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Piezoelectric Actuators and Motors – Types, Applications, new Developments, Industry Structure and Global Markets

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Abstracts

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Piezo actuators are electromechanical “motors”, based on the solid state piezomechanical deformation effect of piezoceramics (PZT lead zirconium titanate). Highlights are unlimited positioning sensitivity (sub-nanometers), high load capability, and high force generation, resulting in ideal mechanical dynamics with reaction times down to microseconds. Only piezo actuation allows top innovations in mechatronics like nano-positioning or high pressure common rail fuel injection.

Piezoelectric actuators are at an important stage of development into a large component market. Market pull is generated by large demand for ultra-small scale precision motion devices used in manufacturing and inspection equipment, high volume, low cost auto-focus assemblies required in phone cameras, and high volume, moderate cost ink printing cartridges used in printers; and partly by demand for micro actuator medical tools used in minimally invasive surgery and micro-grippers required in manufacturing micro-sized objects such as stents; and partly by dynamically-driven high temperature actuators for diesel injector valves in automobiles. Cost, yield and reliability are important concerns for each of these six applications. A number of these concerns relate to basic material science issues in the manufacture of the piezoelectric actuators for these targeted, diversified applications.

This report also deals with ultrasonic motors (USMs) that belong to the class of piezoelectric motors. In this work, the term “USM” will be used for the motor only (in

other words, power electronics and closed-loop controls are not included). The system composed of the motor, power electronics, and closed-loop control will be called the ultrasonic actuator or piezoelectric actuator. The working principle of these motors has been well known for at least 50 years. However, they generated widespread interest only with the influential work of Sashida in 1982. Before that time, piezoceramic materials with high conversion efficiency and fast electronic power control of ultrasonic vibrations were not available.

Due to their specific advantages compared to conventional electromagnetic motors, USMs fill a gap in certain actuator applications. A key advantage of USMs over electromagnetic motors is their compactness, i.e., their high stall torque-mass ratio and high torque at low rotational speed, often making speed-reducing gears superfluous. Additionally, with no voltage applied, an inherent holding torque is present due to the frictional driving mechanism. It is also notable that their compactness and the high frequency electrical excitation make quick responses possible. USMs also offer a high potential for miniaturization. These actuators produce no magnetic field, since the excitation is quasi-electrostatic.

STUDY GOAL AND OBJECTIVES

This study focuses on key piezoelectric-operated actuators and motors and provides data about the size and growth of these markets, along with company profiles and industry trends. The goal of this report is to provide a detailed and comprehensive multi-client study of the markets in North America, Europe, Japan, China, India, Korea and the rest of the world (ROW) for piezoelectric-operated actuators and motors, as well as potential business opportunities in the future.

The objectives include thorough coverage of underlying economic issues driving the piezoelectric-operated actuators and motors business, as well as assessments of new, advanced piezoelectric-operated actuators and motors that are in development. Also covered are legislative pressures for more safety and environmental protection, as well as users' expectations for economical actuators and motors. Another important objective is to provide realistic market data and forecasts for piezoelectric operated actuators and motors. This study provides the most thorough and up-to-date assessment that can be found anywhere on the subject. The study also provides extensive quantification of the many important facets of market development in piezoelectric-operated actuators and motors. This, in turn, contributes to a determination of the kinds of strategic responses companies may adopt in order to compete in these dynamic markets.

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Users of piezoelectric actuators and motors in developed markets must contend with twin pressures – to innovate and, at the same time, to reduce costs. New applications, such as piezo fuel injectors, ink cartridges in printers, micro-pumps, micro-grippers, and micro-surgery tools for piezoelectric actuators and motors, have been proposed in recent years. This study condenses all of these business related issues and opportunities.

REASONS FOR DOING THE STUDY

The piezoelectric actuator and motor market is an attractive and still-growing multi-million dollar market characterized by very high production volumes of actuators and motors that must be both extremely reliable and low in cost. Growth in the market continues to be driven by increasing demand in camera phones for auto-focus mechanisms, data storage, semiconductors, micro-electronics production, precision mechanics, life science and medical technology, optics, photonics, nanometrology, robots, toys, HVAC control systems, and other applications such as piezo fuel injectors, ink cartridges in printers, micro-pumps, micro-grippers and micro-surgery tools.

