Bacterial infections have a large impact on the health of the general public, however individuals with cystic fibrosis (CF) are immensely susceptible to acquire pulmonary infections with environmental bacteria, viruses and fungal species. Ultimately pulmonary infections are the major cause of morbidity and mortality in CF patients. The genetic defect of CF patients alters the environment of the airways aiding P. aeruginosa to persist and establish chronic infections. Chronic P. aeruginosa infections in CF patients are characterized by conversion to a mucoid and intensive biofilm formation. Different microenvironments within the airways of the patients lead to phenotypic and genotypic diversification, sculpting the bacteria to become an efficient colonizer despite the environmental niche in the CF airways. Despite intensive antibiotic treatment and a profound immunologic response, the infections persist. The ongoing polymorphonuclear leukocyte (PMN) immune response contributes to the generation of oxygen changes in the CF airway environments in a major way. P. aeruginosa is capable of growing in anoxic environments which makes it capable of adapting to different niches of the airways, while the ongoing immune response gradually leads to pulmonary deterioration. Physiologically different oxygen environments are present in the different compartments of the CF airways and this has a profound impact on bacterial growth and the effect of chemotherapeutics to eradicate the bacteria.

Several in vivo and in vitro model systems are available to study CF associated bacterial infections. In vivo systems like the widely used mouse model primarily lack essential CF related traits as the development of the significant spontaneous lung disease. In vitro systems like the flow cell system has proven essential aspects on biofilm formations, however generates highly artificial biofilms that lack several CF airway scenarios.

The driving force and the heart of this project has its origin in the study of the role played by P. aeruginosa in the CF airways. One of the aims of this thesis was to develop an accurate tool for growing biofilms that can mimic the cystic fibrosis airways, emulating one of the most important characteristics of the human airways, the oxygen environments. Microfluidic approaches that allow biofilm formation under controllable oxygen concentrations, and furthermore enable migration between the individual compartments, are proposed in this thesis. An approach to mimic the accumulation of thickened mucus that supports biofilm growth in a 3D matrix within the CF airways is furthermore proposed.

The use of our already set flow cell systems was extended to another biofilm forming S. cerevisiae. The potential positive impact that the flow cell system can have on studies with other fungal species as the opportunistic pathogens, A. fumigatus or C. albicans, is without a doubt highly relevant.

The presented microfluidic systems are in line with the thought of developing in vitro systems to obtain optimal conditions for CF research, replace animal models and reduce chemicals used.