Composite Nano Carbon - Electric Voltage

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Abstract:
The paper uses the theory of modified quadrilateral displacement (HSDT-4) and Navier root form (double Fourie series) to analyze the individual oscillation of single-walled carbon nanotube reinforced composite panels carbon nanotube - SWNT), integrated with piezoelectric materials. The dynamic equilibrium equations for the quasi-quadrant rectangular plate are established from Hamilton's principle and Maxwell's equation.
Keywords: *Theory of four hidden displacement; separate oscillation analysis; piezoelectric materials*

1. Introduction

Based on the idea of the mechanical distribution of FGM (Functionally Graded Material) and the special mechanical properties of carbon nanotubes, Shen proposed composite materials with variable mechanical properties with fiber reinforcement being tubes. carbon nanotubes (functionally graded carbon nanotube-reinforced composite - FG-CNTRC), in which carbon nanotubes are arranged, somehow distributed on a polymer or metal substrate. Currently, FG-CNTRC material has been recognized by the community of scientists and technology around the world as a new generation composite material, attracting interest in research and application in many different fields.

Piezoelectric material (piezoelectric material) is a material with the ability to change shape and size when placed under the influence of an electric field. On the contrary, when deformed, piezoelectric material will generate an electric field. Composite structures with piezoelectric layers or layers, referred to as piezoelectric composite structures, have also been studied and applied in many different industries. However, studies on the mechanical behavior of structures made of nanoscarbon composite materials - piezoelectricity (PFG-CNTRC) in general and structures like PFG-CNTRC composite shell in particular are still very limited. published amount.

Material development requires suitable models for the analysis and calculation of structures made from these new materials. The accuracy and efficiency when analyzing the mechanical behavior of sheets and shells depends much on calculation theory. Three-dimensional elastic theory (3D) is said to be the correct theory. However, the 3D elastic equations for multilayer sheets and shells are often mathematically cumbersome, so they are difficult to solve, especially for complex boundary conditions and loads. One of the popular alternatives to 3D theory are the equivalence monolayer theories (ESL), such as classical theory (CST), first order theory (FSDT), and higher order theory (HSDT) was presented by researchers to reduce 3D elastic equations into two-dimensional (2D) expressions. In the above-mentioned single layer theory, CST theory is only suitable for thin sheet and shell because it completely ignores the effect of cross-sectional strain. The FSDT theory can be calculated for medium thickness panels and sheaths. However, the shear strain in this theory is constant according to the structure thickness, so for better results it is necessary to have the shear correction coefficient. The determination of the shear correction factor is complex because it depends on many factors: material, boundary conditions, load. To overcome the disadvantages of FSDT, the theory of high degree shear strain (HSDT) was developed by expanding displacement components in the form of polynomial series. The HSDT has the disadvantage of not satisfying the zero condition of the cross-sectional stress at the top and bottom of the shell, and the equations are also quite cumbersome and complex. Hence the Bid will not be used if not required. In recent years, the theory of displacement quadruple shear strain (HSDST-4) has been developed on the basis of analysis of displacement components into two components: components due to bending moment and force component cause cut. This theory has advantages such as little unknowns, no need to use the shear correction factor and the satisfaction of the condition that the cross-sectional stresses are suppressed at the two surfaces of the structure. Therefore, the improvement, development and effective application of Pre-Set 4 will bring many scientific and practical meanings.

2. Literature review

2.1. Composite materials

Composite materials are materials consisting of two or more component materials, which combine at a macroscopic level and do not dissolve each other. In general, each composite material consists of one or more discontinuous phases distributed in a single continuous phase. The continuous phase, called the substrate, is usually responsible for linking the discontinuous phases. A discontinuous phase called reinforcement or reinforcement is mixed into the substrate to increase the mechanical properties, ensuring that the composite has the necessary mechanical properties.

There are basically two types of reinforcement materials, namely, fiber-like (short or long) and granular. There are many commonly used fibers eg fiberglass, carbon fiber, Kelver-49. There is also a group of less common fibers such as boron fiber, aluminum oxide fiber and silicon carbide fiber. In practice, there are two types of composites that are used a lot: fiberglass polymer-based composite and carbon fiber polymer-based composite. During fabrication, the fiber reinforcement is applied to the substrate. Substrates can be made from a variety of materials such as metals, polymers or ceramics [31, 52]. A structure can consist of multiple layers of fiber-reinforced composite. Each layer can have different yarn thickness and angle as shown in figure 1. Each layer can also be made of a different material. Furthermore, material properties in different directions can be different in each layer, however, the direction with the largest modulus of elasticity is called the longitudinal direction, the direction perpendicular to the fiber is called the transverse direction. These two directions form the material coordinate system (1,2,3) of each layer. The fiber angle of each material layer plays an important role in optimizing the design. For example, a different configuration of the fiber angle in the layers will make the composite structure have different bearing capacity [3, 31, 52].

