators

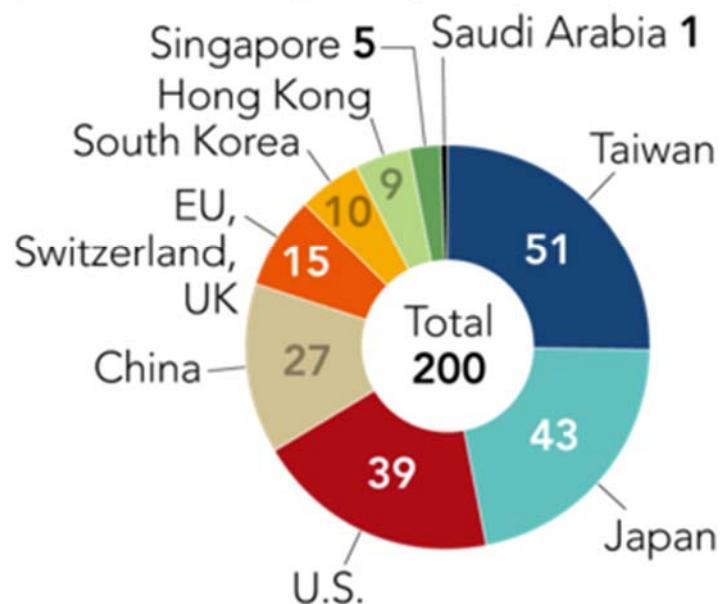
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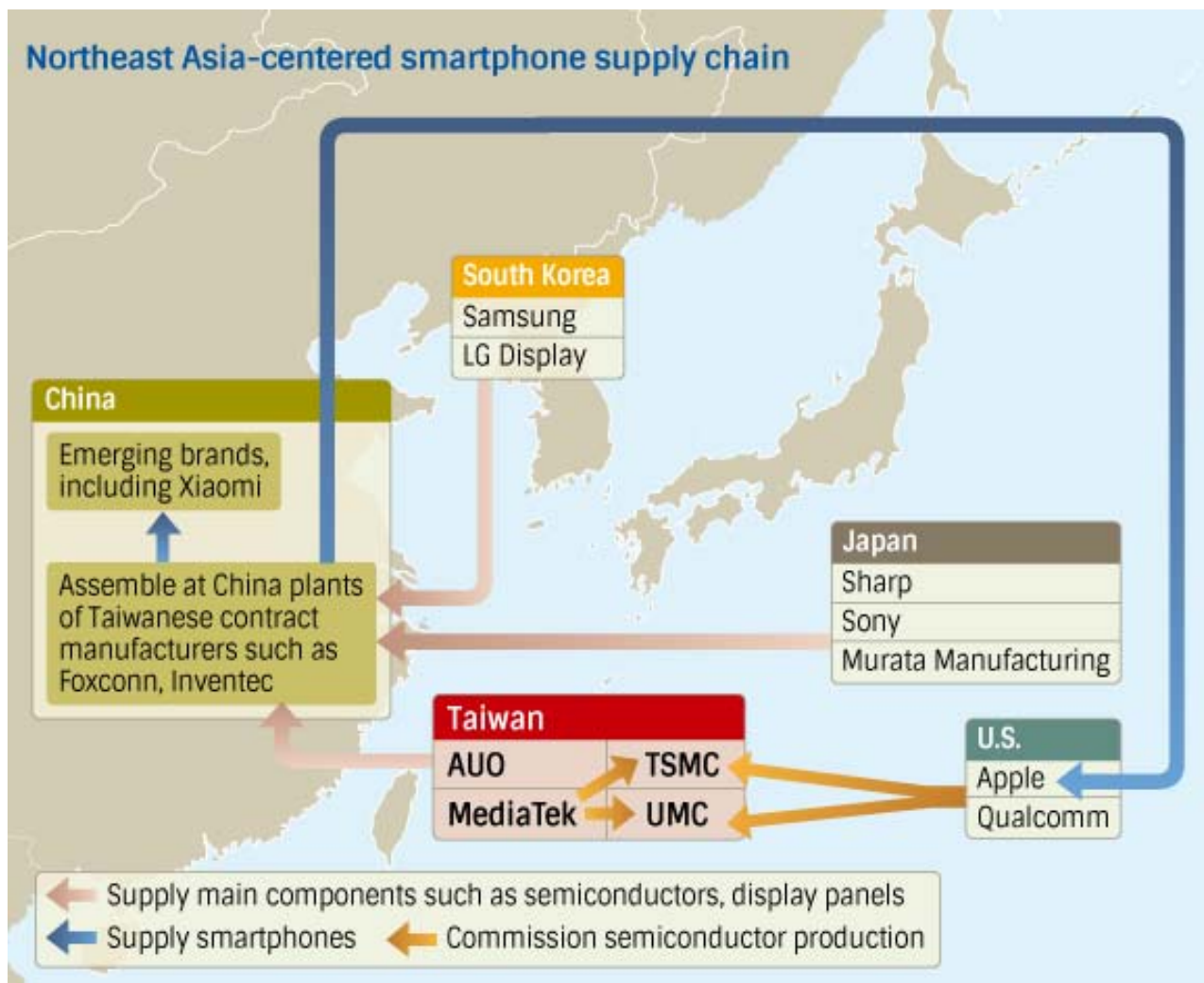
Critical Roles Played in IC World