The piezoelectric-operated actuator and motor industry is complex and fast moving, with manufacturers increasingly adopting a truly global view of the market. Around the world, consumers are demanding a high power density as well as extremely long cycle life. Against this difficult background, manufacturers have attempted to achieve growth through company mergers and acquisitions, and by implementing global strategies. Piezoelectric-operated actuators and motors, once a technological novelty, have now entered the mainstream and are showing significant sales volumes.

iRAP conducted this study in 2007. However, with increased demand for these devices, and with improved and emerging technologies as well as applications, iRAP felt a need to conduct a detailed study and update technology developments and markets. The report identifies and evaluates piezoelectric-operated actuators and motors and technologies which show potential growth.

CONTRIBUTIONS OF THE STUDY

The report covers technology, product analysis, manufacturers' profiles, competitive analysis, raw material suppliers, electronic suppliers, system integrators, material and material cost analysis, market dynamics and patent status of leading players ,to provide a complete picture of the status and growth of the piezoelectric actuator market on a global scale from 2009 to 2014.

This study provides the most complete accounting of the current market and future growth in piezoelectric actuators and motors. The study also provides extensive quantification of the important facets of market developments in emerging markets for these actuators and motors, such as China.

SCOPE AND FORMAT

The market data contained in this report quantify opportunities for piezoelectric-operated actuators and motors. In addition to product types, this report also covers the many issues concerning the merits and future prospects of the business, including corporate strategies, information technologies, and the means for providing these highly advanced product and service offerings. This report also covers in detail the economic and technological issues regarded by many as critical to the industry's current state of change. It provides an overview of the piezoelectric actuator and motor industry and its structure, and of the many companies involved in providing these products. The competitive positions of the main players in the market, and the strategic options they face, are also discussed, along with such competitive factors as marketing, distribution and operations.

TO WHOM THE STUDY CATERS

Audiences for this study include marketing executives, business unit managers and other decision makers in piezoelectric-operated actuators and motors companies and companies peripheral to this business. The study will benefit existing manufacturers of actuators and motors who seek to expand revenues and market opportunities by expanding in new technology such as piezoelectric-operated actuators and motors, positioned to become a preferred solution for many applications. This study also will benefit users of piezoelectric-operated actuators and motors who deal with actuators where electromagnetic field generation is an issue and operational performance parameters and space are important considerations, such as in auto-focus lens mechanisms of camera phones, nanometrology, precision linear /rotary drives, drug delivery systems, antenna array deployment, and other fields such as piezo fuel injectors, ink cartridges in printers, micro-pumps, micro-grippers and micro-surgery tools.

REPORT SUMMARY

A confluence of new piezo-based technology has breathed new capability into the nano- and micro-positioning world. Piezo actuation is increasingly suitable for applications formerly addressable only by magnetic motors, and the technology offers significant benefits in terms of size, speed, fieldlessness, reliability, vacuum compatibility, resolution and dynamics. These benefits, in turn, enable significant advances in existing and new applications. Examples of these applications abound. For instance, optical assemblies of escalating sophistication require multiple axes of nanoprecision alignment that must remain aligned for months of round-the-clock usage. Another example is emerging nano-imprint lithography methods which demand exacting positioning and trajectory control and must retain alignment integrity under significant physical and thermal stresses. Applications ranging from cell phone cameras to endoscopy and fluid delivery mechanisms require exceedingly small but stiff, responsive, and reliable positioning of optics, probes and shutters. Until recently, these conflicting requirements had no solution.

Piezomotors and actuators typically eliminate any need for gear reduction because they drive loads directly. One way to understand how a piezomotor generates motive force is to examine the SQUIGGLE® motor. It can move with 1,000 times more precision than an electromagnetic motor while hitting nanometer resolutions. In contrast, electromagnetic motors struggle to give micrometer resolution.

Piezoelectric actuators have been commercialized in various areas such as information technology, robotics, biomedical engineering, automotive, ecological and energy engineering. They are coming to be preferred over electromagnetic-type actuators, due mainly to suitability to miniaturization, lack of electromagnetic generation, higher efficiency and non-inflammability.

