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This book presents a modern introduction of PDE constrained optimization. It provides a precise functional analytic treatment via optimality conditions and a state-of-the-art, non-smooth algorithmical framework. Furthermore, new structure-exploiting discrete concepts and large scale, practically relevant applications are presented. The main focus is on the algorithmical and numerical treatment of PDE constrained optimization problems on the infinite dimensional level. A particular emphasis is on simple constraints, such as pointwise bounds on controls and states. For these practically rrnportant situations, tailored Newton- and SQP-type solution algorithms are proposed and a general convergence framework is developed. This is complemented with the numerical analysis of structure-preserving Galerkin schemes for optimization problems with elliptic and parabolic equations. Finally, along with the optimization of semiconductor devices and the optimization of glass cooling processes, two challenging applications of PDE constrained optimization are presented. They demonstrate the scope of this emerging research field for future engineering applications.