The function of the fiber is to bear force, while the substrate mainly plays a role in keeping the structure shape and connecting the yarn together, transmitting force to the yarn. Fiber-reinforced composites have applications in a wide range of industries, such as marine, construction, mechanical, aerospace, gas storage, oil storage, sports equipment, and the umbrella industry. bowl [52]. The most common application is in aerospace engineering as the industry is looking for lightweight materials to reduce fuel consumption.

2.2. Carbon nanotubes

Carbon nanotubes (CNT) were discovered in 1991 by Iijima [29]. With special crystal properties and outstanding mechanical, physical, and chemical properties such as high strength, high hardness while small density, good electrical conductivity, good thermal conductivity, electrical reflectivity properties strong words. Nanotubes are increasingly interested in research and application widely in many different fields of science and technology. Carbon nanotubes have two main forms, single-wall and multi-wall

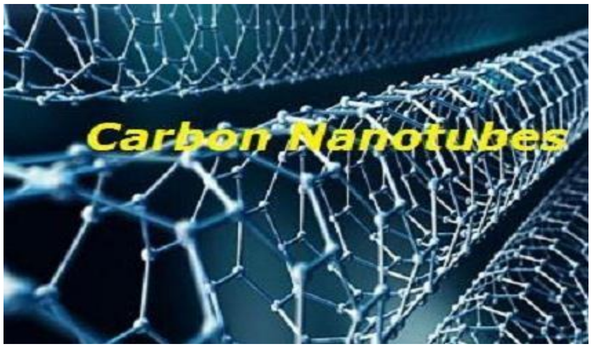

Figure 1. Single-walled carbon nanotubes

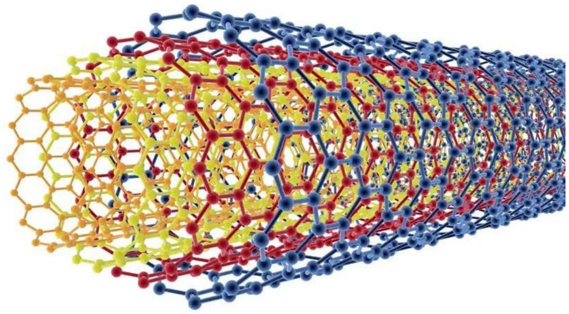

Figure 2. Multi-walled carbon nanotubes

The single-walled form [10, 29] (SWCNT: single-walled carbon nanotube) is structured like a rolled up graphene sheet. The multi-walled form [29] (MWCNT: multi-walled carbon nanotubes) is structured like many interlocking graphene sheets and then rolled up or a sheet of graphene rolled into layers. Graphene has a stable texture even at normal temperatures. Graphene's hardness is much greater than that of other materials (harder than diamond and about 200 times stronger than steel). This is due to the carbon-carbon bonds in graphene. Graphene is believed to have tensile strength in the plane up to 1.06 TPa and thus carbon nanotubes also exhibit the same hardness [35]. Overney et al. [67] calculated and found that the elastic modulus of single-walled nanotubes was equivalent to that of graphene with a value of about 1500 GPa. In 1997, Wong et al. [104] used an atomic microscope to directly measure the hardness of a multi-walled carbon tube and showed that the elastic modulus of this material was 1.28 TPa. The study of Salvetat et al. [77] showed that the mean value of the elastic module of multi-walled carbon nanotubes was about 810 GPa.

Carbon nanotubes are used as reinforcement materials in composite materials and as a result nano composite materials are introduced with improved mechanical, physical, and chemical properties. Based on the very good electrical conductivity and low density of CNT, Kilbride et al. Have fabricated a conductive resin with super high permeability and measured alternating current and conductivity directly in the membrane. thin composite. Furthermore, Biercuk's group [12] used single-walled carbon nanotubes to increase the heat transfer properties of industrial epoxy and the expected results, the thermal conductivity and mechanical properties of the SWCNT-epoxy composite. greatly improved.

