

Cryocoolers 16 Preface

The objective of *Cryocoolers 16* 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 their contributions at the 16th International Cryocooler Conference that was held in Atlanta, Georgia, on May 17-20, 2010. The program of this conference consisted of 116 papers; of these, 89 are published here. Although this is the sixteenth 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 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 from the University of Wisconsin web site: <http://conferences.library.wisc.edu/icc> or via the 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 content of *Cryocoolers 16* 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 1-30 K temperature range for space applications. This is followed by a chapter on GM-based cryocoolers for low temperature (4-30K) ground applications. These two low-temperature chapters are then followed by three chapters covering single-stage regenerative cryocoolers (small, medium and large capacity) for the common 50-80K temperature range. Following them are chapters on regenerative-cooler modeling and performance investigations, and on associated compressor and regenerator research.

Following the chapters on regenerative cryocooler technologies, two chapters cover recuperative cryocoolers, including Joule-Thomson and Sorption cryocoolers, and unique sub-Kelvin, magnetic, and novel refrigerators.

The last four chapters of the book deal with integration technologies, cryocooler drive electronics, and experience to date in a number of representative space and commercial applications. 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 16*, we note the continued strong interest in the development of pulse tube cryocoolers for a growing variety of long-life, high-reliability cryocooler applications. These range in cooling power from less than a watt to over a kilowatt. In total, nearly half of this proceedings covers new developments in the pulse tube arena.

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 60 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. A third type of pulse tube cooler is driven by a thermoacoustic oscillator, a heat engine that functions well in remote environments without electricity.

Example applications of pulse tube cryocoolers include, space infrared sensors, hydrogen liquefaction, cooling of HTS and LTS superconducting magnets and electronics, control of cryogen boil-off, and precooling for cryogen-free sub-Kelvin applications.

Several papers describe cooler developments for these sub-Kelvin temperatures, i.e. temperatures below 1 K. 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).

In the higher temperature markets, pulse tube and Stirling coolers are complemented by closed-cycle J-T or throttle-cycle refrigerators that take advantage of mixed refrigerant gases to achieve low-cost systems in the 65 to 80 K temperature range. Most of the papers in this area are focused at microcoolers for on-board chip cooling for micro-scale electronics applications.

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