# Formation of Fine and Ultrafine Particles during Waste Combustion


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# Outline

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- **Methods**
  - Pilot circulating fluidized bed combustion (CFBC)
  - Experimental methods
- **Results**
  - Waste fuels
  - Particle size, composition, concentration
- **Conclusions**

# Background

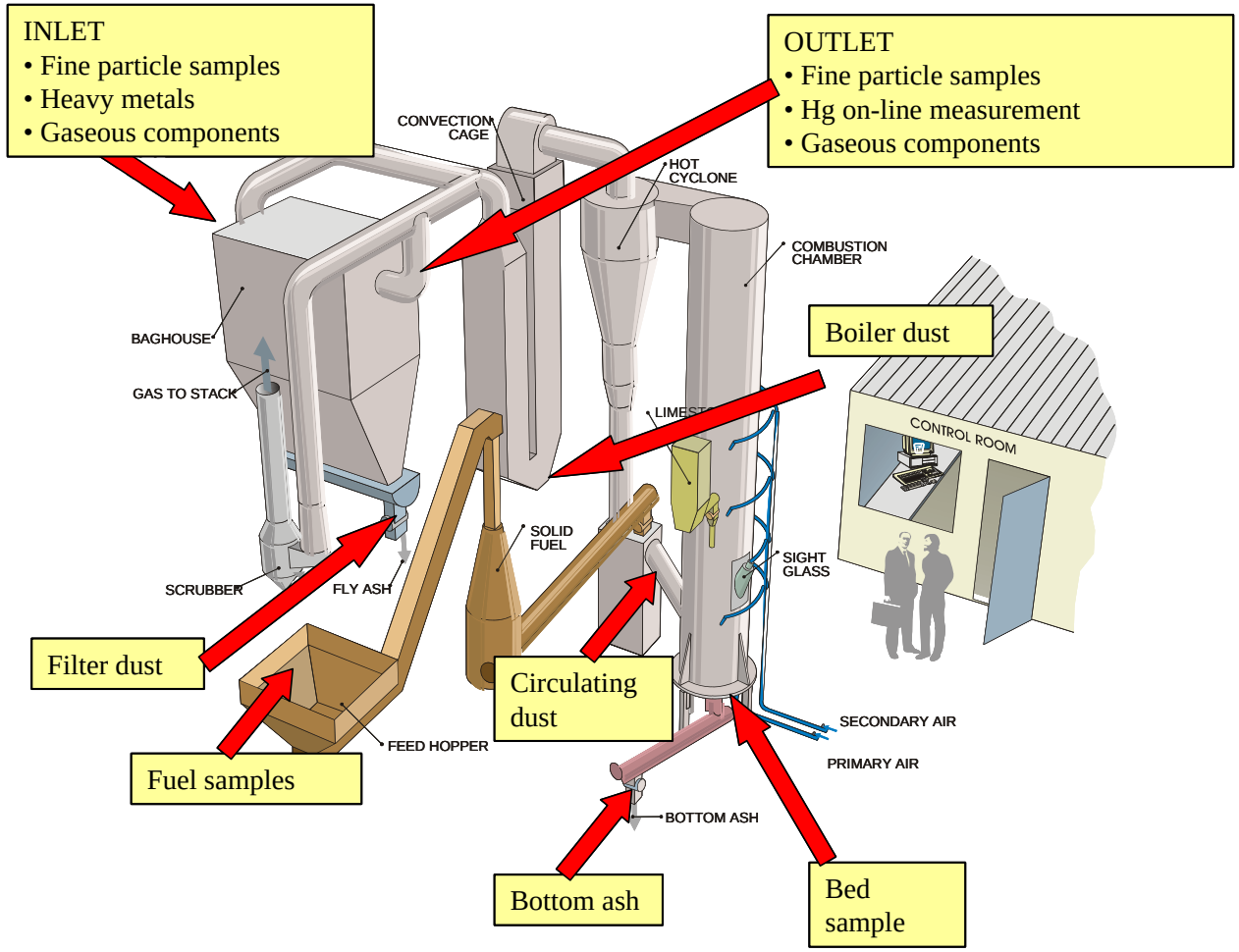
-Waste combustion to reduce the amount of waste and produce power

