

Contents

1	Fundamentals of Focal Plane Arrays	1
1.1	History and Trends of Infrared Imaging Detectors	1
1.2	Introduction to Advanced FPAs of HgCdTe and AlGaIn	5
1.2.1	Outline	5
1.2.2	Improving DRI Range by High Spatial and Temperature Resolutions	7
1.2.3	Improving DRI Range by Multiband Imaging	13
1.2.4	Improving Compactness and Intelligence by Integrated Processing Chip	16
1.3	Summary	16
	References	16
2	Design Methods for HgCdTe Infrared Detectors	17
2.1	Introduction	17
2.2	Simulation and Design of HgCdTe Infrared Detectors	18
2.2.1	Foundation for HgCdTe Infrared Detector Designs	18
2.2.2	Design of Heterojunctions HgCdTe Infrared Detectors	31
2.2.3	Design of Long Wavelength HgCdTe Detectors	42
2.2.4	Design of Two-Color HgCdTe Detector	64
2.3	Methods of Extracting Parameters from HgCdTe Materials and Chips	83
2.3.1	Extracting Device Parameters by Electrical Method	83
2.3.2	Extracting Device Parameters by Photoelectric Method	99
2.4	Summary	114
	References	115
3	CdTe/Si Composite Substrate and HgCdTe Epitaxy	121
3.1	Introduction	121
3.2	Basic Models on Si-Based HgCdTe Epitaxy	122
3.2.1	Physical Model of Selective Growth on Si Surface (Mechanism of as Passivation on Surface)	123
3.2.2	Atomic Distribution Model of Si Substrate ZnTe/CdTe	133

3.2.3	Arsenic Impurity in MCT.	140
3.2.4	Amphoteric Doping Behavior of as in MCT.	154
3.3	HgCdTe Growth on Si by MBE	173
3.3.1	ZnTe/CdTe Grading Buffer on Si by MBE.	173
3.3.2	HgCdTe Growth on Large-size Alternative Substrates	189
3.3.3	Extrinsic Doping in HgCdTe by MBE.	197
3.4	Si-Based HgCdTe LPE Technology.	219
3.4.1	The Surface Treatment of CdTe/Si Composite Substrate	221
3.4.2	LPE Process Optimization	224
3.4.3	Basic Properties of HgCdTe LPE Materials	227
3.4.4	Remaining Issues and Analysis.	236
3.5	Thermal Stress of Si-Based HgCdTe Materials	239
3.5.1	Spectral Characteristics of Si-Based HgCdTe Materials . . .	240
3.5.2	Theoretical Analysis of Stress of Multilayer Structure Materials	245
3.6	Summary	254
	References	255
4	AlGaN Epitaxial Technology	265
4.1	Introduction	265
4.2	Basic Properties of GaN-Based Material and Preparation Techniques	266
4.2.1	The Basic Properties of GaN-Based Material and Its Use in Ultraviolet Detectors.	266
4.2.2	MOCVD Epitaxial Deposition System and In Situ Monitoring Method	268
4.3	MOCVD Epitaxial Growth Technique of AlGaN Material	279
4.3.1	AlGaN Epitaxial Technology on GaN Buffer Layer.	280
4.3.2	AlN Buffer Layer and AlGaN Epitaxial Technique	299
4.3.3	The P-Type Doping Technique of GaN Material.	318
4.4	Overall Performance Analysis of AlGaN Material	323
4.4.1	Effects on Optical and Electrical Properties of GaN Material from Dislocations	323
4.4.2	Measurement of Al Components in AlGaN and Determination of Its Strain State	328
4.4.3	Uniformity of AlGaN with High Al Component	334
4.4.4	Oxidation of AlGaN Materials	337
4.5	Summary	342
	References	343
5	HgCdTe Detector Chip Technology	351
5.1	Introduction	351
5.2	HgCdTe Detector Chip Processing Technologies.	354
5.2.1	Isolation Technology of HgCdTe Micro-Mesa Array	354

5.2.2	Micro-Mesa Photolithography	415
5.2.3	High-Quality Sidewall Passivation Technique of Micro-Mesa Arrays	418
5.2.4	Metallization of Micro-Mesa Array	426
5.2.5	Indium Bump Preparation and Hybridized Interconnection of Micro-Mesa Array	434
5.3	Two-Color Micro-Mesa Detector Chip	440
5.3.1	Selection of Two-Color Detector Chip Architecture	440
5.3.2	Fabrication of Two-Color HgCdTe Micro-Mesa Preliminary Detector	444
5.3.3	Simultaneous 128×128 Two-Color HgCdTe IRFPAs Detector	447
5.4	Si-Based HgCdTe Processing Technology	449
5.4.1	Stress Analysis and Structure Design of Si-Based HgCdTe	450
5.4.2	Low Damage Stress Chip Processing Technology of 3-Inch Si-Based HgCdTe Wafer	461
5.5	Summary	471
	References	473
6	Chip Technique of AlGaIn Focal Plane Arrays	477
6.1	Introduction	477
6.2	AlGaIn P-I-N Solar-Blind UV Detectors-Model and Design	478
6.2.1	Material Parameters of AlGaIn Thin Films	479
6.2.2	Response Model and Design of AlGaIn P-I-N Detector	479
6.3	AlGaIn Resonant-Cavity-Enhanced UV Detectors	487
6.3.1	The Basic Structure of Resonant-Cavity-Enhanced UV Detectors	489
6.3.2	Design and Fabrication of RCE Ultraviolet Detectors	491
6.4	AlGaIn Detector Chip Fabrication	498
6.4.1	Mesa Formation Technology	500
6.4.2	Passivation of the Chip	523
6.4.3	Ohmic Contact	524
6.5	Irradiation Effects of AlGaIn Ultraviolet Detectors	561
6.5.1	Proton Irradiation Effects	562
6.5.2	Electron Irradiation Effects	564
6.5.3	γ Irradiation Effects	570
6.5.4	Irradiation Hardening Study of the GaIn-Based UV Detectors	573
6.6	Imaging and Application of UV Focal Plane Assembly	582
6.6.1	Imaging of Quartz Tube Heated by Oxyhydrogen Flame	582
6.6.2	Imaging in Visible-Blind Waveband	583

6.6.3	Imaging of Outside Scene	584
6.6.4	Aerial UV Photographs of Oil on Sea Surface	584
6.7	Summary	585
	References	587
7	Readout Integrated Circuit, Measurement, and Testing	
	Technology for Advanced Focal Plane Array	595
7.1	Introduction	595
7.2	Introduction and Development for Readout Integrated Circuit	596
7.3	Dual-Band Readout Integrate Circuit	598
7.3.1	Conventional Topologies of a Dual-Band ROIC	600
7.3.2	The Proposed Topology for a Simultaneous Dual-Band ROIC	612
7.3.3	The Implementation of a Dual-Band Infrared ROIC and an Ultraviolet ROIC	616
7.4	Digital Transmission System on Chip for IRFPA.	632
7.4.1	The Architecture of the Digital System for IRFPA	633
7.4.2	Algorithms for the Implementation of ADC on the Focal Plane	638
7.4.3	Implementations for the ADC on Focal Plane	652
7.5	Measurement and Testing Technology for Focal Plane Array	678
7.5.1	Measurement of Parameters for Infrared FPA	679
7.5.2	Measurement of Parameters for Ultraviolet FPA	685
7.6	Summary	687
	References	688

Technology for Advanced Focal Plane Arrays of HgCdTe
and AlGaIn

He, L.; Yang, D.; Ni, G.

2016, X, 690 p. 620 illus., 299 illus. in color., Hardcover

ISBN: 978-3-662-52716-0