PZT and Crystal Composite

At Innovia, composite material is composed of PZT ceramic or PMN-PT, PIN-PMN-PT crystal and epoxy. Compared with pure ceramic and crystal transducers, composite material based transducer has several advantages:

1) Increased sensitivity
2) Broader bandwidth
3) Improved impedance match
4) Reduced cross-talk

Innovia offers both 1-3 or 2-2 type dice-and-fill composite. Composite products are highly customizable. Wide options of properties are available, including thickness, fill factors, acoustic impedance, dielectric constant and electrodes.

Innovia develops its own proprietary processes to ensure the best valued products to be delivered. For instance, our proprietary Cu electrode is strong in adhesion, and our epoxy comes with standard application temperature of 50 dC and high application temperature of 90 dC. Currently, PZT and crystal composite materials are actively being used by our customers on NDT and Medical Ultrasound probes.

Properties of Innovia Dice-and-Fill PZT Composites	
Resonance Frequencies	300 kHz ~ 10 MHz
Fill Factors (PZT %)	25% ~ 75%
Typical Coupling Coefficient kt	0.55 ~ 0.70
***Acoustic Impedance**	9 ~ 22 MRayl
***** Dielectric Constant**	600 ~ 3,000
Typical Surface Roughness Ra	0.3 μ m
Epoxy Material Hardness	80~90 Shore D
Electrode (Solder-able)	Cu
Maximum Dimension	70mm*80mm

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Comparison between PMN-PT Crystal and PMN-PT Crystal Composite

Materials / Properties	PMN-PT crystal	PMN-PT crystal composite (44% filling rate)
Longitudinal velocity m/s	4300	3680
Shear velocity m/s	-	-
Density g/cc	8.05	3.6
Impedance MRayls	35	13
Dielectric constant	6000	1700
Plate Coupling K_t	0.63	0.81
Mechanical loss tangent %	-	-
Electrical loss tangent %	0.5	2

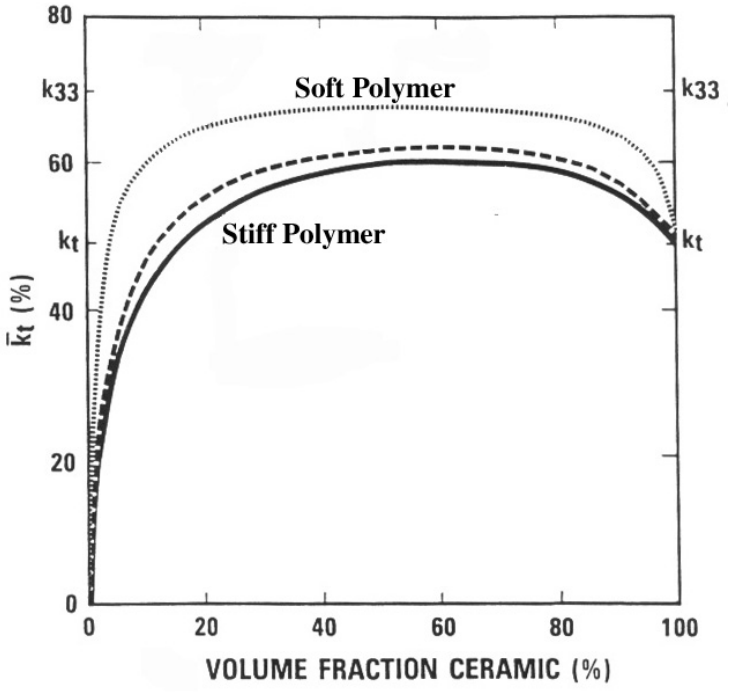
*Dielectric constant of composite is modeled as parallel capacitors:

$$\varepsilon_{Composite} = v\varepsilon_{Ceramic} + (1-v)\varepsilon_{Epoxy}$$

* Acoustic impedance of composite is modeled as parallel springs:

$$Z_{composite} = vZ_{Ceramic} + (1\text{-}v)Z_{Epoxy}$$

where v is fill factor (volume % of ceramic) in above two equations.



Composites' coupling coefficient kt is dependent on fill factors

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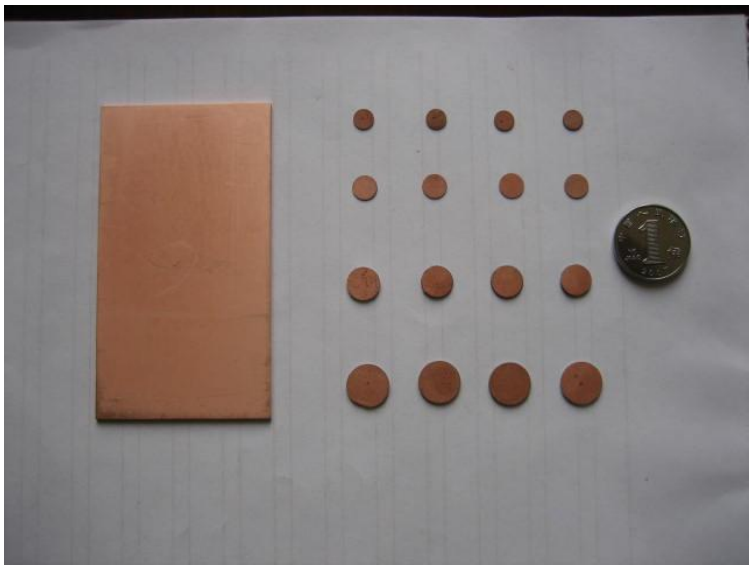

Innovia's composites with electrodes

PZT Ceramic Properties (Select)

		Units	PZT Trade Names		
			PZT5H	I57	PZT5A
Dielectric Constant @ 1kHz	K^T3		4000	5700	1500
Loss @ 1kHz		%	1.8	2.5	2.0
Density		g/cc	7.7	8.2	7.9
Curie Temperature	T_c	dC	210	155	300
Quality Factor	Q_m		50	120	50
Coercive Field	E_c	kV/cm	6.7	4.2	8.7
Remnant Polarization	P_r	$uCoul/cm^2$	39		
Coupling	k_p		0.70		0.71

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	k_{33}		0.75		0.77
	k_{31}		0.43	0.4	0.42
	k_t		0.51	0.5	0.51
	k_{15}		0.77		
Piezoelectric Constant	d_{31}	c/N*10^{-12} or	-325	-365	-205
	d_{33}	m/V*10^{-12}	645	750	440
Piezo Charge Constant	g_{31}	Vm/N*10^{-3} or	-9.2	-7.2	-12.3
	g_{33}	m^2/c	18.2	15	26.2
Frequency Constant	N_p	Hz*m	1930		1980
Young's Modulus	c_E^{11}	N/m^2*10^{10}	13.3	12.4	15.2
	c_E^{33}	N/m^2*10^{10}	12.4		13.0
Poisson Ratio			0.26		0.30

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