2.3. Piezoelectric materials

Piezoelectric materials are materials that have the ability to change shape and size when placed under the impact of an electric field or generate an electric field when they are deformed. Piezoelectric materials are increasingly used in structures to make them "smart". Ancient Egyptians discovered this material, noticed their electrical properties, especially its ability to generate static charges when rubbed. The word "piezoelectricity - piezoelectricity" was named after two French mineralists, Jacques and Pierre Curie. In 1894, in Voigt's research, the application of a voltage on a piezoelectric material causes a geometric change, known as the piezoelectric effect (actuator) [96] and the phenomenon of spontaneous electricity generation. when deformed is called the reverse pressure effect (sensor - sensor). The use of piezoelectric materials for sensing or excitation is important. Piezoelectric sensors can be used to measure physical quantities such as stress and strain in the structure, whereas piezoelectric excitation is used to actively induce deformation in a structure by using voltage. The piezoelectric response diagram in the piezoelectric material is illustrated in figure 1.5. The difference in the mean positions of positive and negative charges results in a piezoelectric response

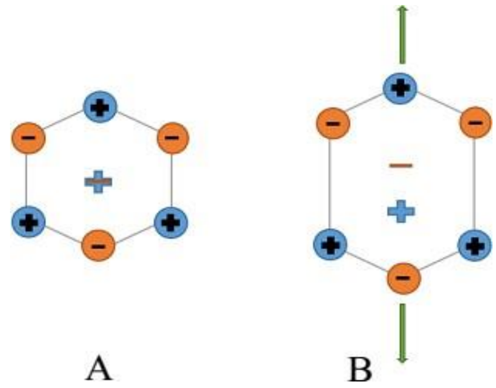

Figure 3. Piezoelectric material crystals in state

A) No deformation, B) Deformation

In recent years, piezoelectric materials have played an important role in industrial engineering and the manufacture of precision equipment. One of the advantages of using piezoelectric materials is that, if produced in solid state, they can work in most extreme environmental conditions such as dust, oil, exhaust gas, and temperature. high and also prevents detrimental vibrations to the structure. Piezoelectric materials exist in a number of natural crystals such as quartz and rochelle salts [94].

2.4. Nano carbon composite material - piezoelectric

Piezoelectric composite is a type of composite with piezoelectric materials. Piezoelectric materials in the form of layers or thin pieces, when embedded or attached to a composite structure, form a piezoelectric composite structure capable of sensing or exciting for kinetic and static responses. Sheet structure, piezoelectric carbon nano composite shell will bring advantages of each component material Currently, the number of studies related to plate structure, piezoelectric carbon nano composite shell (PFG-CNTRC) is still quite modestly. Existing publications only focus on structural objects. Kiani [36] used the Ritz method with the Chebyshev polynomial function to analyze the free oscillation of the FG-CNTRC plate attached to the piezoelectric layers. Selim [82] and colleagues studied and controlled oscillation of the PFG-CNTRC sheet structure using the new IMLS-Ritz free element method based on the Reddy tertiary shear strain theory. In the study of Nguyen et al. [65] used the isometric method, the theory of cubic shear strain to study the dynamic response of multi-layered FG-CNTRC plates with piezoelectric layers. According to the analytical approach, using the new modified quadruple plate theory, two studies on static analysis and separate vibration analysis of the CNT reinforced piezoelectric layer structure have been studied by the authors of the thesis. This project was recently published [CT6, CT7, CT8, CT10]. With the achieved results, the above two studies will be the main basis for verification problems and surveys that the thesis author performs in the content of the next chapters.

One of the studies that serve as a good scientific basis for the studies of piezoelectric composite structures must include the doctoral thesis of the author Le Kim Ngoc [2]. In this study, the author has made a relatively in-depth analysis on the electromechanical behavior of piezoelectric materials and piezoelectric composite panels. The author of the thesis conducted static analysis and free oscillation of the rectangular piezoelectric layer structure by mathematical method.

3. Research method

The research method used in the dissertation is to study specific theory, which is to build models and computer programs to simulate the mechanical behavior of the two-curvature sheets and shells. The two specific methods used in the thesis are:

• Analytical method: Set up the main equations, solutions and compute programs to analyze the static and unique vibrations of the plate, shell of two nanoscale composite curvatures - quasi-quadruple piezoelectric piezoelectricity.