- Fluidized beds (FBC) suitable for wide range of fuel characteristics, e.g. moisture, ash content
  - Low temperatures
  - Even gas composition
  => low emissions and steady operation

- Emissions can be limited with modern gas-cleaning technology
  => fine and ultrafine particle formation and emissions not known

# Pilot-scale Circulating Fluidized Bed

- 1 MW Pilot CFBC
- Fabric filter for particle removal
- Possibility for activated carbon and lime injection



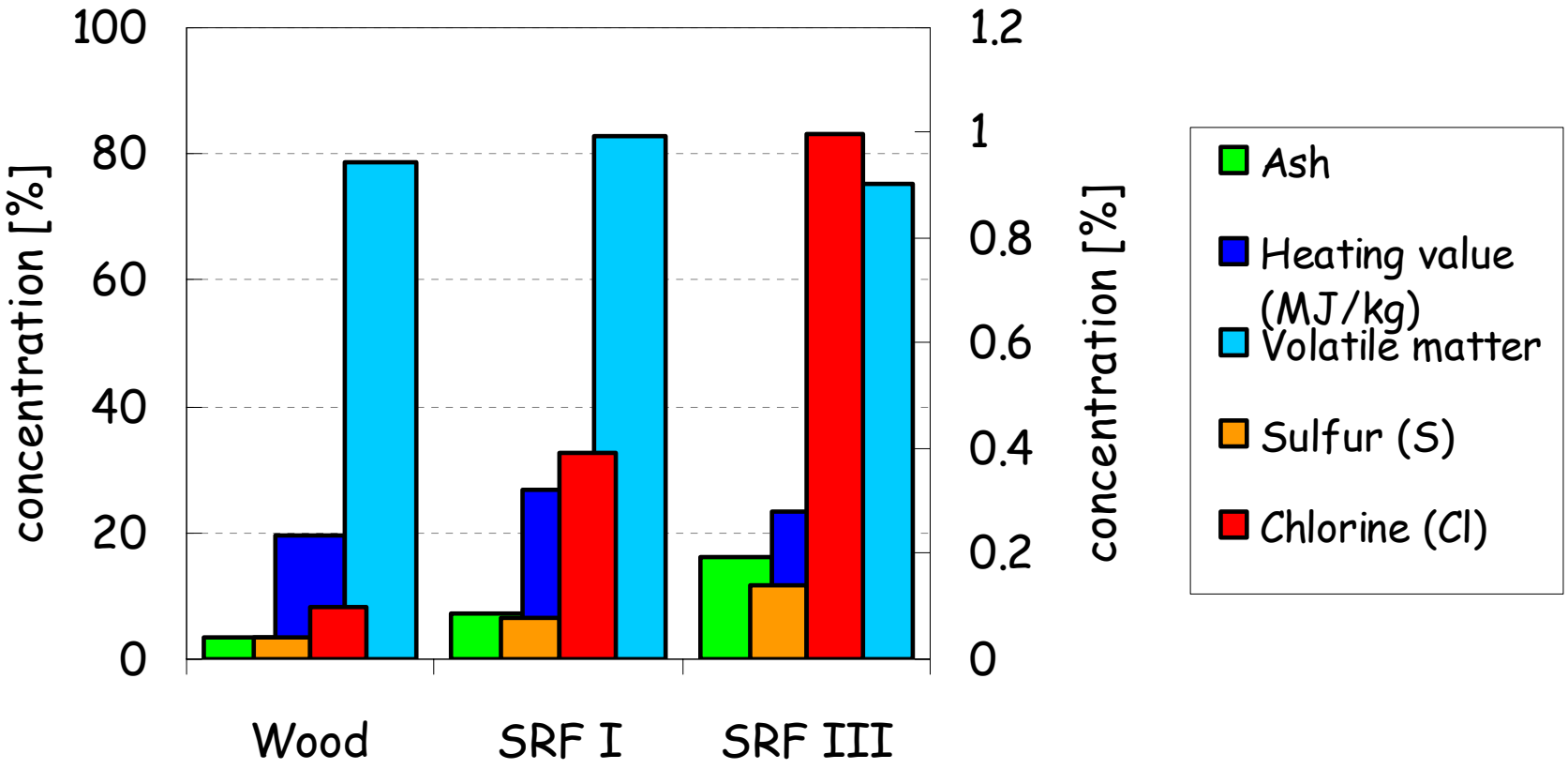
# Methods

- Berner Low-Pressure Impactor
- Thermophoretic sampling for TEM and SEM
  - Analysis with Philips SM200 FEG/STEM, at 200 kV and point resolution (TEM-mode): 0.24 nm
- Electrical Low-Pressure Impactor (ELPI)
- Filter sampling – total particles and heavy metals
- Mercury measurements – sampling and continuous
- Gas composition, also HC