Piezoelectric actuators and motors vary significantly in shapes and manufacturing technologies in order to address distinctly different market segments such as ultra-small scale precision motion devices in manufacturing and inspection equipment, phone cameras, ink printing cartridges, micro-actuator tools used in minimally invasive surgery, micro-grippers required in manufacturing micro-size objects such as stents, and high temperature actuators for diesel injector valves in automobiles.

Major findings of this report are:

- The 2009 global market for piezoelectric operated actuators and motors was estimated to be \$6.6 billion, and the market is estimated to reach \$12.3 billion by

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2014, showing an average annual growth rate of 13.2% per year.

The market for piezoelectric-operated actuators and motors in ultra-small scale precision motion related applications will be the largest segment, estimated to have reached $3,200 million (48.6% share) in 2009 and projected to reach $6,000 million in 2014, for an AAGR of 13.4%. The other major segment includes phone cameras, digital cameras, microscope lenses, mirrors and optics, estimated at $2,800 million (42.5% share) in 2009 and $5,200 million in 2014, for an AAGR of 13.1%.

The remaining 8.9% ($587 million) is a third market segment consisting of auto fuel injectors, micro-pumps, micro-blowers, printer cartridges, surgical instruments, mini-robots, etc.). In 2014, this market segment will have a share of 8.7% ($1,090 million).

The manufacturers of optics, photonics and nanometrology equipment have been the major consumers of piezoelectric-operated motors and actuators.

Life sciences and medical technology also constitute a high-growth segment of the piezoelectric-operated actuators and motors market. This area is expected to grow at 18.7% annually and could record an even higher growth rate if there is wider acceptance by end users. It is still going through a gestation period.

Over the projected period of five years, market share of piezoelectric-operated actuators and motors will increase, taking share from electromagnetic motors.

In terms of regional market share, North America leads, with 40.5% in 2009, followed by Europe with 34%, Japan with 20%, and the balance 5.5% for China and the rest of the world.

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Contents

INTRODUCTION

Study Goal and Objectives
Reasons for Doing the Study
Contributions of the Study
Scope and Format
Methodology
Information Sources
Target Audience for the Study
Author's Credentials

EXECUTIVE SUMMARY

Summary Table Global Market Size/percentage Share for Piezoelectric Actuators and Motors by Application, Through 2014
Summary Figure Global Share for Piezoelectric Actuators and Motors by Application, 2009 and 2014 ($ Millions)

INDUSTRY OVERVIEW

Industry Dynamics
Industry Structure
Industry Structure (continued)
Table 1 Company Product Reference for Piezoelectric Actuator and Motor Manufacturers, Material Suppliers, System Integrators/amplifier and Controller Suppliers
Table 1 Continued

TECHNOLOGY OVERVIEW

Piezo Mechanics
Symbols and Definitions
Piezoelectric Constants
Figure 1 Designation of the Axes and Directions of Deformation
Table 2 General Piezo Symbols
Table 2 Cotinued
Piezo Theory
Piezoelectric Materials

Figure 2 pzt Elementary Cell Before and After Poling (DC Field Applied)
Figure 3 Electrical Dipole Moments in Weiss Domains
Types of Piezoelectric Actuators
Types of Piezoelectric Motors
Types of Piezoelectric Motors (continued)
Figure 4 Standing Wave Ultrasonic Motor
Table 3 Formulas Used in Piezoelectric Technology
Table 3 Continued
Materials for Piezoelectric Actuators and Motors
Table 4 Material Constants of Piezoceramic Materials Used in Piezoelectric-Driven Actuators and Motors
Table 4 Continued
Electrode Materials
pzt Material Characteristics
Hysteresis
Creep
Extension Under Load
Power Dissipation
Operation Under Reverse Bias
Figure 5 Hysteresis Behavior of Piezoelectric Material
Linearity
Thermal Properties and Temperature Coefficients
Materials for Construction of Piezoelectric Actuators and Motors
Table 5 Materials Used for Fabricating Basic Piezo Electric Actuators
Table 5 Continued
Table 5 Continued
Manufacture of Multilayer Co-fired Actuators
Figure 6 Process Followed in Co-fired Piezoelectric Material
Metallization
Pzt-based Mems Devices
Table 6 Typical Materials Used in Pzt-based Mems Devices
Electronics (amplifiers and Controllers) Used With Piezoelectric Actuators
Table 7 Amplifiers and Controllers Used for Ultra-small Scale Motion of Piezoelectric Actuators
Electronics Used With Piezoelectric Motors/ultrasonic Motors in Auto-focus and Zoom Functions in Phone Cameras
Case Studies of Usage of Piezoelectric Actuators and Motors
Ultra-small Scale Precision Motions
Figure 7 Piezo Electric Nano Manupulator

