



**G. Gottstein · D. A. Molodov (Eds.)**

# Recrystallization and Grain Growth

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# Recrystallization and Grain Growth

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# Preface

During heat treatment of crystalline solids recrystallization (ReX) and grain growth (GG) are the major processes that modify the granular microstructure besides phase transformations. Owing to their strong impact on material properties and subsequent processing these phenomena have been extensively investigated in the past with the first publication on ReX dating back to 1881, i.e. more than 100 years ago and at the same time Lord Kelvin (then Sir William Thompson) studies soap froth to determine curved interfaces and optimum position of space.

A huge amount of data has been collected in particular on *ReX&GG* of commercial alloys, and the fundamental underlying phenomena have been identified. Nevertheless, despite of all these efforts, there remains a substantial lack of understanding of the essential mechanisms of ReX and GG. This is mainly due to two reasons:

- a) *ReX&GG* are not equilibrium phase transformations and, therefore, do not comply with equilibrium thermodynamics. Rather they are microstructural instability phenomena and, therefore, subject of reversible thermodynamics in terms of entropy production.
- b) Instability phenomena proceed from locations which are untypical for the average microstructure of the material. In fact homogeneous microstructures strongly resist recrystallization and markedly slow down grain growth. The crucial microstructural features for nucleation of recrystallization have, in principle, been identified but their mechanisms are not understood. Equally the growth of recrystallized or coarsening grains are commonly perceived as grain boundary motion in a homogeneous environment, which may be far from the truth. Only very recently it was demonstrated that in connected grain boundary systems there are also other microstructural elements that may play an essential role, like grain boundary junctions which are comparable in number to the frequency of grain boundaries. Another issue is the entire negligence of the role of internal stresses on nucleation of recrystallization and grain boundary migration, and until recently, high angle grain boundaries were tacitly assumed not to couple with mechanical stresses at all and, therefore, to remain unaffected by internal stresses except for the stored dislocation energy acting as thermodynamic driving force for recrystallization.

Owing to an insufficiently deep understanding of *ReX&GG* and, therefore, the inability of making reliable predictions on microstructure evolution, in particular crystallographic texture, during heat treatment of deformed materials, this research field was essentially dormant for decades, and the collection of data bases rather than the development of predictive power was the guideline of materials producers.

In the beginning of the 1990's interest in this field was suddenly rekindled in particular due to the development of novel research tools, like high resolution

TEM, orientation mapping by EBSD, and computer simulation owing to the availability of high performance computers and new theoretical concepts of microstructure modeling.

Besides workshops and topical conferences like the RISØ International Symposium, International conferences on ReX and GG were initiated separately in Wollongong, Australia (1990) and Rome (1991), respectively. Conferences on ReX followed in San Sebastian, Spain (1992), Monterey, USA (1996), and Tsukuba, Japan (1999). The Rome conference on GG was succeeded by ICGG-2 in Kitabyushu, Japan (1995) and ICGG-3 in Pittsburgh, USA (1998).

While the ReX conferences were more strongly oriented towards applications, the GG conferences focussed on the scientific aspects of the evolution and behavior of granular microstructures. The complementarity of both approaches attracted essentially the same core audience so that both conference series decided not to merge but to have a joint conference with common sessions of general interest and specific topical sessions on the core issues of both conference series. The contributions to these proceedings are the manuscripts presented in both conferences and are designed to provide both, a general but comprehensive review and detailed information on current research in *ReX&GG*.

We hope the reader will find valuable information to guide his own work or to acquaint him with new concepts and modern issues in *ReX&GG*.

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Aachen, August 2001

# Recrystallization

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