



IBULE PHOTONICS

A world leader in the development of high performance piezoelectric single crystals and applications.



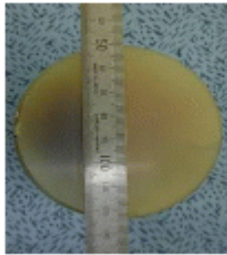
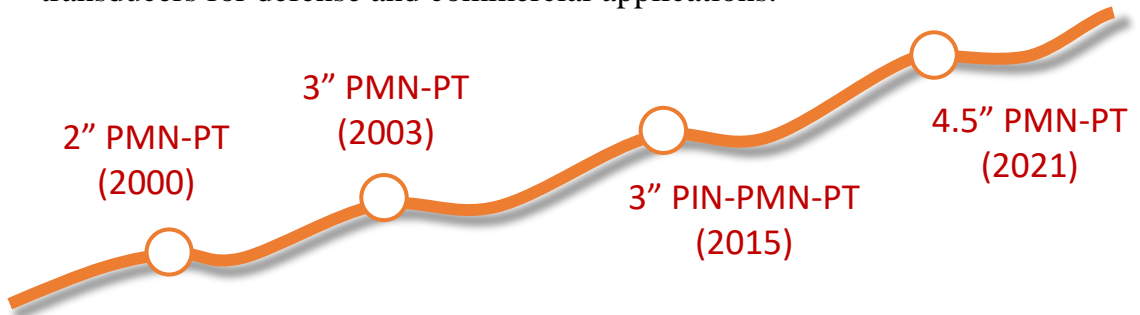
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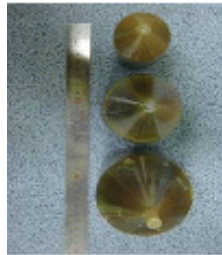
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Company and Products

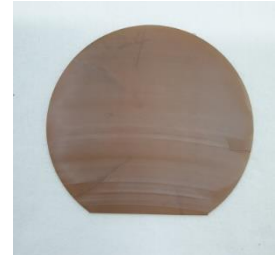
- Founded in 1999, iBULe Photonics had successfully developed the single crystal growing technology based on the Bridgman method, and is currently producing PMN-PT, PIN-PMN-PT and Mn:PIN-PMN-PT with [001], [011] and [111] growth directions in sizes up to 4.5" in diameter.
- iBULe is now a world leader in the development and manufacture of high-performance single crystals, and is rapidly expanding production capacities in order to provide customers with new opportunities for the next generation of transducers for defense and commercial applications.



1st Generation
PMN-PT



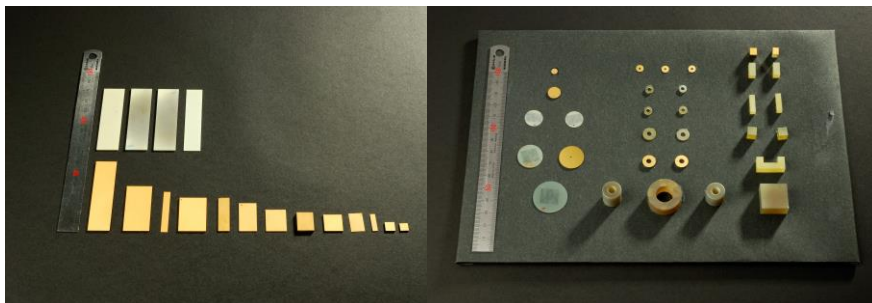
2nd Generation
PIN-PMN-PT



3rd Generation
Mn: PIN-PMN-PT

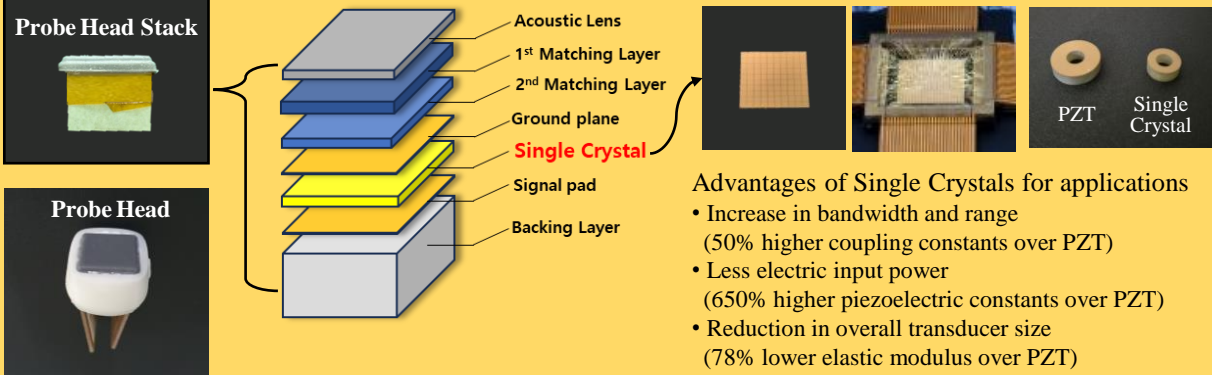
Commercialization

iBULe, with over 20 years of experience in single crystal growth and characterization, has commercialized producing various sizes of [001]-poled PMN-PT wafers for medical ultrasound imaging transducers.