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Ultra-small Scale Precision Motions (continued)
Part-piezo Electric Motors
Part-piezo Electric Motors (continued)
Figure 8 Typical Optical Zoom Using two Squiggle® Motors
Part-piezo Electric Motors (continued)
Piezo Motors in Surgical Robots
Figure 9 Surgical Micromanipulator With two Fingers Operated by Piezo Actuators
Piezo Motors in Surgical Robots (continued)
Piezo Motors in Surgical Robots (continued)
Applications
Ultra-small Scale Precision Motion Devices
Table 8 Market Segments Employing Ultra-small Scale Motion Piezoelectric Actuators
Table 8 Continued
Table 8 Continued
Ultra-small Scale Precision Motion Devices (continued)
Ultra-small Scale Precision Motion Devices (continued)
Nano-positioning Systems
Table 9 Types of Basic Piezo Electric Actuators for Ultra Small Scale Precision Motion
Table 9 Continued
Table 9 Continued
Table 9 Continued
Commercial Designs in Use
Table 10 Typical Shape Variants and Brands of Piezoelectric Actuators Commercialized for Small Scale Precision Motion
Table 10 Continued
Table 10 Continued
Table 10 Continued
Table 10 Continued
Table 10 Continued
Auto-focus Applications in Phone Cameras and Commercial Types
Discrete Versus Continuous Movement Motors
Discrete Versus Continuous Movement Motors (continued)
Discrete Versus Continuous Movement Motors (continued)
Ultrasonic Motors
Figure 10 Mobile Phone Camera Auto-focus Module Using a Piezo Motor
Ultrasonic Motors (continued)
Table 11 Types of Piezoelectric Motors
Table 11 Continued
Table 11 Continued

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Table 11 Continued
Table 11 Continued
Applications in ink Printing Cartridges
Applications in ink Printing Cartridges (continued)
Table 12 Microvalve Actuators and Piezo ink Cartridges
Table 12 Continued
Table 12 Continued
Table 12 Continued
Applications in Micro-mirrors, Micro-pumps and Micro-blowers
Table 13 Piezo Micro-mirrors, Micro-pumps and Micro-blowers
Table 13 Continued
Table 13 Continued
Table 13 Continued
Table 14 Representative Characteristics of Fabrication Technologies for Piezo Actuators
Applications in Micro-actuator Tools Used in Minimally Invasive Surgery and Micro-grippers Required in Manufacturing Micro-size Objects Such as Stents
Table 15 Piezo Micro Surgery Tools, Micro-grippers and Mini-robots
Table 15 Continued
Applications for Diesel Injector Valves in Automobiles
Applications for Diesel Injector Valves in Automobiles (continued)
Table 16 Types of Piezo Unit Injectors
Table 16 Continued

PRICE STRUCTURE

Table 17 Typical Prices for Piezoelectric Actuators for Ultra-small Scale Precision Motions
Table 18 Price Structure Variation for Piezoelectric Actuators / Motors for Five Other Market Segments
Table 18 Continued
Table 19 Typical Price Patterns of Electronic Controls of High Volume, low Cost Piezoelectric Motors for Auto-focus and Zoom Functions in Phone Cameras

INDUSTRY STRUCTURE AND DYNAMICS

Business Models and Industry Players
Business Models
Business Models (continued)

Market Dynamics
Competition
Mergers, Acquisitions and Divestitures
Table 20 Acquisition Deals Among Manufacturers of Piezoelectric Motors and Actuators From 2004 to 2009

