Safety aspects of nanoparticle reactions and explosions, their detection/identification and protective/preventive measures

NANEX

merging with NANOWORKS

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Background

Nanoparticles are going to be used in larger scales:

- **Powders and porous structures in manufacturing and storage**
- **Suspensions/Emulsions of nano-particles for storage and handling**
- **Spraying and thin films for coatings and feeding**
- **Inert atmospheres needed => high costs**
- **Incorporated in materials with high surface contact**
- **Guideline and regulation needed for industrial users – especially SMEs have not the means for investigations**

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Effects

Explosion: severe explosions, faster conversion, higher pressure rises, Deflagration-Detonation-Tranfer enhanced, severe explosion of porous Si

Ignition: sensitivity against stimuli increased, temperatures lowered (> 1000 K for super thermites – metal/metaloxide mixtures)

Thermal explosion in air: critical diameters as for other hazardous materials: particles in air are oxidised at lower temperatures

Surface reactions dominate at small diameters: nanoscale reactions (e.g. passivation) become important at small diameters also with small reactions constants

Stability:Long term compatibility of materials changes

Scientific and technical objectives

Physical and chemical characterisation of nanoparticles and suspensions/sprays (with nanoparticles) and measurement techniques to detect and identification and assessment of hazards

Mechanisms:

Chemical reaction kinetics: single particle reactions, catalytic effects and cloud propagation, surface reactions, heterogeneous reactions

Phenomena: Ignition, self heating/thermal explosion, fire and explosions in nanoparticles processes, long term reaction on storage - compatibility

Simulation, prevention and protection against these hazards

Regulation and technical recommendations on handling nanoscale particles, suspensions and sprays

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Workprogramme

Measurement technologies

• Online/ in-situ measurement: detection, identification and kinetics to avoid risks
• methods for particle size, surface morphology, concentration, chemical composition
• easy to handle and on-/-inline applicable equipment including calibration and verification
• nanoparticles and suspensions/sprays (with nanoparticles) with respect to reactive properties, surface morphology (increased surface area compared to spheres, surface layers (oxide layers))

Basic reaction mechanisms and experiments

• Chemical reaction kinetics, diffusion of gases and liquids in nanostructures and surfaces, single particle reactions and cloud propagation reactions, solid-solid reactions, catalytic effects
• Slow long term reactions, stability and compatibility with other materials, accelerated measurements (T, P) Self heating/thermal explosion, ignition sources, fires and explosions of nanoparticles, nano-dusts and nano-structured materials
• Fires and explosions of nanoparticles, solids in liquids and liquid sprays, clouds

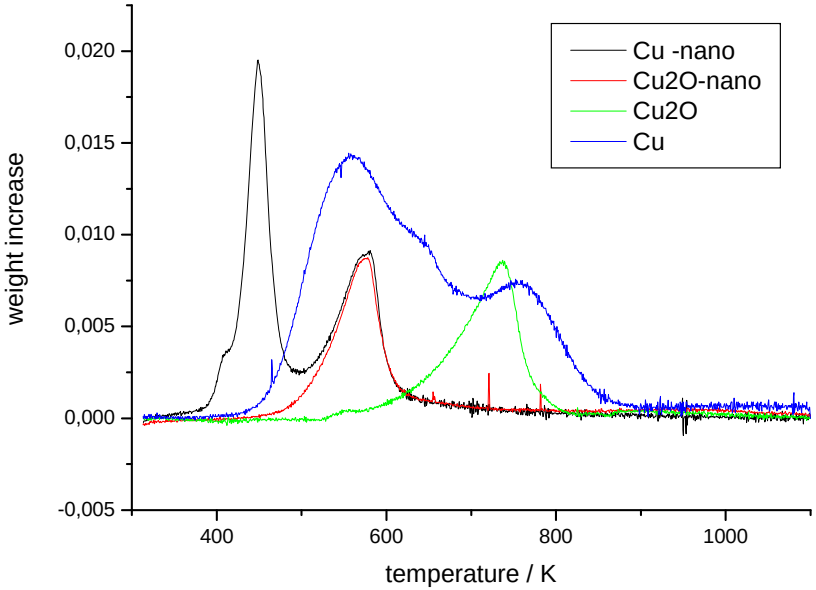
Verification; preventive/protective measures

