



# Hot Deformation and Processing of Aluminum Alloys (Manufacturing Engineering and Materials Processing)

By Hugh J. McQueen, Stefano Spigarelli, Michael E. Kassner, Enrico Evangelista

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A comprehensive treatise on the hot working of aluminum and its alloys, **Hot Deformation and Processing of Aluminum Alloys** details the possible microstructural developments that can occur with hot deformation of various alloys, as well as the kind of mechanical properties that can be anticipated. The authors take great care to explain and differentiate hot working in the context of other elevated temperature phenomena, such as creep, superplasticity, cold working, and annealing. They also pay particular attention to the fundamental mechanisms of aluminum plasticity at hot working temperatures.

Using extensive analysis derived from polarized light optical microscopy (POM), transmission electron microscopy (TEM), x-ray diffraction (XRD) scanning electron-microscopy with electron backscatter imaging (SEM-EBSD), and orientation imaging microscopy (OIM), the authors examine those microstructures that evolve in torsion, compression, extrusion, and rolling. Further microstructural analysis leads to detailed explanations of dynamic recovery (DRV), static recovery (SRV), discontinuous dynamic recrystallization (dDRX), discontinuous static recrystallization (dSRX), grain defining dynamic recovery (gDRV) (formerly geometric dynamic recrystallization, or gDRX), and continuous dynamic recrystallization involving both a single phase (cDRX/1-phase) and multiple phases (cDRX/2-phase).

A companion to other works that focus on modeling, manufacturing involving plastic and superplastic deformation, and control of texture and phase

transformations, this book provides thorough explanations of microstructural development to lay the foundation for further study of the mechanisms of thermomechanical processes and their application.

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## **Editorial Review**

### **About the Author**

**Hugh J. McQueen** is professor emeritus of materials and manufacturing in mechanical engineering at Concordia University and has served one term as the department chair. Since 1965, he has been conducting hot working research in industrial alloys of Al, Cu, Ni and Fe with special emphases on Al alloys and composites and on stainless steels. He has broadened his experience with sabbatical leaves at Comalco and BHP Research Centers (Melbourne), Norwegian Institute for Technology (Trondheim), Universities of Ancona, Erlangen-Nürnberg and Hamburg-Harburg. Professor McQueen also has taught undergraduate and graduate courses in mechanical properties and forming technology and has produced a short film on Dislocations. Before coming to Concordia in 1968, he had conducted research at CANMET and been associate professor at Ecole Polytechnique, Montreal. In 1961, he obtained his Ph.D. in Metallurgy from Notre Dame University (Indiana), following a B.Eng from McGill University in 1956 and a B.Sc from Loyola of Montreal in 1954. He is a fellow of Canadian Institute of Metallurgy, the Institute of Metals, Materials and Minerals the American Society for Metals and of the Canadian Society for Mechanical Engineering. In 2000, he received the Alcan Award in recognition of research and education contributions. From 1986 to 1998, Dr. McQueen served the Metallurgical Society CIM as a member of the Board and as chairs of the Microstructural Science Section and of the Metal Fabrication Section. He organized the International Conference on Strength of Metals and Alloys in Montreal in 1985 and served on its advisory council.

**Prof. Stefano Spigarelli** has been a professor of metallurgy on the engineering faculty at Università Politecnica delle Marche, Ancona, Italy, since April 2005. His research activity is mainly focused on the high-temperature mechanical properties of light metals and steels. His current interests include creep and hot working of steels and aluminium and magnesium alloys, as well as the characterization of nanostructured coatings and the study of non-conventional welding processes and cryogenics treatments. His worldwide scientific collaborations have led to numerous joint publications co-authored by scientists from Japan, Korea, Norway, Israel, Russia, United States and Czech Republic. He has author or co-authored more than 150 published articles and serves as reviewer for several International Journals. Professor Spigarelli is member of Italian Association of Metallurgy (AIM).

**Prof. Michael Kassner** is director of research at the Office of Naval Research. He assumed the position in October 2009, while on leave from the University of Southern California, where he was made chairman of the mechanical and aerospace engineering department in 2003, as well as a professor of mechanical engineering and materials science. He graduated with a B.S. in Science-Engineering from Northwestern University in 1972, and an M.S. and Ph.D. in materials science and engineering from Stanford University in 1979 and 1981, respectively. Kassner worked at Lawrence Livermore National Laboratory from 1981 to 1990. During that period, he was head of the physical metallurgy and welding section and performed basic research on the mechanical behavior of metals. In 1984, he spent a year on leave as a Fulbright Senior Scholar at the University of Groningen in The Netherlands. In 1990, Kassner accepted a faculty position in the mechanical engineering department at Oregon State University, where he was Northwest Aluminum Professor of Mechanical Engineering, and director of the interdisciplinary Ph.D. program in materials

science. Prof. Kassner is currently active in pursuing research at USC on creep, fracture, fatigue and thermodynamics and has published two books?one on the fundamentals of creep plasticity in metals and another on phase diagrams. He has also authored or co-authored more than 200 published articles. He serves on several editorial and review boards for major scientific journals and is a Fellow of American Society of Metals (ASM), a Fellow of the American Society of Mechanical Engineers (ASME) and a Fellow of the American Assoc. for the Advancement of Science (AAAS).

**Enrico Evangelista** is an Emeritus Professor of Metallurgy in Mechanical Engineering at Polytechnical University of Ancona, Italy. He started research on high-temperature internal friction behavior of pure and low-alloyed aluminum at University of Bologna. During a sabbatical, (1980) at Concordia University (Montreal), as visiting research associate, he was introduced to hot deformation of industrial alloys. During subsequent years, he was served as visiting professor at Universities of Trondheim (Norway), Oregon State (USA), Chiba (Japan), and Pohang, (Korea). In the hot working field, he provided practical advice to Italian industry. At University of Ancona, where he became professor of metallurgy in 1983, he created a research group devoted to deformation behavior of metals investigated by means of hot torsion and creep tests. He studied numerous experimental and industrial aluminum alloys and composites, magnesium and titanium alloys, as well as low alloy, stainless and duplex steels. The mechanical behavior was clarified through microstructural investigation by TEM. Professor Evangelista has coauthored more than 250 published papers and is a fellow of ASM. He is also a member of the European Academy of Sciences (EAS) and THERMECT 2011 Distinguished Award recipient.

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