# Three Waste Fuels

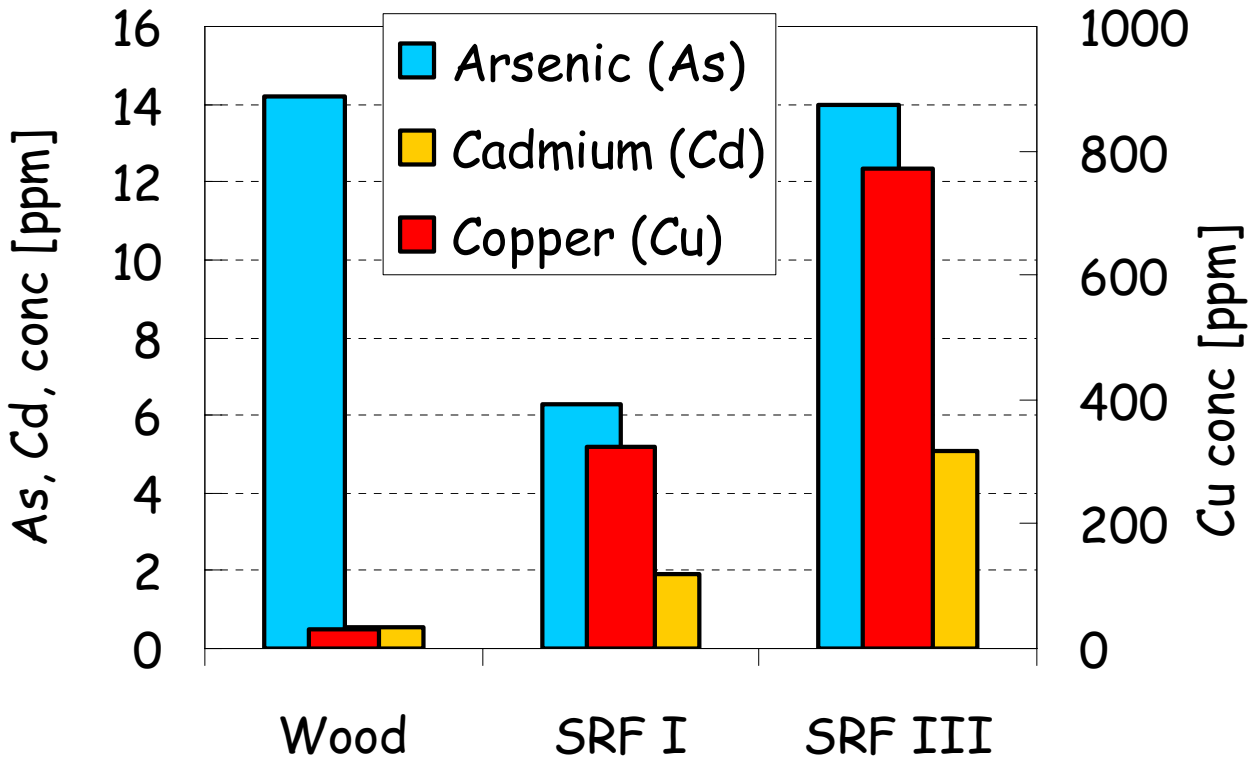
| Type of waste | Composition |
|---|---|
| Construction wood waste | Construction (mainly) and demolition waste wood |
| Solid recovered fuel, class I (SRF I) | Commercial and package waste (mainly paper, board and plastics) |
| Solid recovered fuel, class III (SRF III) | Produced from the dry fraction of source separated household waste |

# Fuel composition



# Fuel composition

Most heavy metal concentrations increase significantly with decreasing waste quality

