

Gallium Oxide: Building the future, one crystal at a time.

Electric vehicles are becoming more popular, but their supporting technology needs improvement. A key issue is the lengthy charging time, caused by the materials used. These materials are pushed to their limits and still don't meet expectations. Imagine if there was a material that could solve this problem and others, one with the ability to detect missiles or electrical discharges in daylight. Such a material could enable ultra-fast charging or support electric rails. This material is Gallium Oxide.

Gallium Oxide is a semiconductor. A semiconductor is a material that sits between a conductor and an insulator, allowing control over when electricity is transmitted. It works basically like a switch. Currently, semiconductors are made from very advanced materials. However, they are not perfect. Typically, semiconductors start to fail when the voltage is too high. They start to heating and don't allow as much electricity through as they could. Gallium Oxide, on the other hand, has the potential to fix this. It can handle far higher voltages without breaking down, meaning it could charge those electric vehicles much, much faster with less energy loss.

Despite its great characteristics, Gallium Oxide is very difficult and expensive to produce and manufacture on a large scale. The quality of the crystal matters enormously. Even a small imperfection at the atomic level (level smaller than the width of a hair!) can affect how well Gallium Oxide performs. This project aims to find a different way of producing Gallium Oxide, both more affordable and more manageable for large-scale production by growing it on Silicon Carbide using Pulsed Laser Deposition.

Gallium Oxide crystals need to be grown on a foundation material called a substrate. This project is using silicon carbide, which is much better at conducting heat and offers a better quality of the grown Gallium Oxide. However, Silicon Carbide and Gallium Oxide have a different crystal structure. This causes strain in the grown Gallium Oxide material. It is like trying to lay two different puzzle pieces on top of each other. The patterns won't align, so you would need to shove it in place. As a result, this crystal needs to be grown under very specific conditions, with all possible variables set to perfection so it grows well together.

The crystal is grown using a pulsed laser directed at powdered puck of Gallium Oxide. The laser strikes the Gallium Oxide, creating a cloud of particles that then rise and build a layer

on top of the substrate. For this to work, several conditions must be precisely controlled. These include the chamber pressure, the distance between the laser and the powder puck, the laser energy, and the temperature. Too much or too little of any of these can cause the crystal to grow poorly, grow at very slow rates or not grow at all.

If made perfectly, Gallium Oxide can be applied to a wide range of subjects. It can enable ultra-fast charging for electric vehicles, help manage enormous voltages involved in power transmission, support electric rail systems, and power data centres. Its ability to detect ultraviolet light while ignoring visible light makes it a candidate for monitoring faults on power lines and even for military sensors capable of tracking missiles in broad daylight.

All of this, for now, begins at the laboratory of NanoLund in Lund, Sweden, where a student is experimenting with Gallium Oxide crystals, one variable at a time, hoping to grow this extraordinary material and transform the world of semiconductors the way we know it now.