

Preface

The idea to write a new book in the field of ferroelectric crystals arose from some considerations reported in the following. In the last 5 years, several groups all around the world in the field of engineering and characterization of ferroelectric crystals have published more than 300 papers. The motivation for such an intense research activity is referable to the fact that the ferroelectric crystals are a key element for the most attractive and useful photonic and optoelectronic devices. In fact, during the 60ies, the scientists realized that the ferroelectric crystals could have been efficiently used to generate new, unavailable frequencies, taking advantage of the freshly proposed birefringent phase-matching method. The synchronized rush for the development of novel coherent sources and for the discovery of the best-suited nonlinear crystals for mixing and generation had started. Consequently, the range of applications of ferroelectric crystals has enormously widened in the last years, especially based on the use of periodically poled structures (i.e., PPLN, PPLT, PPKTP, or PPKTA) to quasi-phase-match optical interactions. A new generation of sources is finding increasing applications in various fields, including high sensitivity trace gas monitoring and any kind of advanced spectroscopic set-ups, thus replacing “old style” gas lasers like Argon-ion or dye lasers. New possibilities are also being explored to engineer ferroelectric crystals with two- or three-dimensional geometries. Results from this field will allow developing photonic devices combining photonic band-gap properties and nonlinear conversion processes, i.e., nonlinear photonic crystals.

Moreover new micro-devices have been developed and built, based on domain-engineering processes, for telecom or sensing applications (filters, ring resonators, whispering gallery mode based sensing devices, etc.). Other interesting and emerging topics are growing rapidly, and one of the most promising is related to the possibility of fabricating structures on micrometre and/or nanometre scale in ferroelectric crystals in order to realize photonic band-gap devices. Several papers appeared on this subject presenting different fabrication approaches (i.e., e-beam processing, poling by atomic force microscope scanning and interference lithography, and subsequent electric poling). Many new configurations for photonic devices would become possible taking advantage of the photonic band-gap related physics with two- and three-dimensional geometries. The appeal of ferroelectric crystals for similar applications also arises from the additional properties they exhibit, e.g., electro-optic, piezoelectric, pyroelectric effects, with respect to other materials, thus making possible unique performances.

Simultaneously several papers appeared during the last years in the most authoritative journals, where new characterization methods have been developed and pro-

posed to investigate the basic properties of ferroelectric crystals (optical microscopy, interferometric, scanning probe microscopy, X-ray diffraction, etc.). Specific methods and procedures have been invented to investigate the structures during the engineering process as well as after the fabrication and while operating into the photonic and optoelectronic devices.

The aim of the present volume is definitely to give an up-to-date source of information in this scientific and technological field of increasing interest and not covered yet by other books. The book gathers the latest achievements in the field of ferroelectric domain engineering and characterization at micron and nano scale dimensions and periods. The results obtained in the last years by the main scientific groups all over the world recognized as the most experts in this area are presented in this book, thus providing, we hope, a valid and precious overview on the last developments and moreover on the future innovative applications of those engineered materials in the field of photonics, for scientists working in this area. The text is aimed at researchers and PhD students who wish to be introduced rapidly in the last achievements in the field of material processing and photonic applications of ferroelectric materials.

The book is organized in 15 chapters grouped into three parts: *Fabrication*; *Characterization*; *Applications*. The first part focuses on the development of advanced methods for micron- and nano-scale engineering of ferroelectric crystals, while the second one deals with the most widely used techniques for the characterization of material and engineering related properties of the crystals. The last part provides an overview of the most important current and future applications of the new ferroelectric structure devices in the field of photonics.

Pozzuoli, August 2008

*Pietro Ferraro
Simonetta Grilli
Paolo De Natale*

Ferroelectric Crystals for Photonic Applications
Including Nanoscale Fabrication and Characterization
Techniques

Ferraro, P.; Grilli, S.; De Natale, P. (Eds.)

2009, XVIII, 424 p., Hardcover

ISBN: 978-3-540-77963-6