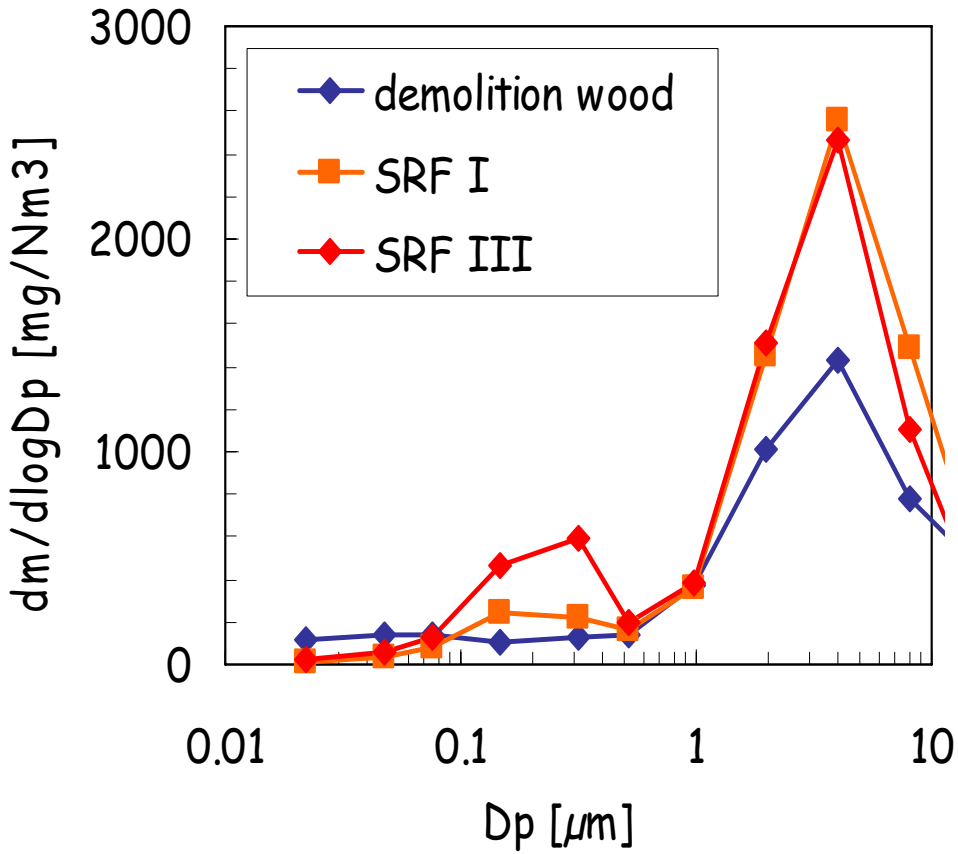


# Flue gas composition

| Fuel | $O_2$ [%, wet] | CO [ppm,wet] | NOx [ppm,wet] | $SO_2$ [ppm,wet] | HCl [ppm,wet] |
|---|---|---|---|---|---|
| Wood | 6.8 | 42 | 140 | 41 | 27 |
| SRF I | 6.8 | 730 | 110 | 54 | 120 |
| SRF III | 7.3 | 230 | 120 | 34 | 380 |

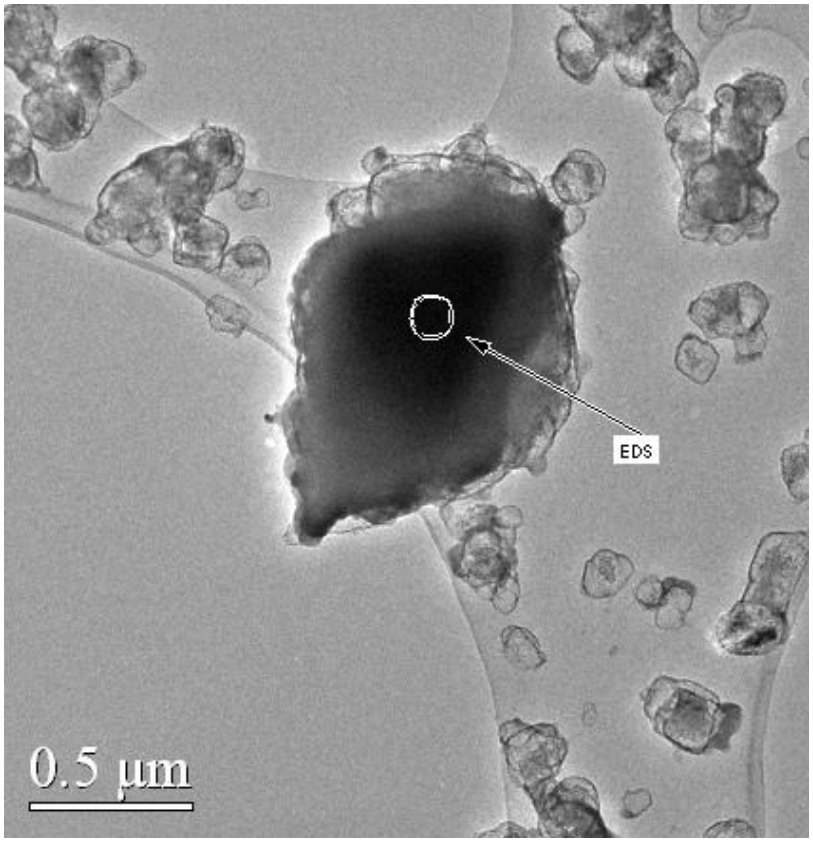
# Particle concentrations and size distributions, FF inlet

