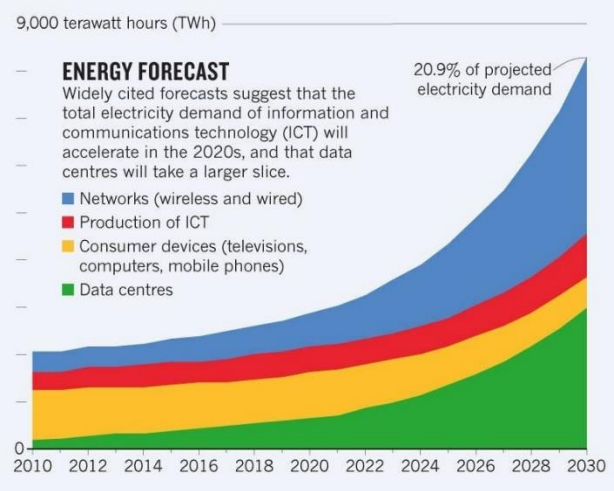
Complex Vanadate Thin Films for Next Generation Low-Power Electronic Devices

Supervisor:	Assoc. Prof. Henrik H. Sønsteby
Preferred background:	Students on the "Renewable Energy and Nanotechnology" program (3rd year bachelor's or master students), or chemistry students with specialization in inorganic chemistry. Some background in thin film deposition techniques would be preferred.
Number of available projects:	2 (working on similar chemistry as a team).
Preferred project period:	June – August 2025, preferably during the summer vacation when access to relevant infrastructure is easier. The project supervisor will be active at the department for most of the period, and available for supervision throughout the project.

Short description:

With the semiconductor industry getting close to the inherent limits of conventional silicon technology, there is a strong interest in designing and implementing new materials that can push and move the field beyond Moore's law. A range of different strategies show great promise, including the use of complex oxides to enhance existing functionalities or generate completely new ones.

Pertinent is also the accelerating energy cost of the information- and communication technology (ICT) sector. ICT currently uses 6-7 % of the world's energy production, but with the increasing demand of data centers and the rapid scaling of AI, this is expected to grow to 20+% by 2030, and with no signs of slowing down.



A. Andrae et. al., figure from https://www.datacenterfrontier.com/sponsored/article/21545695/power-efficiency-and-sustainability-trends-the-data-center-is-evolving-are-you (Dec 24)

At the thin films subgroup of NAFUMA at the Chemistry Department, we work closely with relevant electronics industry to develop new materials systems that can overthrow the silicon hegemony and offer new low-power electronics. Currently, materials exhibiting memristive effects (non-volatile changes in resitivity as a function of applied field) are of great interest, with theoretical savings of 99 % as the switching threshold voltage is lowered by several orders of magnitude. We have already studied several such materials systems in the group but are continuously probing new ones to obtain a large and versatile toolbox for different applications.

In this project, we are looking to explore a rather elusive materials system: The rare earth vanadates ($ReVO_{4-x}$). These are highly interesting in memristive devices, due to redox mechanisms on vanadium sites that significantly alter the electrical functionality. In sandwich with a different oxygen acceptor with a different band structure, it is likely that the vanadates may provide memristive functionality when applying an external field. We are also considering the possibility of incorporating a ferroelectric that can store the field information by its inherent polarization, which would be a starting point for co-location of computing and storage devices.

The project that the summer students will take on is to develop atomic layer deposition processes for vanadium oxide and relevant rare-earth vanadates. Tasks will be:

- Develop ALD process for V_2O_5 using known precursor combinations.
- Employ the new V_2O_5 process together with known processes for rare-earth oxides, such as La_2O_3, Nd_2O_3 and TbO_x to form lanthanum-, neodymium and terbium vanadate.
- Test the electronic properties of vanadium oxide and the rare earth vanadates by temperature controlled 4-point probe resistivity measurements.

If time:

- Co-deposit the rare earth vanadates in a sandwich structure with other complex oxides known in the group, such as $(Hf,Zr)O_2$ and $LaNiO_3$, to explore the possibility of storing resistivity values and thus creating a simple multi-level logic device.

The project is created so that each step is important and carries significant own-value. I.e. the risk of not getting important and valuable results is very low.