Getting to the heart of nanomaterial risks

A variety of nanomaterials are used today in the development of semi-conductors, as companies seek to further improve the performance of integrated circuits. While these materials are increasingly central to modern semi-conductors, their hazardous properties and the associated risks are not fully understood, an issue scientists at the nanotechnology research centre in Leuven are investigating. “We are regularly asked about the safety of different materials used in semi-conductor development, and we identified that we needed to intensify research in this area,” says Dr Dimiter Prodanov. From this, researchers established the NanoStreeM project, a consortium which brings together partners from both the public and private sectors to build a deeper understanding of the hazards and risks associated with using nanomaterials. “The consortium is uniquely well positioned to look into the safety of nanomaterials used in the semi-conductor industry,” outlines Dr Prodanov.

Nanomaterials

The nanomaterials themselves are broadly defined as those that have a certain percentage of particles at the nanoscale, between 1 and 100 nanometres. Particles of this size can pass easily through alveoli, get deposited in the lungs, or even disperse in the body; Dr Prodanov says these nanoparticles can act as carriers of other materials. “The majority of bulk materials are not really toxic as such. We are looking into the modification of the primary hazards, by considering the process residues on one hand, and also into new materials that may find their way into future applications. These are mostly carbon-based materials, for example nanotubes,” he explains. Nanoparticles are increasingly used in polishing slurries in semi-conductor development, which can leave certain workers exposed to potentially hazardous materials during the fabrication process. “Most of these processes are done in closed environments. So it’s only when you clean the chambers, or if you deal with residuals from spills, that you come directly into contact with these particles,” continues Dr Prodanov.

There are five workpackages within the project, with one workpackage dedicated to investigating risk assessment methodologies for the use of these nanomaterials, as well as risk management and control strategies. Dr Prodanov says there are three main types of approaches to risk assessment. “There are categorical or qualitative approaches, there are semi-quantitative approaches, then there are more quantitative approaches,” he explains. The main problem with respect to quantitative models is that typically they need access to parameters which are not directly accessible. “This means that we have to monitor the exposure of nanomaterials in processing, over a certain period of time, in order to assess the emissions and then derive Occupational Exposure Limits (OELs),” says Dr Prodanov. “However, there is not enough high-quality toxicological information to derive rigorous OELs. So the typical approach is to divide the available OELs for a bulk material by a certain factor, based on expert opinion.”

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The approach on the semi-quantitative side is effectively to devise some scores for each of the processes, to classify the processes accordingly, and then to assign specific control measures to protect the health of workers. However, similar problems apply as with the quantitative models. “If you don’t have data then you have to apply some modelling. The question then is if the assumptions in these models actually fit the application. Then there’s the problem of the lack of toxicological information - only a few nanomaterials have been studied sufficiently well to justify a quantitative or semi-quantitative approach,” explains Dr
Prodanov. The third approach is qualitative - or categorical - risk assessment. “Most industrial practitioners are more familiar with qualitative approaches. One of the tasks in the project is to devise a comprehensive risk assessment methodology and identify the best tools for the semi-conductor industry,” says Dr Prodanov.

Generic methodology
This methodology could be applied to a new material with mostly unknown properties, providing a basis to establish initial control measures and exposure limits. These measures may at times be more stringent than actually required, but the precautionary principle applies here, and they could be relaxed in future when more is known about the toxicity of the specific material. “When more information becomes available, certain control measures can be relaxed to a more appropriate level, reflecting the application and state of knowledge,” says Dr Prodanov. This methodology will be one important outcome from the project, while Dr Prodanov says their research will also have an impact in other areas. “We have developed an inventory of the nanomaterials that are currently used, analysed the trajectory of nanomaterial use; we will also build a database of materials that could be used in future,” he outlines.

Researchers aim to identify a set of OELs, which will be used as an input for the risk assessment methodology, while there is also a training element to the project. The nanoelectronics industry is central to Europe’s economic future, and technological innovation is key to its ongoing development, yet this must not come at the cost of compromising environmental standards. “We have identified some information about nanomaterials which is important for safety professionals and process engineers,” outlines Dr Prodanov. Beyond nanoelectronics, Dr Prodanov says the project’s research could also hold relevance for other industries. “Some outcomes from the project are sufficiently generic to be translated to other industries; for example, the suppliers of reagents and also possibly in waste treatment industries. We think that the risk assessment methodology and the training packages can be translated across different industries,” he continues.

The focus in NanoStreeM has been mainly on coordination and sharing information which was already collected. In future, Dr Prodanov would like to pursue further research, taking new measurements using the tools that have been developed in the project to build a fuller picture of the hazards associated with the use of nanomaterials. “We can monitor how these tools are actually being used and cover the whole lifecycle. At the moment, we are looking into the fabrication, but we’re not looking at the whole lifecycle of a nanomaterial which enters the semi-conductor industry, as there are other projects doing so,” he says. The project is collaborating with other initiatives in complementary areas, building relationships and laying the foundations for continued research. “Our project is part of the EU NanoSafety cluster, so when we have different events we advertise them and try to interact with different stakeholder communities,” continues Dr Prodanov.