What are the Life Cycle Environmental Impacts of Synthetic Diamond?

OUR RESEARCH
Synthetic diamond is conventionally produced via high-pressure high-temperature (HPHT) synthesis, while microwave chemical vapor deposition (MW-CVD) is also used but to a lesser extent. China dominates the global production of synthetic diamond. Life cycle assessment (LCA) is a method commonly applied to assess the environmental impacts of products. The product's entire life cycle (cradle-to-grave) or parts of its life cycle such as from raw material extraction to production (cradle-to-gate) can be included in an LCA. The purpose of this study is to assess the life cycle environmental impacts of synthetic diamond production via HPHT and MW-CVD synthesis, i.e., a cradle-to-gate LCA. Results are provided for the conventional production of 1 g diamond single crystals, < 1 mm, via HPHT and 1 g diamond layer via MW-CVD.

PRELIMINARY RESULTS
Preliminary results from the study indicate that the cemented carbide (WC-Co) parts required for the high-pressure apparatus and the metal solvent input constitute hotspots in the HPHT synthesis, while the required electricity constitutes a hotspot in the MW-CVD synthesis. Scenarios were constructed to assess the importance of the type of electricity mix applied in the production. This shows that the impacts are reduced by 3-8% and 51-92% in HPHT and MW-CVD production, respectively, when solar electricity is used instead of a Chinese electricity mix. Thus, changing the type of electricity applied in the production constitutes a large potential for improvement, especially for MW-CVD synthesis. The results from this study can be used in future full LCA studies, which then also include the use and waste treatment processes of the product under study.

Anna Furberg1*, Rickard Arvidsson1, Mikael Larsson2, Mats Zackrisson2, Kristin Fransson2, Sverker Molander1
1Environmental Systems Analysis, Chalmers University of Technology
2Research Institute of Sweden, RISE
*anna.furberg@chalmers.se

Climate change [kg CO₂ eq/g]

Terrestrial acidification [kg SO₂ eq/g]

Cumulative energy demand [MJ eq/g]