CONTENTS

Chapter 1 Introduction

1.1 Historical development ........................................ 3
1.2 Ultrasonic transducers ......................................... 7
  1.2.1 Ceramic Transducers ................................. 7
  1.2.2 Piezopolymer Transducers ......................... 8
  1.2.3 Radiated fields ....................................... 9
  1.2.4 Focusing ............................................. 9
  1.2.5 Sound levels and decibel scale .................. 9
1.3 Properties of transducer arrays ............................... 10
  1.3.1 Array gain ........................................ 11
  1.3.2 Shading and Superdirectivity ....................... 11
  1.3.3 Array Beamsteering ................................ 11
  1.3.4 Directivity index .................................. 11
1.4 Ultrasonic testing techniques ................................ 12
  1.4.1 Ultrasonic probes .................................. 12
  1.4.2 Through transmission technique .................. 12
1.4.3 Resonance Technique 13
1.4.4 Pulse echo technique 14
1.4.5 Modes of display 14
1.5 Motivation for the present work 14
1.6 Brief description of the present work 16

Chapter 2 Review of past work

2.1 Transducer design 20
2.2 PVDF transducers 24
2.3 Sound field 27
2.4 Pulsed transducers 29
2.5 High frequency transducers 30
2.6 Transducer arrays 31

Chapter 3 Methodology

3.1 Ultrasonic waves 36
   3.1.1 Compressional waves 37
   3.1.2 Shear waves 37
   3.1.3 Surface waves 38
   3.1.4 Plate waves 38
   3.1.5 Plane waves at solid liquid interface 39
3.2 Methods and instrumentation 42
   3.2.1 Design considerations 42
   3.2.2 Single crystal vertical (0°) probes 43
   3.2.3 Single crystal angle probe 44
   3.2.4 Transmitter receiver (TR) probes or twin probes 45
3.3 Ultrasonic testing techniques

3.3.1 Through transmission technique
3.3.2 Resonance Technique
3.3.3 Pulse echo method
3.3.4 Modes of display

3.4 Properties of transducer arrays

3.4.1 Array gain
3.4.2 Beam Pattern
3.4.3 Shading and Superdirectivity
3.4.4 Array beamsteering
3.4.5 Directivity index
3.4.6 Acoustic pressure field

<table>
<thead>
<tr>
<th>Chapter 4 Beam characteristics of annular ring and annular cylindrical arrays</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Inspection system</td>
</tr>
<tr>
<td>4.2 Crosscorrelation coefficients</td>
</tr>
<tr>
<td>4.2.1 Annular ring array</td>
</tr>
<tr>
<td>4.2.2 Annular cylindrical array</td>
</tr>
<tr>
<td>4.3 Array gain</td>
</tr>
<tr>
<td>4.4 Beam pattern</td>
</tr>
<tr>
<td>4.4.1 Annular ring array</td>
</tr>
<tr>
<td>4.4.2 Annular cylindrical array</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 5 Effective acoustic pressure of annular ring and annular cylindrical arrays</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Computation of effective acoustic pressure at a point</td>
</tr>
</tbody>
</table>
5.1.1 Multiple point source 76
5.1.2 Annular ring array 77
5.1.3 Annular cylindrical array 84
5.2 Impulse response 89
  5.2.1 Impulse response of a circular piston 90
  5.2.2 Impulse response of annular ring and annular cylindrical arrays 91
5.3 Transient response 92

Chapter 6 Conclusions
6.1 Highlights 95
6.2 Scope for further work 99

Appendix 1 Performance evaluation of (3,3) Mode PVDF transducer elements for
Ultrasonic NDE
A.1 Design 100
A.2 Measurement set-up 103
A.3 Reciprocity theorem 104
A.4 Reciprocity calibration 104
A.5 Results 105
A.6 Conclusions 106

References 113
Index 128
List of publications of the author 134
Reprints of journal papers published 135