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NanoStreeM final webinar

by NanoStreeM

The project has gathered a substantial understanding into how nanomaterials are used in the semiconductor industry. On 6th Dec 2018 the experts from the project held the final webinar of NanoStreeM. The recording of the event is available on YouTube: `https://www.youtube.com/watch?v=sLXtasXAC0I`

The presentations outlined how nanomaterials are used in semiconductor industry and what measures are taken to identify and contain possible risks. The concluding webinar also highlights some of the most important gaps that were uncovered and will comment on best practices used within the industry to control emerging hazards.

Novel materials and nano-risk in semiconductor industry

by NanoStreeM

The NanoStreeM project has organized a satellite technical workshop at the Semicon Europa on 14th Nov 2018. The event was organized in collaboration with the Nanotechnology Industry Association. The workshop has explored how novel types of nanomaterials can be used in semiconductor manufacturing.

Advanced materials, such as engineered nanomaterials and carbon-based materials, are expected to become a pillar of the European industrial development. The market acceptance of such materials depends on the sufficient understanding of their health safety properties both in terms of occupational hazards and in the impact on the ecosystem. The workshop aims at discussing the risk assessment frameworks, which are applicable to engineered nanomaterials used in semiconductor industry. The meeting will present how and where nanomaterials are used in typical semiconductor fabs based on the findings of NanoStreeM. The workshop will conclude with a panel discussion on the steps necessary to further enable use of nanomaterials throughout the industry and appropriately govern the emergent risks.

The panel statement and the full report can be found on the project web-site:


Last project meeting in Grenoble

by NanoStreeM

NanoStreeM held its last project meeting in Grenoble. The meeting was co-hosted by ST in Crolles on 8th Oct 2018 (see photo) and CEA in Grenoble on the 9th Oct 2018. The meeting was open for the local health and safety professionals. Participating experts enjoyed a virtual clean room visit at the Crolles site and a guided tour of the clean room of CEA LETI.

The project coordination team would like to thank the local organizers for their hospitality and excellent organization. We had a remarkable time together.

Grenoble is located in the Auvergne-Rhône-Alpes region at the foot of the French Alps where the river Drac joins the Isère. The city has grown to be one of Europe’s most important research, technology, and innovation centers. Some people call the Isère valley "the Silicon valley" of Europe. We would like to thank the hosts for their hospitality and commitment.
How are nanomaterials used in the semiconductor processing?

by NanoStreeM WP1

What has been assessed?

◊ ENM: Use of ENM in the semiconductor device production process has been assessed by a structured survey among the companies and research institutes participating in NanoStreeM. In two rounds the survey has been also extended to members of the European Nanotechnology Industry association and the BioNanoNet Association.

◊ Process-generated nanomaterials: The use of process-generated nanomaterials was assessed by a survey among the companies and research institutes participating in NanoStreeM.

What has been found?

◊ The final database contained an inventory of 47 products containing ENM used throughout semiconductor industry in Europe at present.

◊ Size and shape information could be made available for the submitted ENM.

◊ ENM are typically used in what is known as a “slurry”. These are stable suspensions of nanomaterials dispersed in water with other chemicals and are used for abrasive surface preparation.

◊ In some well-defined production steps nanomaterials can be generated as process residues.

Data Gaps Encountered

◊ The physico-chemical and toxicological properties necessary to perform safety assessment of nanomaterials are not readily available for the safety professional. The standard (compliant to the CLP) safety data sheets for chemical products do not contain information about eventual presence of nanoforms and their characteristics.

◊ In most of the cases acute and chronic toxicity information of the bulk material is also absent.

◊ Many nanotoxicity databases developed to date are not available for public use or the available data cover only few materials which are not used in the semiconductor device manufacturing.

Use Patterns and Expected Exposure Scenarios

◊ Collected 107 tasks and operations involving handling or generation of nanomaterials.

◊ After aggregation, a total of 41 relevant typical exposure scenarios identified:

◊ 33 related to worker exposure

◊ 8 related to potential environmental release

ENM were identified in two types of operations:

- Chemical Mechanical Polish (CMP) involving slurries (SiO2, CeO2, Al2O3) - photolithography involving coloured resist In addition, one generic scenario identified: Nanoparticles generated from alumina silicate ceramic fibre isolation material through thermal treatment.

What is the impact on the industry and the society?

◊ The overall use of ENM in semiconductor manufacturing is limited to few well-defined operations.

◊ Exposure to workers during production is likely in only a limited number of operations and it is expected to be low.

◊ Exposure during maintenance can occur only in a limited number of operations, however it is expected to be larger.

◊ Finished products (i.e. computer chips) do not contain ENM.
How can we perform risk assessment of ENM?

by NanoStreeM WP3

What has been assessed?

- 32 risk assessment tools have been identified providing quantitative and qualitative methodologies for risk assessment. Based on the collected potential exposure scenarios a detailed recommendation has been formulated.

- A tiered approach was advised based on the state-of-the-art tools including: - Use of risk banding approaches in the first tier to categorize risk: the ISO Standard ISO/TS 12901-2:2014 or StoffenManager Nano. - Use of (semi) quantitative tools in the second tier: NanoSafer, Consexpo and Advanced REACH Tool (ART) - Use of detailed emission measurement data in the third tier.

- The applicability of the guidance was evaluated by the industrial partners

What has been found?

- Exposure scenarios identified by the industrial safety experts were prioritized for evaluation of the guidance.

- Four common risk scenarios have been selected for further evaluation using the prescribed tools: - 2 scenarios from chemical mechanical planarization operations and - 2 scenarios related to maintenance of deposition tools.