• Finite element method: Constructing finite element model and calculating program to analyze static, specific oscillation and dynamic response of plate, double-curvature composite nano carbon - piezoelectric shell with modulation different boundary facts.

The test examples performed confirmed the reliability of the established computer program and model.

4. Result

In terms of materials, the two-curvature casing studied in the thesis is made of composite materials with variable mechanical properties in many layers, in which each layer consists of an isotropic material (polymer or metal) base phase and increased phase. Strength is carbon nanotubes arranged according to a certain rule (Figure 2.2) according to the thickness of the structure. In addition, two layers of piezoelectric layers are added to the upper and lower sides of the case

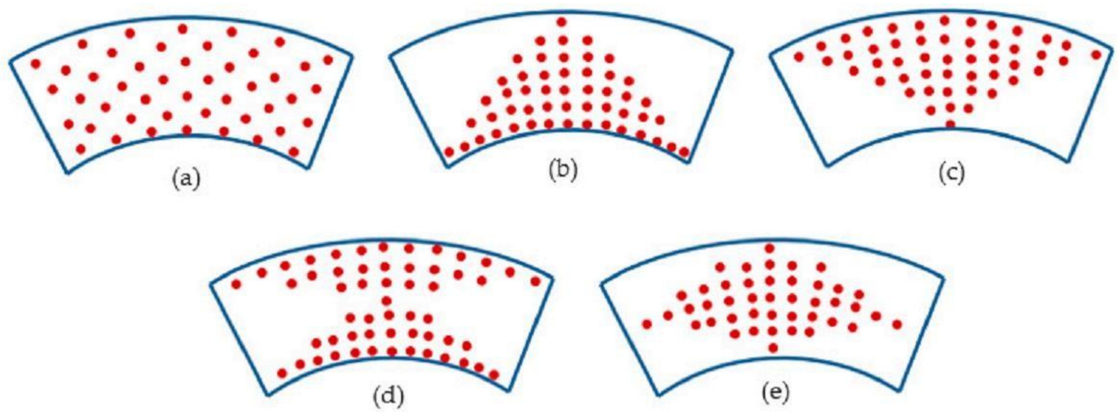

Figure 4. Some types of distribution of CNT:

(a) UD; (b) FG-□; (c) FG-V; (d) FG-X; (e) FG-O

As proposed by scientists, there are currently five typical CNT distribution types: regular distribution (UD), shaped distribution □ (FG-□), V-shaped distribution (FG-V), distribution X-shaped layout (FG-X) and O-shaped distribution (FG-O). In the FG-X type, the distribution of CNT is maximum near the upper and lower surfaces while the mid plane has no CNT. However, for FG-O, the upper and lower surfaces are CNT free, and the middle surface of the sheet and shell are CNT enriched. While FG-V, the top surface is CNT enriched and the bottom surface has no CNT, FG-□ in contrast, the bottom surface is CNT enriched and the top surface has no CNT. UD, CNT styles are evenly distributed according to the thickness of the plate and shell structure. The distribution patterns of carbon nanotubes in each layer are functions of z and y (or z and x), but for simplicity it can be assumed that the mathematical model describing the CNT distribution rules depends only on Variable thickness z and is determined according to [83]:

Table 1. First specific oscillation frequency (m = 1, n = 1) □ (Hz) of piezoelectric isotropic casing when closed circuit (a / b = 1, Ry / a = 5)

a/R_x	h/a	h_p/h	□mạch kín (Hz)

			GT	□ $_{GT}^{*}$ (%)	PTHH	□PTHH* (%)	[80]	□ [76]* (%)	[79]
-0.2	0.1	0.1	**823.192**	-0.104	**819.860**	-0.508	823.997	-0.006	824.049
		0.2	**787.731**	-0.089	**784.513**	-0.497	788.091	-0.043	788.430
0	0.1	0.1	**839.095**	-0.033	**836.793**	-0.307	839.316	-0.006	839.368
		0.2	**801.515**	-0.035	**797.661**	-0.515	801.457	-0.042	801.794
0.1	0.1	0.1	**853.034**	-0.013	**848.321**	-0.566	853.095	-0.006	853.147
		0.2	**813.258**	-0.019	**811.429**	-0.244	813.081	-0.041	813.413
0.2	0.1	0.1	**870.667**	-0.004	**865.714**	-0.573	870.655	-0.006	870.705
		0.2	**828.014**	-0.011	**827.979**	-0.015	827.775	-0.039	828.101