- Output value of the local semiconductor industry is likely to expand 0.9 percent to NT\$2.64 trillion (US\$85.75 billion) in 2019, up from NT\$2.62 trillion in 2018.
- Taiwanese industry is the second place in global production value with a market share of 20 percent, second only to the United States.

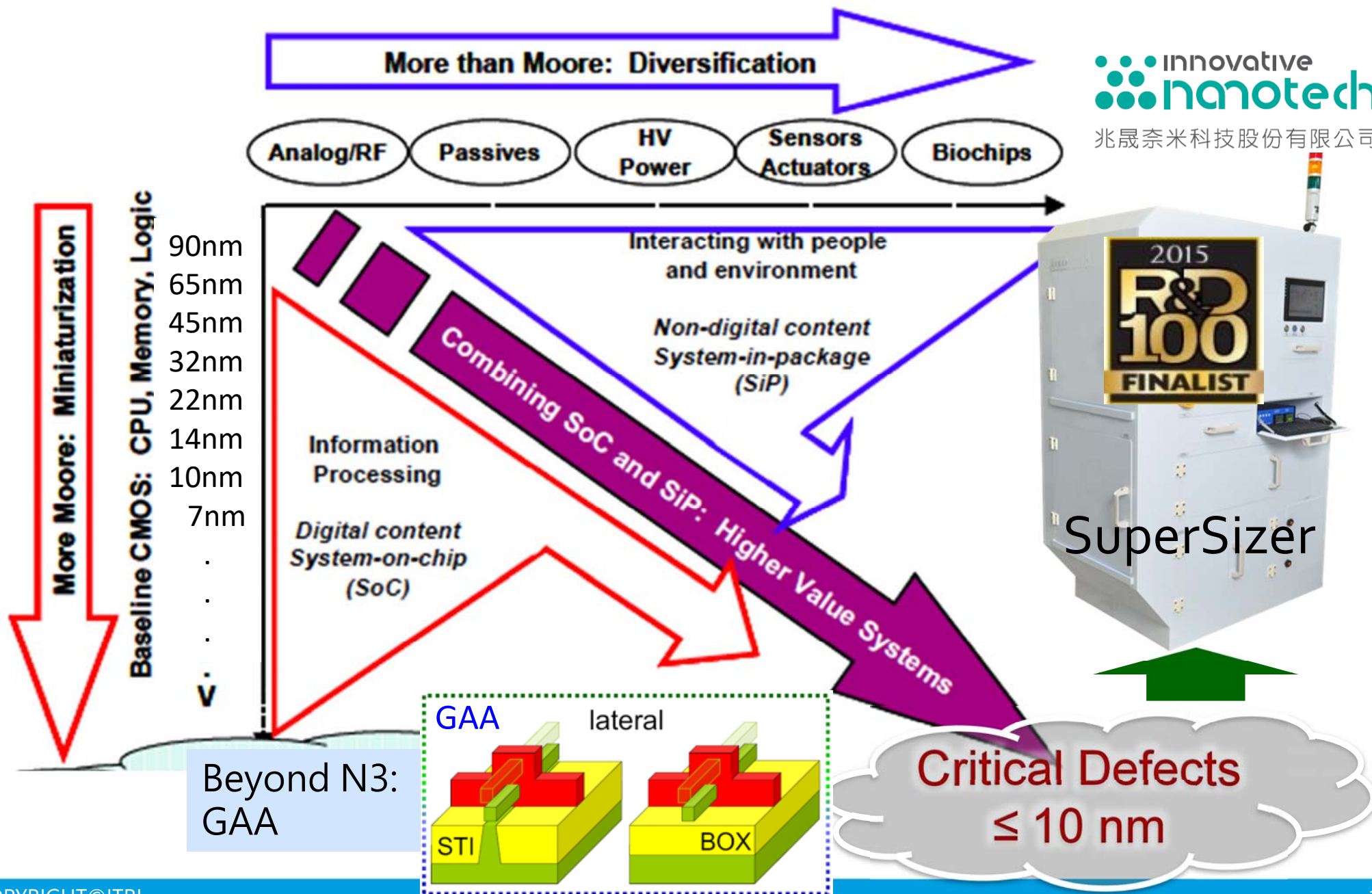
Where Apple suppliers are headquartered
(number of companies)