- Prescribed tools have been tested using the scenarios

- We have established a necessity for grouping of nanomaterials in similarity groups (i.e., such as hazard bands or classes) until suitable quantitative tools are adapted.

What is the impact on the industry and the society?

- The findings of NanoStreeM demonstrate where ENMs are used in a representative portion of the manufacturing facilities in Europe.

- The findings of NanoStreeM demonstrate common and typical exposure scenarios.

- It is important to establish a harmonized protocol for emission/exposure measurements in semiconductor clean rooms.

- It is important to get reliable toxicological information about the nanomaterials used by the semiconductor industry.

- Since ENM are used intentionally for their properties application of the STOP principle is limited. Instead, focusing on Safer by Design approaches may be advantageous.

Data Gaps Encountered

- Many control banding tools require toxicological information about the nanoform without prescribing clear workarounds if such information is absent.

- The ISO Standard ISO/TS 12901-2:2014 requires collection of detailed information, which is not required for the risk categorization and is not readily available even for well-established slurries on the market.

- NanoSafer, Consexpo and ART could not be used without adaptation for the selected typical scenarios. As such adaptation is outside of the scope of the project this represents a clear direction for future development.
How can we measure nano-emissions in air and water?

by NanoStreeM WP2

What has been assessed?

- Identified state-of-the-art air sampling and monitoring instruments, which can be used in clean room environments.
- Identified latest developments in terms of proposed occupational exposure limits based on particle type and characteristics.
- Different protocols and standards were identified and analyzed, to assess their applicability to measure ultrafine and nanoparticle emission in semiconductor processing.
- Identified field studies of occupational exposure in semiconductor industry and compared to other industries.
- Identified analytical approaches for nanomaterial in waste water.
- Investigated potential sources of exceptional risk in waste water.

What has been found?

- The absence of background is a major advantage that facilitates and enhances the measurement sensibility.
- It was established that contamination risk of the clean room by the instruments is not a real concern, as most of the devices do not generate particles or their emissions can be controlled. This is an important conclusion in view of the acceptance of nanoparticle emission measurement as part of the routine EHS or quality control procedures in industrial clean rooms.
- Several wearable devices suitable for individual monitoring were identified.
- The analysis of the exposure assessment protocols demonstrate that they share some common principles. The OECD tiered approach is recommended to the industrial partners.

Data Gaps Encountered

- The use of air nanoparticle emission measurement devices and the interpretation of the obtained results need special training.
- Recommended devices provide number concentration which can be linked only indirectly to mass-based exposure limits if such are available.
- So far, no regulatory Occupational Exposure Limits (OEL) addressing nanomaterials have been adopted by the EU or by any national/international authority. A set of guidance values have been proposed by different regulatory bodies both nationally and internationally. The OEL proposed by different regulatory institutions for the same material are not completely homogeneous, even though most of them report the same range of values.
- Only DLS (Dynamic Light Scattering) technique was identified as a routine technique applicable for water and waste water analysis. However, DLS does not provide number or mass estimate.

What is the impact on the industry?

- Usual methods for nanomaterials monitoring are applicable to clean room environment.
- For the environmental impact related to industries waste water containing nanomaterials, the dedicated techniques are limited and need to be further developed. For such samples, research analysis exists but cannot be applied routinely in clean room environment due to cost and complexity issues.
Competences development and training  
by NanoStreeM WP4

Semiconductor industry operates with a large number of chemical products due to increasing processing complexity. The properties of nanomaterials are not well known. Significant information gaps regarding nanomaterials exist that preclude the typical EHS chemical risk assessment methodologies to be applied. Available public information is focused only on a very limited set of materials while the safety data sheets fail to convey all the information necessary to conduct risk assessment. In such condition it is important to train engineers and researchers to understand the properties of nanomaterials and the methods to conduct risk assessments.

What has been assessed?

- Collected Safety training curricula. It was identified that only 4 partners had any form of nanosafety trainings.
- Identified external nanosafety training resources
- Collected existing nanosafety training resources

What has been developed?

Developed 3 safety training packages developed, all with focus on semiconductor industry processes and environments.

- training package for operators and other technical personnel semiconductor industry handling nanomaterials with no prior experience.
- training package for safety professionals to aid in their education concerning nanomaterials and how to conduct risk banding, risk assessments and monitoring of nanomaterials.
- “Train the trainer” guidelines tool box

What is the impact on the industry?

The training packages will be adopted by the consortium partners. Definite need for competence development was established in term of

- Awareness of the properties of nanomaterials;
- Awareness about the dedicated nanotoxicology knowledge base;
- Awareness of the limitations and boundaries of the application of the traditional EHS chemical risk assessment to nanomaterials.

NanoStreeM publishes a chapter on
Risk Assessment for Nano-Materials
by Dimiter Prodanov

The findings the approach explored in Work package 3 of the project was generalized to a contribution to the monograph Occupational Health and Safety: A Multi-Regional Perspective was recently published by Intech Open.

The chapter provides an overview of several control banding tools for risk assessment of ENM. Their application to semiconductor production processes has been presented as a preliminary use case in view of the information collected in the NanoStreeM project. Identified gaps in the state of the art demonstrate the main advantages and limitations of the different control banding tools. Substantial knowledge gaps can be identified for even widely used by the industry ENM, such as CeO2 and Al2O3 nanoparticles. The situation is even worse for materials with promising nanoelectronic applications, such as CNTs and graphenes. Furthermore, it was found that the ISO Technical Standard ISO/TS 12901-2:2014 needs further clarification in order to improve its usability. NanoStreeM generalized tiered risk assessment approach allows for the use of different, possibly even sector-specific tools, in combination with emission or exposure measurement field studies.

The chapter is freely available on http://dx.doi.org/10.5772/intechopen.70949