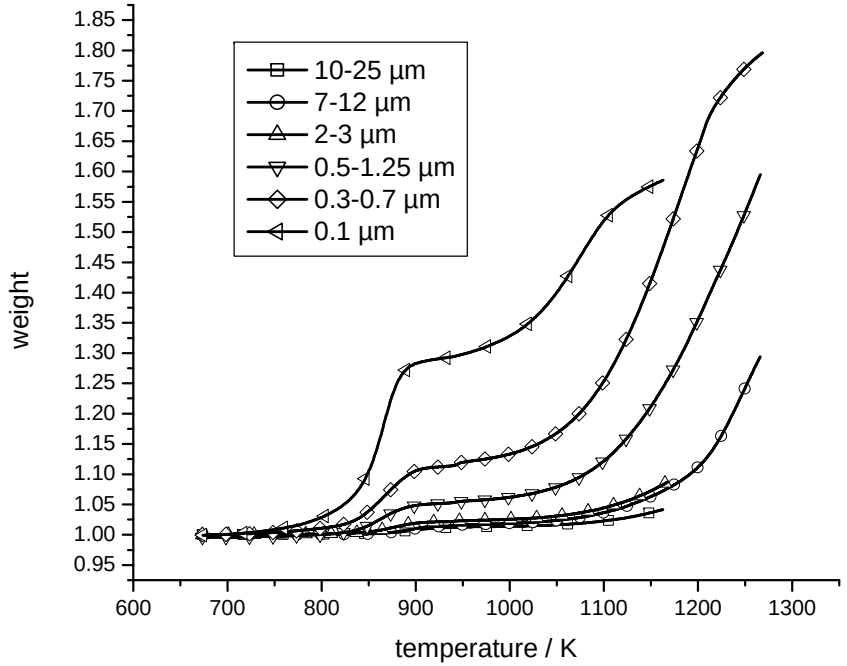
• Verification by larger scale experiments, long time storage experiments, simulated by accelerating tests
• Simulation, prevention and protection against fire and explosions of nanoparticles and nanostructured materials (exposed to reactive gases)
• Definition test methods for various hazards which might later become standard
• Risk evaluation tools and regulations,

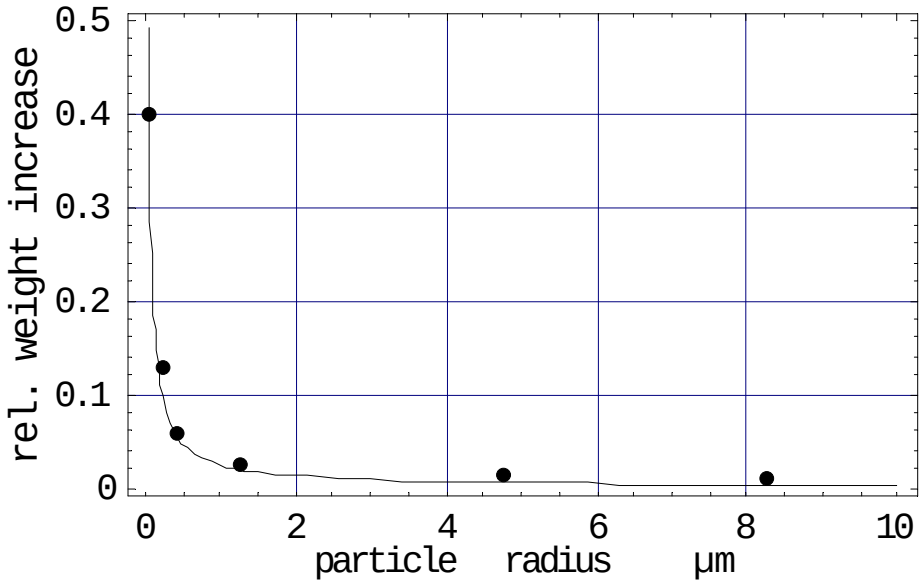
Example: Oxidation behaviour of nano metal particles

nano-particles react:

- **at lower temperatures**
- **in a different way, chemically dominated not only diffusion controlled**







Al-powders oxidised at rate 5 K/min,

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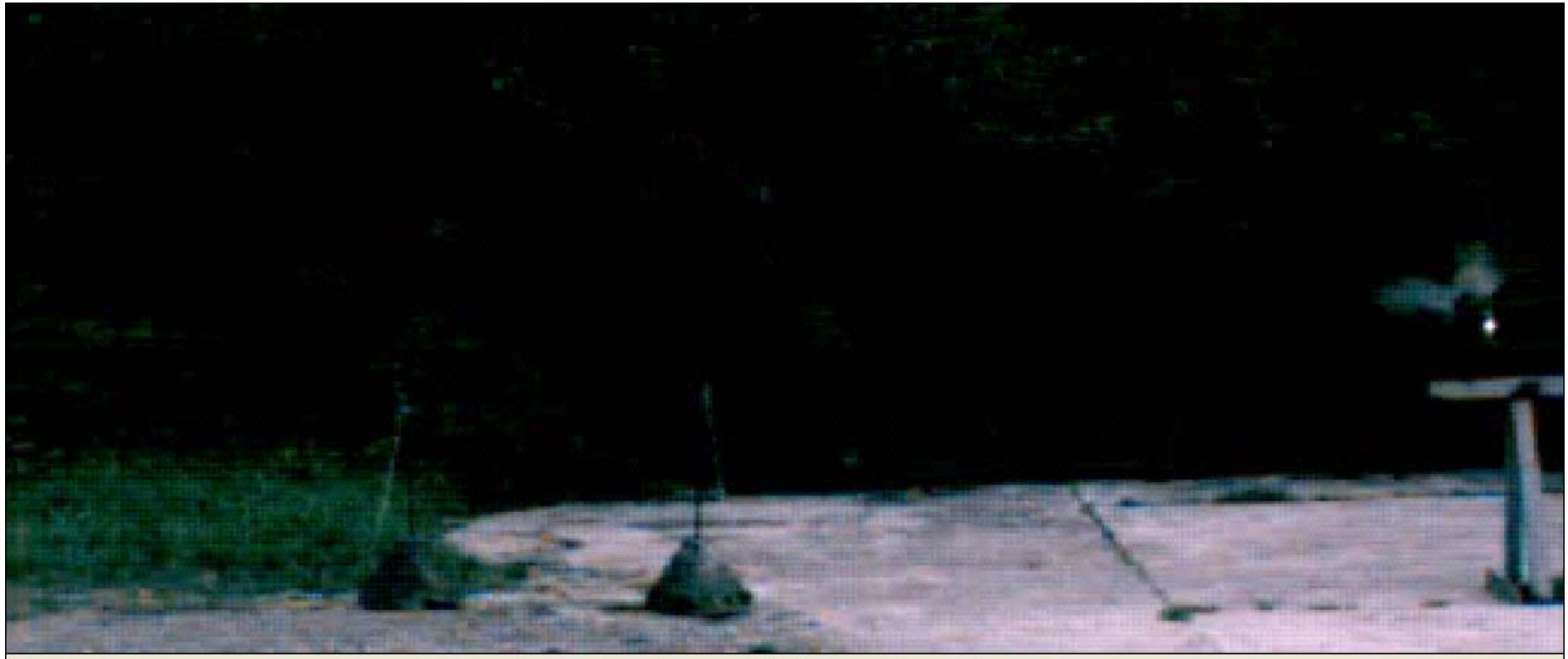
Al-slurry explosion in air