Therapeutic & Diagnostic Ultrasound System

iBULe has developed a piezoelectric single crystal 2D array probe with integrated diagnostic and therapeutic functions, and built a portable system by merging it with a system board equipped with beamforming and 3D imaging function.



Probe Head Stack

- Acoustic Lens
- 1st Matching Layer
- 2nd Matching Layer
- Ground plane
- Single Crystal**
- Signal pad
- Backing Layer

Probe Head

PZT **Single Crystal**

Advantages of Single Crystals for applications

- Increase in bandwidth and range (50% higher coupling constants over PZT)
- Less electric input power (650% higher piezoelectric constants over PZT)
- Reduction in overall transducer size (78% lower elastic modulus over PZT)

Therapeutic & Diagnostic Ultrasound Probe : 2rd Generation Single Crystal



Serial Number	iBULe-S1	iBULe-S2
Element Pitch	1.05 mm	
Transverse Aperture	11 mm	
Number of elements	64 ch (8×8)	
Center Frequency	3MHz	2.5 MHz
Band Width	42%	63 %
Max Intensity	951 mW/cm ²	301 mW/cm ²
Lateral resolution	<4mm	<2mm

- High piezoelectric coefficient and bandwidth characteristics enable integration of therapeutic and diagnostic functions
- 2D phased array technology allows for 3D imaging
- Smaller size compared to same frequency PZT probes
- High acoustic strength and broad bandwidth models available depending on cell fabrication type

Therapeutic & Diagnostic Ultrasound System



Pulse type	Bipolar
Available pulse voltage	±60V
Frame rate	>5 Hz
Frequency	1~5MHz
Voltage Gain	30dB
High Pass Filter	75kHz (analog)
Low Pass Filter	10MHz (analog)
Size	350x250x75 mm ³

- Multi-dimensional, real-time diagnostic capabilities with 3D imaging
- Beam focusing capability for treatment during diagnosis
- Synthetic focusing enables multi-angle, high-resolution image acquisition
- Portable system operable with a laptop

Single Crystal Properties

1G: PMN-PT

Parameter	Units	[001] poled		[011] poled	
		Low-PT	High-PT	Low-PT	High-PT
$\epsilon_{33}^T/\epsilon_0$	–	4842	7000	3760	5770
d_{ij}	$\times 10^{-12}C/N$	$d_{33}=1282$	$d_{33}=1620$	$d_{32} = -1140$	$d_{32} = -1820$
s_{ij}^E	$\times 10^{-12}m^2/N$	$s_{33}^E=47$	$s_{33}^E=56$	$s_{22}^E=53$	$s_{22}^E=78$
Trt	°C	95	85	95	85
Ec	KV/cm	2	2.5	2	2.5
Density	kg/m^3	8080			

2G: PIN-PMN-PT

Parameter	Units	[001] Poled		[011] Poled	
		Low-PT	High-PT	Low-PT	High-PT
$\epsilon_{33}^T/\epsilon_0$	–	4457	5666	3449	4656
d_{ij}	$\times 10^{-12}C/N$	$d_{33}=1226$	$d_{33}=1840$	$d_{32} = -1323$	$d_{32} = -1870$
s_{ij}^E	$\times 10^{-12}m^2/N$	$s_{33}^E=49$	$s_{33}^E=79$	$s_{22}^E=72$	$s_{22}^E=99$
Trt	°C	120	90	120	90
Ec	KV/cm	4	6	4	6
Density	kg/m^3	8154			

3G: Mn : PIN-PMN-PT

Parameter	Units	[001] Poled	[011] Poled
		Middle-PT	Middle-PT
$\epsilon_{33}^T/\epsilon_0$	–	4583	3747
d_{ij}	$\times 10^{-12}C/N$	$d_{33}=1465$	$d_{32} = -1696$
s_{ij}^E	$\times 10^{-12}m^2/N$	$s_{33}^E=64$	$s_{22}^E=86$
Trt	°C	120~130	120~130
Ec	KV/cm	6~8	8~11
Density	kg/m^3	8220	

Unique piezo single crystal properties create opportunities for unprecedented system performance.