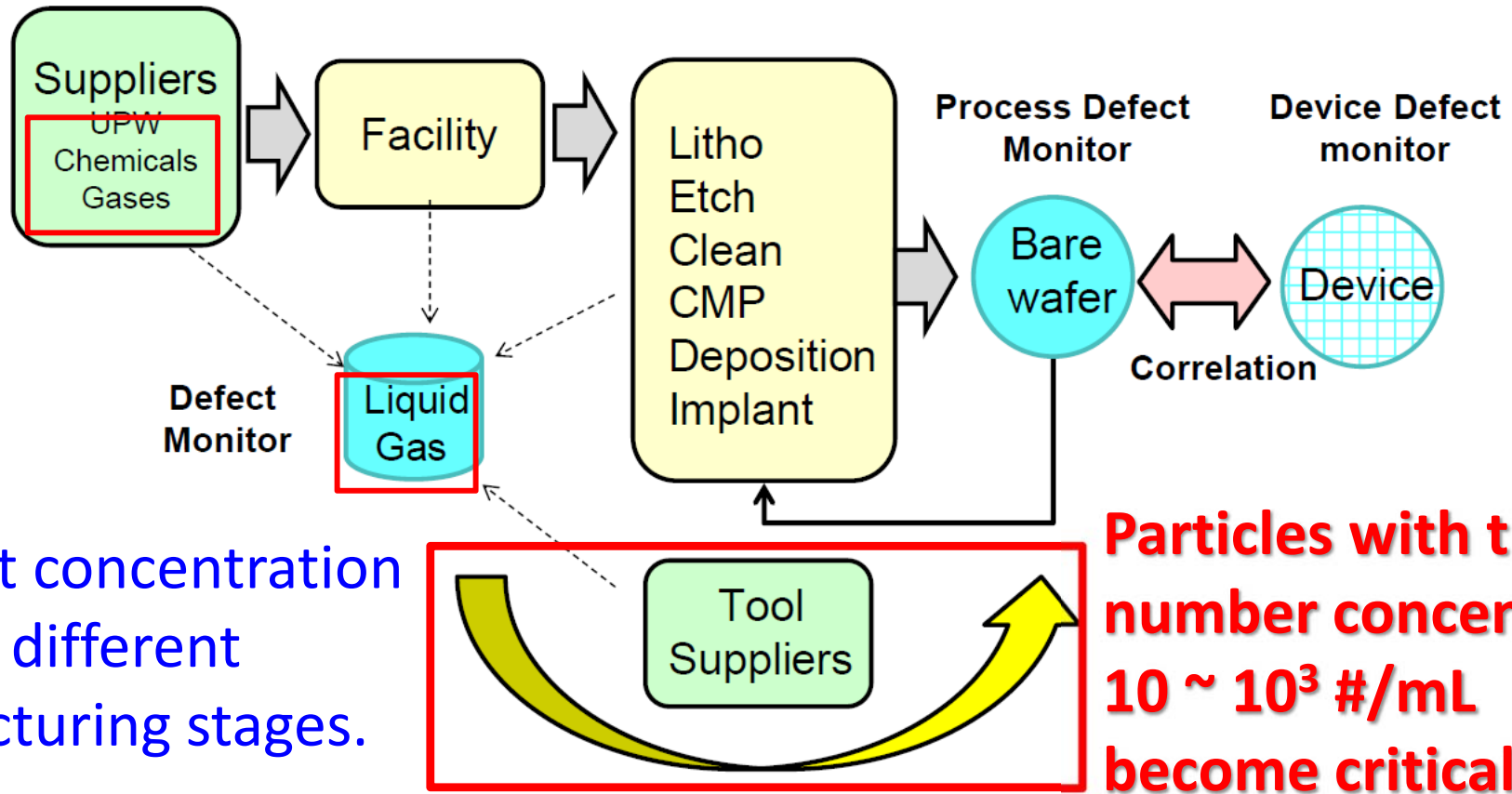
Source: Apple's list of suppliers for 2018