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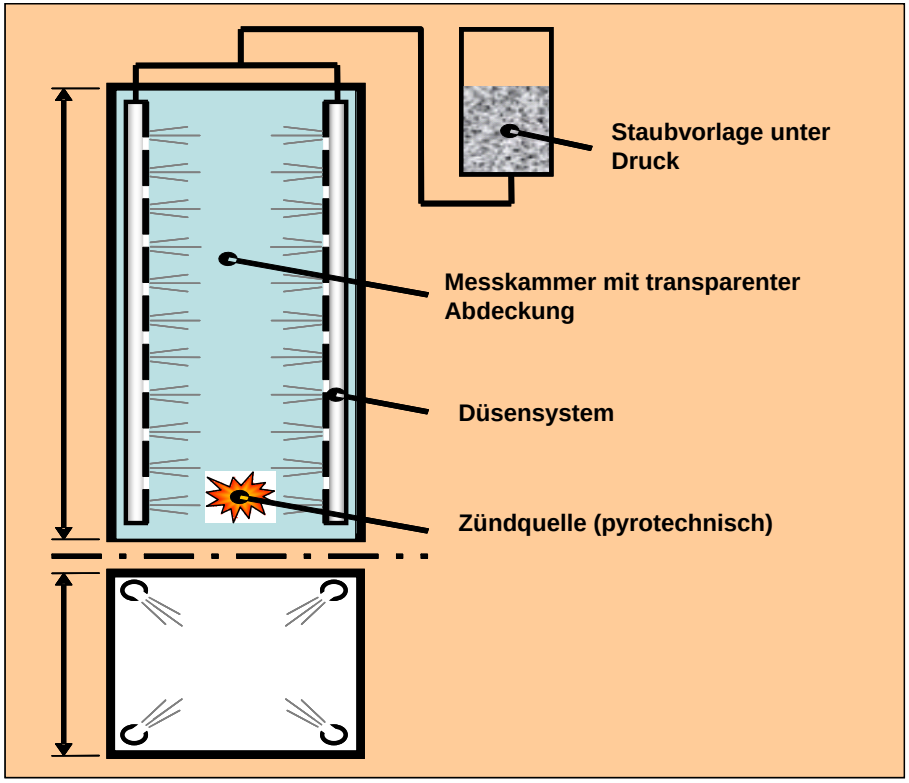
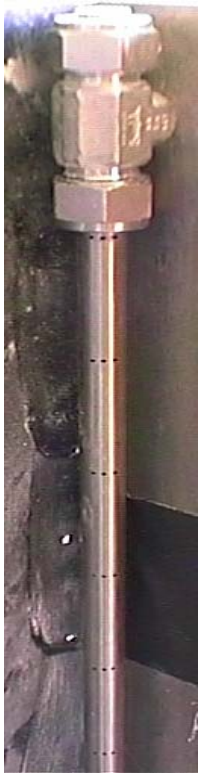
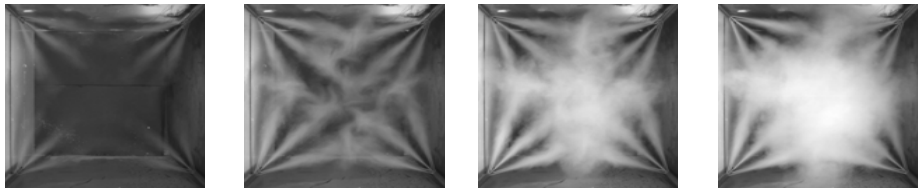
Fire/Explosion chamber: particles/sprays controlled turbulence

Flame propagation depending on parameters

Temperature/species profiles of flames and particles







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