Table 2. First specific oscillation frequency (m = 1, n = 1) □ (Hz) of piezoelectric isotropic casing when closed circuit (a / b = 1, Ry / a = 5)

a/R			□mạch hở (Hz)						
a/R_X	*h/a*	*hp/h*	GT	□ $_{GT}^{*}$ (%)	PTHH	□PTHH* (%)	[80]	□ [76]* (%)	[79]
-0.2	0.1	0.1	**840.146**	-0.124	**837.910**	-0.390	843.029	0.219	841.189
		0.2	**820.045**	-0.053	**817.088**	-0.413	826.775	0.768	820.477
0	0.1	0.1	**855.975**	-0.056	**855.630**	-0.096	858.249	0.209	856.455
		0.2	**833.727**	-0.006	**829.869**	-0.469	840.162	0.765	833.781
0.1	0.1	0.1	**869.731**	-0.037	**867.071**	-0.343	871.706	0.190	870.057
		0.2	**845.161**	0.006	**844.859**	-0.029	851.309	0.734	845.108
0.2	0.1	0.1	**887.099**	-0.028	**881.408**	-0.670	888.783	0.161	887.350
		0.2	**859.456**	0.013	**859.359**	0.001	865.231	0.685	859.347

Table 3. Dimensional deflection and stress of a relaxed cylinder shell (CYL) PFG- CNTRC, configuration [p / 0/90/0 / p], SSSS boundary conditions, bending resistance by mechanical load pz + (N / m2) and the voltage applied to the upper piezoelectric layer Vt (Volt) of the sinusoidal distribution

		V_t=0		V_t=-100		V_t=+100	
		GT	PTHH	GT	PTHH	GT	PTHH
	UD	-0.161	-0.162	-10.842	-10.929	10.521	10.606
	FG-□	-0.164	-0.165	-12.139	-12.250	11.811	11.920
w	FG-V	-0.163	-0.164	-10.074	-10.146	9.747	9.817
	FG-X	-0.152	-0.153	-10.244	-10.321	9.940	10.015
	FG-O	-0.169	-0.170	-11.490	-11.585	11.152	11.245
	UD	-0.482	-0.484	-56.061	-56.187	55.096	55.218
		0.479	0.478	16.697	16.797	-15.739	-15.840
□ *xx*	FG-□	-0.015	-0.017	-1.540	-1.712	1.511	1.679

		0.874	0.876	33.436	33.876	-31.688	-32.125
	FG-V	-0.876	-0.882	-99.268	-99.620	97.516	97.855
		V_t=0		V_t=-100		V_t=+100	
		GT	PTHH	GT	PTHH	GT	PTHH
		0.014	0.016	0.651	0.788	-0.622	-0.755
	FG-X	-0.900	-0.907	-106.287	-106.719	104.486	104.905
		0.894	0.896	29.660	30.066	-27.872	-28.275
	FG-O	-0.014	-0.016	-1.381	-1.529	1.354	1.497
		0.014	0.015	0.681	0.823	-0.654	-0.792
	UD	-0.160	-0.159	-11.400	-11.675	11.081	11.357
		0.148	0.148	12.717	12.498	-12.422	-12.201
	FG-□	-0.006	-0.006	-0.632	-0.774	0.621	0.761
		0.212	0.213	20.437	19.843	-20.014	-19.418
	FG-V	-0.235	-0.233	-14.363	-14.945	13.894	14.479
□ *yy*		0.005	0.006	0.222	0.203	-0.211	-0.190
	FG-X	-0.297	-0.297	-21.107	-21.831	20.512	21.237
		0.275	0.277	23.968	23.489	-23.418	-22.934
	FG-O	-0.005	-0.005	-0.510	-0.634	0.501	0.624
		0.004	0.005	0.173	0.144	-0.164	-0.135
	UD	0.007	0.007	0.685	0.699	-0.671	-0.685
		-0.011	-0.010	-0.615	-0.617	0.594	0.596
	FG-□	0.006	0.007	0.678	0.694	-0.665	-0.681
		-0.012	-0.012	-0.802	-0.807	0.777	0.783
□ *xy*	FG-V	0.008	0.008	0.742	0.755	-0.727	-0.739
		-0.010	-0.009	-0.514	-0.514	0.494	0.495
	FG-X	0.008	0.008	0.822	0.839	-0.806	-0.823
		-0.012	-0.012	-0.723	-0.726	0.698	0.702
	FG-O	0.006	0.006	0.596	0.608	-0.584	-0.596
		-0.009	-0.009	-0.546	-0.547	0.528	0.530
	UD	-0.194	-0.195	-2.301	-2.243	1.913	1.854
		V_t=0		V_t=-100		V_t=+100	
		GT	PTHH	GT	PTHH	GT	PTHH