| Waste | PM1.0 [mg/Nm³] | Total [mg/Nm³] |
|---|---|---|
| Wood | 130 | 2 500 |
| SRF I | 240 | 4 200 |
| SRF III | 340 | 4 500 |

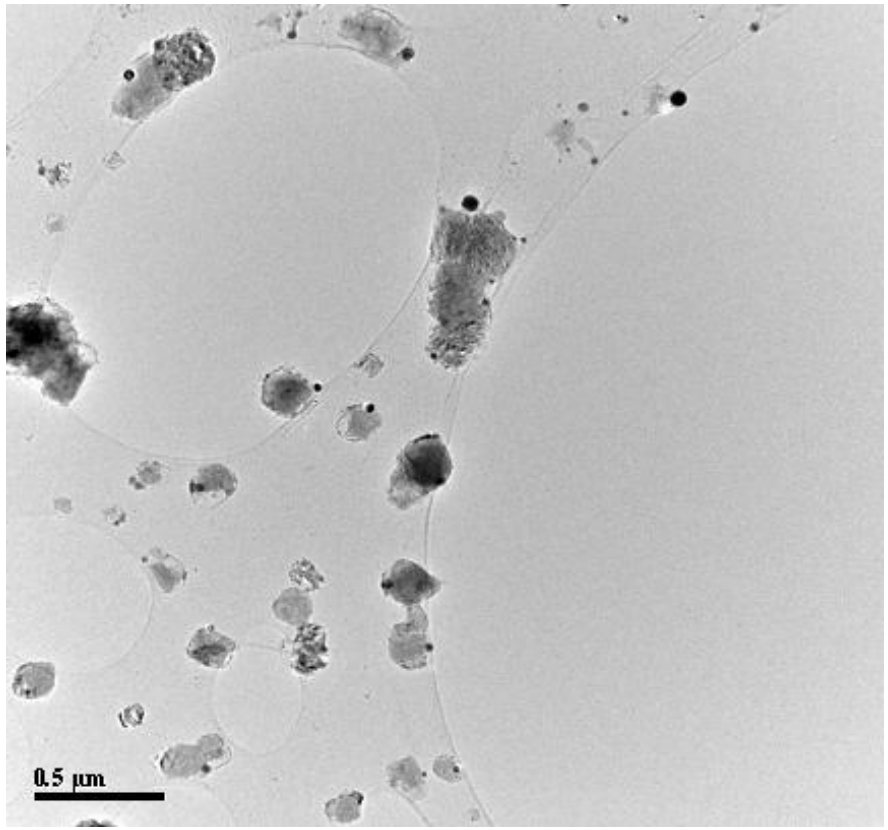


# Fine particles

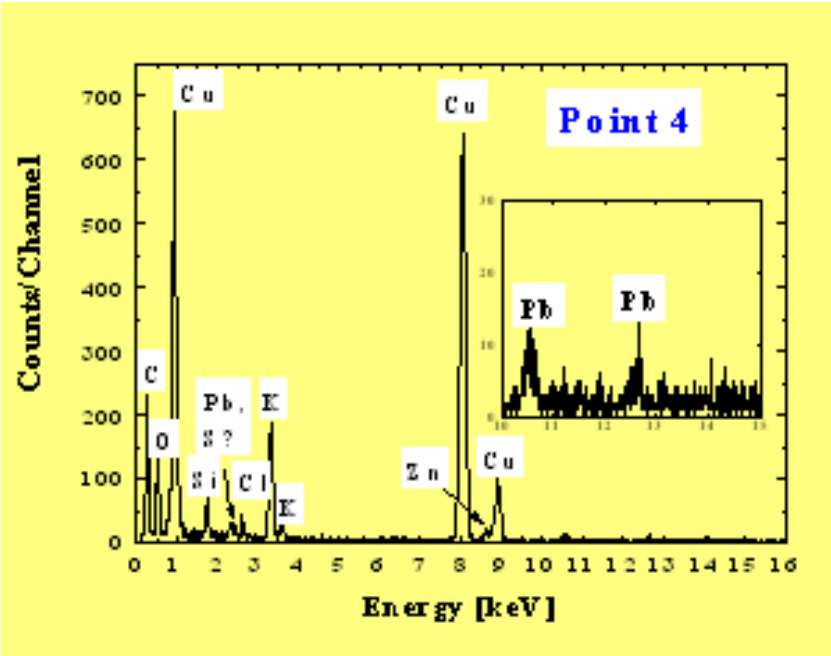
## Wood Waste

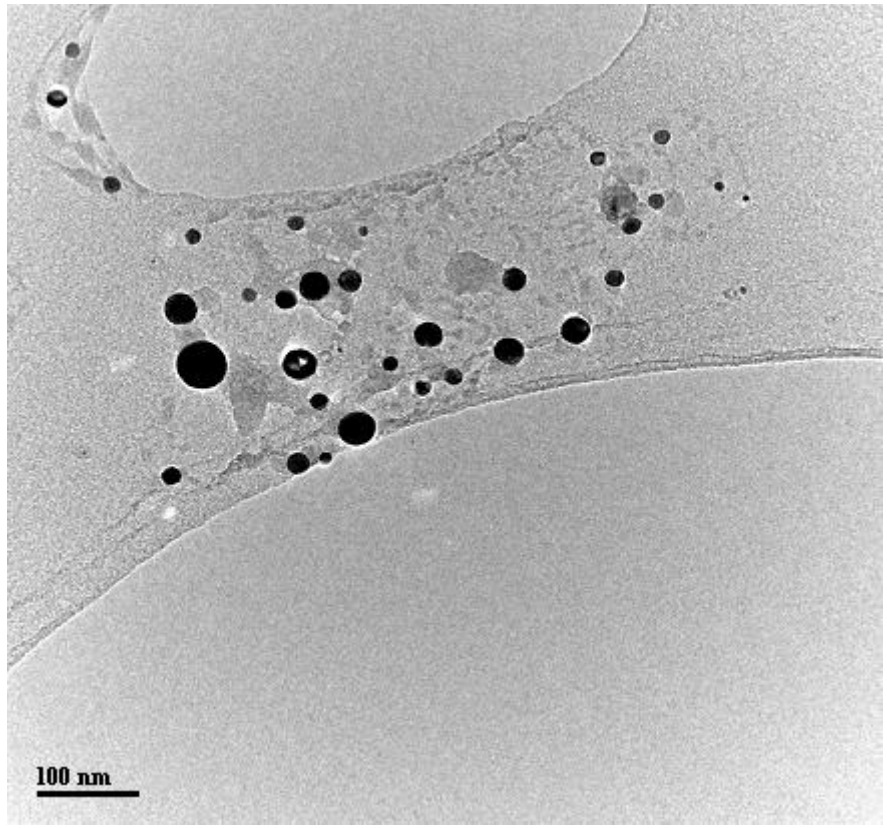



## SRF III



# Ultrafine particles, SRF III




100 nm

# Conclusions

- **Waste quality had an effect on the fine particle concentrations and composition**

  => higher PM1.0 concentration with lower waste quality

  => higher concentration of heavy metals with lower w.q.

- **Two types of submicron particles:**

1. 0.3 µm alkali-rich particles
2. 10 – 50 nm Pb and Cu particles, concentrations increased with decreasing fuel quality

   => particle removal equipment needs to be efficient even in the ultrafine particle size range