Metrology is Crucial for Process Control



Nanoparticle Metrology in Demand



Different concentration range in different manufacturing stages.

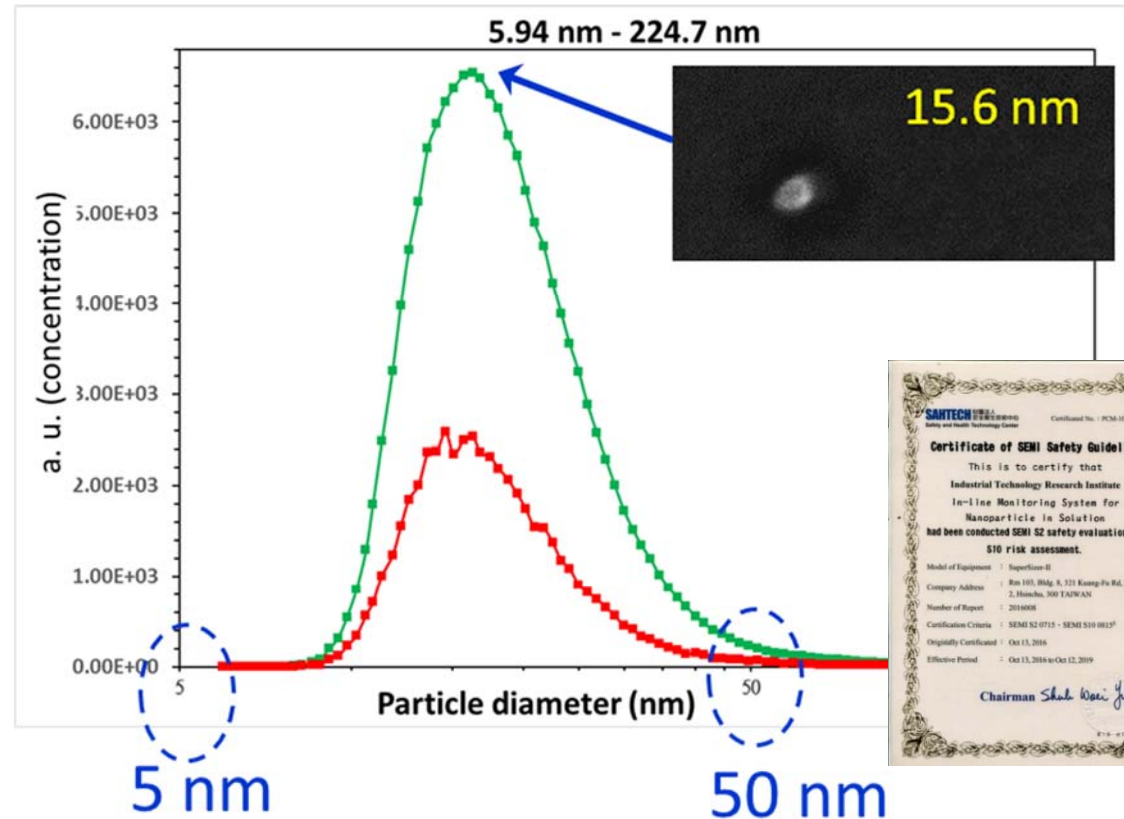
Year of production	Size spec.	Number concentration spec. (#/mL)				
		2017	2018	2019	2020	2021
Post-CMP clean chemicals	≥ 65 nm	500	400	200	100	50
Cleaning Chemicals	≥ 12 nm	10	10	10	10	10
UPW	≥ 6 nm	10	10	10	10	10

