Detection and analysis of ultrafine particles using Self Mixing Interference

The aim of this MSc graduation project, carried out at Philips Research, was to test if it is possible to detect particulates smaller than 100nm using laser self mixing interferometry with a vertical-cavity surface emitting laser-diode as source. The technology and hardware were available at the start of this research, but it was unknown if it was able to detect ultrafine particles. For this reason, a controllable environment was built to test the hardware. Particle size, concentration and velocity are controllable within this environment. In addition, a detection algorithm software is written and optimized. As a result, the sensor is found to be capable to detect particles down to 60nm.

The detection algorithm is based on applying a threshold value in both the time and frequency domain. By applying a threshold in the time domain first and only continue to the frequency domain when this threshold is surpassed, the CPU time is decreased by 97% at the cost of 17% count rate. The threshold values are optimized to minimize false positives, minimize CPU time and maximize count rate. This resulted in a sensor with the highest possible count rate, 0% false positives and the ability to work in real-time when used with the optimized algorithm. The count rate for a heavily polluted environment (400,000 particles per cm^3) is approximately 110 particles per second. For every particle that is detected per second, 0.1 second in CPU time is needed, meaning the algorithm can only work real-time when the count rate is 10 or lower. In order for the algorithm to fully work real-time, either the hardware or the software has to be improved, which is not within the scope of this thesis.