	FG-□	-0.159	-0.159	-2.164	-2.054	1.846	1.735
□	FG-V	-0.241	-0.241	-2.507	-2.393	2.026	1.910
yz	FG-X	-0.237	-0.238	-2.616	-2.541	2.141	2.065
	FG-O	-0.162	-0.162	-2.066	-2.021	1.743	1.696
	UD	-0.194	-0.194	-2.303	-2.238	1.915	1.849
	FG-□	-0.241	-0.243	-3.281	-3.459	2.798	2.973
□ xz	FG-V	-0.159	-0.159	-1.657	-1.491	1.339	1.172
	FG-X	-0.237	-0.238	-2.618	-2.535	2.143	2.060
	FG-O	-0.162	-0.162	-2.068	-2.016	1.745	1.692

Table 4. Dimensional Deflection and Stress of Sheet (PLA) PFG-CNTRC, configuration [p / 0/90/0 / p], SSSS boundary conditions, bending resistance by mechanical load pz + (N / m2) and the applied voltage Vt (Volt) of the sinusoidal distribution

V		V_t =0		V_t =-100		V_t =+100	
		GT	PTHH	GT	PTHH	GT	PTHH
	UD	-0.161	-0.162	-10.822	-10.914	10.500	10.589
	FG-□	-0.164	-0.166	-12.090	-12.201	11.762	11.870
\	FG-V	-0.164	-0.166	-10.079	-10.160	9.751	9.828
	FG-X	-0.153	-0.154	-10.224	-10.305	9.919	9.998
	FG-O	-0.169	-0.171	-11.471	-11.571	11.132	11.229
	UD	-0.482	-0.484	-55.879	-55.934	54.914	54.966
		0.482	0.484	16.828	16.948	-15.864	-15.980
	FG-□	-0.015	-0.017	-1.529	-1.697	1.500	1.664
		0.878	0.883	33.576	34.034	-31.820	-32.267
□	FG-V	-0.878	-0.883	-99.073	-99.325	97.317	97.558
xx		0.015	0.017	0.658	0.797	-0.629	-0.764
	FG-X	-0.900	-0.905	-105.938	-106.237	104.138	104.427
		0.900	0.905	29.898	30.337	-28.097	-28.526
	FG-O	-0.014	-0.016	-1.374	-1.518	1.346	1.486

		0.014	0.016	0.687	0.831	-0.659	-0.800
	UD	-0.154	-0.155	-10.982	-11.248	10.674	10.939
□		0.154	0.155	13.094	12.890	-12.786	-12.581
yy	FG-□	-0.005	-0.006	-0.620	-0.761	0.609	0.748
		0.224	0.224	21.257	20.684	-20.809	-20.237

5. Conclusion

Nowadays, the piezoelectric phenomenon is widely applied in techniques serving daily life such as lighters, sensors, ultrasonic machines, small angle control of laser reflectors, devices, Small-sized engines, many research programs are currently being developed such as insects, artificial mechanics, shape-shifting aircraft wings, sound suppression chambers, structures. Smartly, most printers today ... one of the most important applications today in engineering is for the use of piezo motors.

Up to now, two basic types of piezo materials have been found: lumps (like ceramics) and thin sheets like film.

The piezoelectric devices are also widely used in the oil and gas industry. The quartz piezoelectric device is an important part of Schlumberger's CQG (Crystal Quartz Gauge), which is used in the pressure sensors of many different tools. Parts made of piezoelectric ceramic materials are key parts of Schlumberger's seismic, acoustic and ultrasonic devices. These include the ultrasonic circuit measuring power supplies and the hydrofones of the Q-Marine marine seismic probe system that records signals separately from each receiver and from the multi-component Q marine bottom survey system. Seabed, as well as from the Sonic Scanner scanning continental shelf ultrasonic receiver and single transmitters, of the Isolation Scanner coherent quality test system and sonic carota instrumentation during Sonic VISION drilling Although the use of piezoelectric devices is currently limited to sensors, it is predicted that the oil and gas equipment industry in the future may apply the piezoelectric effect in devices to collect energy (energy harvesting) and in the microprocessor operations.

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