A New Generation Monitor for Nanoparticles in Solutions

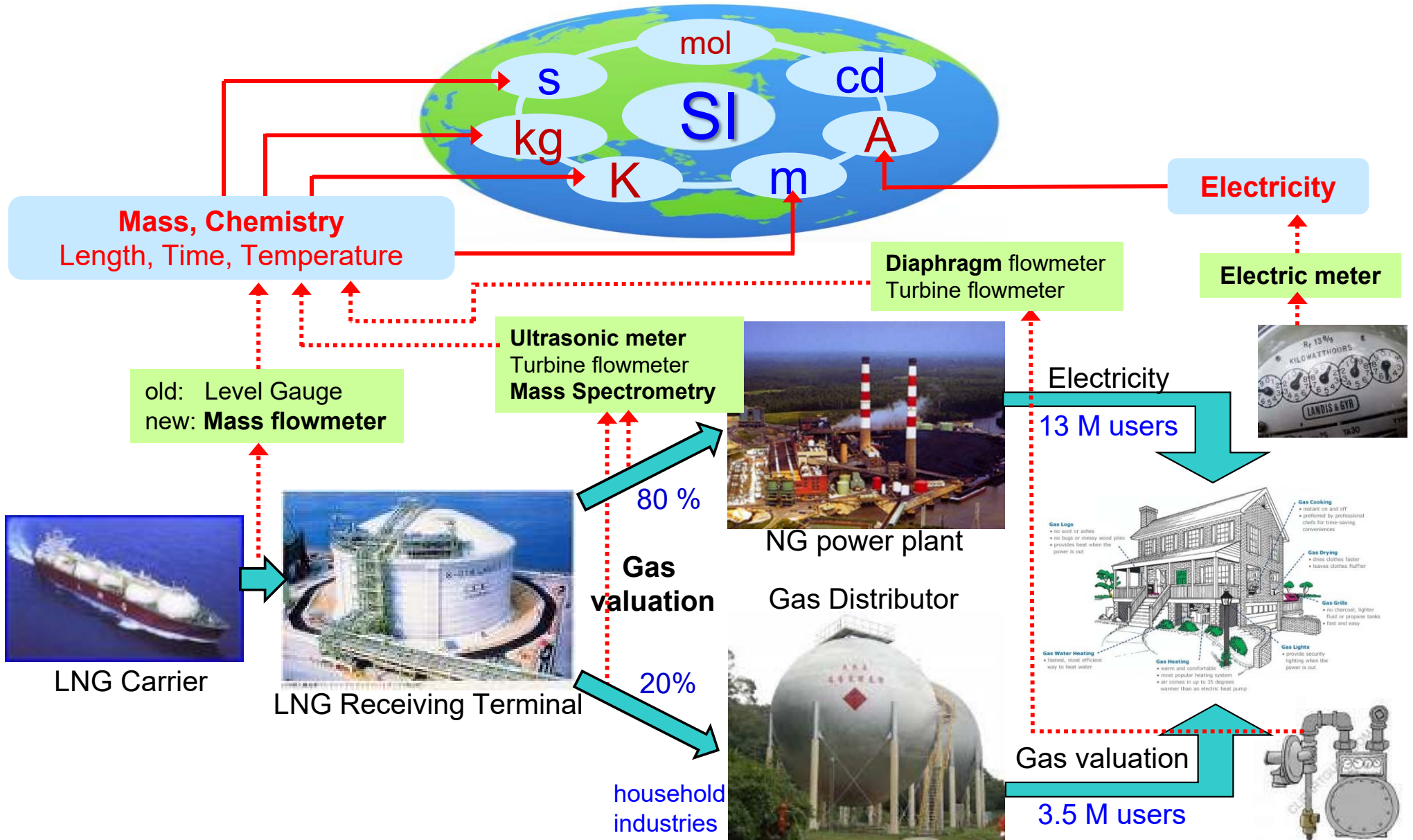


innovative
nanotech
兆晟奈米科技股份有限公司

- Metrology tool company spin-off from CMS/ITRI
- Established in 2018
- Key process control tool for N7 and beyond



Clean Energy Replacing Coal with LNG



Summary

- Revision of SI has been timely implemented to support economic growth and sustainable environment
- National QI of Air Quality Monitoring has been enhanced
- Particle metrology has applied to meet environmental and industrial needs
- Proverb: “Let the priest coming far preach”



CMS/ITRI 30th Anniversary



Symposium on International Trend of Metrology — Metrology for Industrial Innovation

國際計量趨勢研討會 — 計量與產業創新



主辦單位 經濟部 檢驗局
執行單位 工業技術研究院 國家度量衡研究所

TAI



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30
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