6 Conclusions

In this thesis the continuum dislocation theory has been used and developed for modeling of microstructures. Both linear and nonlinear theory are applied into specific approaches. In the first approach we have shown that there exists a sequence of piecewise constant plastic distortions reducing the energy of the relaxed state of the bent beam and exhibiting the polygonization. We mention that the theory developed above does not provide any information about the kinetics of polygonization, which may be quite complicated due to the temperature-dependent dislocation climb and due to the interaction between dislocations and vacancies. Thus, for the kinetics of polygonization the knowledge about dissipation due to the dislocation climb becomes unavoidable.

Moreover, the one-dimensional theory of bending of a single crystal beam taking into account continuously distributed dislocations has been developed. The threshold bending moment exhibiting the size effect has been found for the case without and with dissipation. We have found also the dislocation density and the moment-curvature curves at loading and unloading. Furthermore, we have shown that there exists a sequence of piecewise constant plastic distortions and piecewise linear displacements reducing the energy of the annealed and relaxed state of the bent beam and exhibiting the polygonization. We mention that the theory developed above does not provide any information about the kinetics of polygonization, which may be quite complicated due to the temperature-dependent dislocation climb and due to the interaction between dislocations and vacancies.

The second approach have we developed the nonlinear CDT for crystals with dislocations and with grain boundaries regarded as the surfaces of weak discontinuity in placement but strong discontinuity in plastic slip. The whole set of equilibrium equations, boundary conditions and jump conditions are derived from the energy minimization problem. We have shown on the examples of crystals deforming in simple shear or in uniaxial compression that the formation of grains with piecewise constant plastic slip and elastic deformation satisfies all equilibrium conditions and provides the energy minimizing sequences to these non-convex variational problems. In case the homogeneous states are
not rank-one connected, the whole set of jump conditions is needed to find the elastic rotation and the plastic slip leading to the energy minimizing sequences. Let us mention that the modification of the surface energy density depending on the misorientation angle in accordance with Read-Schockley’s energy would make the theory more suitable for low angle tilt boundaries.

In future works, we would like to applied these theories into more general cases which can explain and understand clearly the formation of microstructures.