<u>Popular Science Summary:</u>

Topology Optimization Approaches for Nanophotonic Applications

In a world increasingly hungry for data, finding energy-efficient ways to transfer all that information is crucial. The main reason for the low energy efficiency in current communication systems is powering the electronic components with electricity. Instead of electricity, using light as the energy source of these electronic parts would massively reduce energy loss in communication systems. This is where a field of science called nanophotonics comes into play, studying how light moves and interacts with materials on a super small scale. This thesis delves into designing nanophotonic devices, even smaller than human hair, to manipulate light in unique ways and improve the efficiency of future communication systems.

The main tool in this research for designing such nanophotonic devices is called topology optimization. Think of it as a smart way to figure out what your device should look like to achieve optimal performance. Instead of arbitrary guessing, topology optimization uses advanced mathematics to determine the best device shape for efficiently solving the design problems at hand. And the cherry on top: this design method is not just theoretical; it also takes into account the real challenges of manufacturing these extremely small devices.

This thesis demonstrates the versatility of topology optimization in three ways. Firstly, it explores the limits of how much we can enhance the interaction between light and matter. Secondly, it seeks to develop new topology optimization approaches to tackle complex design problems related to applications that aim to integrate more light-powered devices into communication systems. Finally, it focuses on how topology optimization can incorporate cutting-edge fabrication techniques to improve ways of manipulating light.