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CRYOCOOLERS 18

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Preface

The objective of *Cryocoolers 18* is to archive the latest developments and performance measurements in the field of cryocoolers by drawing upon the work of leading international experts. In particular, this book is based on the 76 peer reviewed manuscripts that were prepared for the 18th International Cryocooler Conference held in Syracuse, New York, on June 9-12, 2014. Although this is the eighteenth meeting of the conference, which has met every two years since 1980, the authors' works have only been made available to the public in hardcover book form since *Cryocoolers 8* in 1994.

Starting with *Cryocoolers 14*, we began publishing the series of *Cryocoolers X* books in-house at ICC Press using all-electronic manuscripts and digital printing. This has allowed us to also include a CD of the book's contents, in color, within the back cover of each book. Also, consistent with the trend toward instant electronic access to important technical works, color PDFs of each contribution in the book are available over the internet via the "past proceedings" link on the ICC web site http://www.cryocooler.org.

Because the book's content is designed for users of cryocoolers as much as for developers of cryocoolers, extra effort has been made to provide a full-text search capability on the CD and web site. Within the book itself, a thorough Subject Index covers the referenced cryocoolers by type and manufacturer's name, as well as by the scientific or engineering subject matter. Contributing organizations are also listed in the Subject Index to assist in finding the work of a known institution, laboratory, or manufacturer. To aide those attempting to locate a particular contributor's work, a separate Author Index is provided, listing all authors and coauthors.

Prior to 1994, proceedings of the International Cryocooler Conference were published as informal reports by the particular government organization sponsoring the conference — typically a different organization for each conference. A listing of previous conference proceedings is presented in the Proceedings Index, at the rear of this book. Most of the previous proceedings were printed in limited quantity and are out of print at this time.

The contents of *Cryocoolers 18* is organized into 15 chapters, covering the various types of cryocoolers and their applications. At the beginning is a chapter on multistage cryocoolers to provide low-temperature cooling in the 4-40 K temperature range for space and military applications. This is followed by three chapters covering single-stage regenerative cryocoolers (small, medium and large capacity) for the common 50-80 K temperature range. Following them are chapters on regenerative-cooler modeling and performance investigations, and on associated regenerator, compressor, and drive electronics research.

Following the chapters on regenerative cryocooler technologies, two chapters cover recuperative cryocoolers, including Joule-Thomson, Sorption, and Brayton cryocoolers, and a chapter is included on unique sub-Kelvin, thermoelectric, and novel refrigerators. Applications requiring sub-Kelvin temperatures include space bolometers and x-ray sensors, and ground-based sensors in materials research, nuclear research, quantum materials research, quantum information technology, metrology, astronomy, and scanning tunneling microscopy (STM).

The last three chapters of the book deal with integration technologies such as use in liquefaction and zero-boil-off systems, lessons learned in representative applications, and product

reliability studies. These articles contain particularly useful information for the potential user of cryocoolers as well as for the developer.

In reviewing the contributions contained in *Cryocoolers 18*, we note the continued strong interest in the development of pulse tube cryocoolers for a growing variety of long-life, high-reliability cryocooler applications. Pulse tube coolers can be driven by several competing compressor technologies. One class of pulse tube coolers is referred to as "Stirling type" because they are based on the linear Oxford Stirling-cooler type compressor; these generally provide cooling in the 10 to 100 K temperature range and operate at frequencies from 30 to 100 Hz. A second type of pulse tube cooler is the so-called "Gifford-McMahon or GM-type." Pulse tube coolers of this type use a GM-type compressor and lower frequency operation (~1 Hz) to achieve temperatures in the 2 to 10 K temperature range.

Also of note, is the significant number of very small (micro coolers) and very large (multi-kilowatt coolers) entering the marketplace...these expand the available operating capacity range to over three orders of magnitude!

Example applications of cryocoolers include sensors for tiny CubeSat satellites, space infrared sensors for large space instruments, precooling for cryogen-free sub-Kelvin applications, cooling of HTS and LTS superconducting magnets and electronics, and helium and hydrogen liquefaction and control of cryogen boil-off. In fact, an entire chapter in *Cryocoolers 18* is devoted to cooler developments for liquefaction and zero-boil-off applications aimed at minimizing losses from liquid helium and hydrogen stored cryogen systems.

In summary, it is hoped that this book will serve as a valuable source of reference to all those faced with the challenges of taking advantage of the enabling physics of cryogenics temperatures. The expanding availability of low-cost, reliable cryocoolers continues to enable major advances in a number of fields.

The Editors