GLOBAL MARKETS AND MARKET TRENDS

Market According to Applications
Table 21 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Application From 2009 to 2014
Figure 11 Global Market Share for Piezoelectric Motors and Actuators by Application From 2009 to 2014
Figure 11 Continued
Market According to Materials Used
Table 22 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Material Used From 2009 to 2014
Figure 12 Global Market Share for Piezoelectric Motors and Actuators by Material Used From 2009 to 2014
Market According to Regions
Table 23 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Region From 2009 to 2014
Figure 13 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Region From 2009 to 2014
Market Drivers and Trends
Miniaturization of Motors
Volume Production of Multilayer Piezo Actuators
Volume Production of Multilayer Piezo Actuators (continued)
Development of Traveling Wave Motors
Development of Standing Wave Motors
Hybrid Designs
Motor Optimization
Motor Optimization (continued)

PATENTS AND PATENT ANALYSIS PATENTS AND PATENT ANALYSIS

Piezo Actuator and Associated Production Method
Method and Device for Controlling a Piezo Actuator
Piezo Actuator Comprising Means for Compensating Thermal Length Modifications and

Fuel Injection Valve Comprising a Piezo Actuator
Piezo-actuator
Piezoelectric Ultrasound Motor
Heat Efficient Micromotor
Piezoelectric Motors and Methods for the Production and Operation Thereof
Piezomotor With a Guide
Multidirectional Piezoelectric Motor Configuration
Multiple Degree of Freedom Micro Electro-mechanical System Positioner and Actuator
Frequency-control-type Piezo Actuator Driving Circuit and Method of Driving the Same.
Control Device for Piezo Actuators of Fuel Injection Valves
Method and Device for Controllling an Injector
Sealing Arrangement for a Piezo Actuator of a Fuel Injector
Method for the Production of Monolithic Multilayer Actuator Made of a Piezoceramic or Electrostrictive Material and External Electrical Contact for the Same
High Resolution Piezoelectric Motor
Multilayer Piezoelectric Motor
Piezoelectric Motors and Motor Driving Configurations
Resonance Shifting
Method for Operating a Piezoelectric Motor, and Piezoelectric Motor Comprising a Stator in the Form of a Hollow-cylindrical Oscillator 118
Process for the Manufacture of Piezoceramic Multilayer Actuators
Method of Fabricating an Array of Multi-electroded Piezoelectric Transducers for Piezoelectric Diaphragm Structures
Piezo Actuator
Piezo Actuator Driving Circuit
Piezo Actuator Comprising a Structured External Electrode
Micro Position-control System
Positioning Device for Microscopic Motion
Poling System for Piezoelectric Diaphragm Structures
Piezo Electronic Throttle Control Actuator.
Tool Using a Piezo Actuator
Replaceable Friction Coupling for Piezoelectric Motors
Sealing Element for the Piezo Actuator of a Fuel Injection Valve
Piezoelectric Diaphragm Structure With Outer Edge Electrode
Miniature Auto-focus Piezo Actuator System
Radially Poled Piezoelectric Diaphragm Structures
Method for Controlling a Piezo-actuated Fuel-injection Valve
Piezo Actuator Drive Circuit
Piezoelectric Valve

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Piezoelectric Ceramic Materials, Based on Lead-zirconate-titanate (pzt), Comprising Valence-compensated Complexes Containing ag
Piezoelectric Device for Injector
Insulation for Piezoceramic Multilayer Actuators
Piezoceramic Multilayer Actuator With a Transition Region Between the Active Region and the Inactive Head and Foot Regions
Piezoactive Actuator With Dampened Amplified Movement
Monolithic Multilayer Actuator in a Housing
Multilayer Actuator With Contact Surfaces of Internal Electrodes of the Same Polarity Arranged Offset for Their External Electrodes
Piezoelectric Device for Injector
Piezoelectric Motors and Motor Driving Configurations
Patent Analysis
Table 24 Number of U.S. Patents Granted to Companies in the Ultrasonic Motors and Piezoelectric Actuator Markets From 2005 Through 2009
Figure 14 top Companies Granted U.S. Patents for Ultrasonic Motors and Piezoelectric Actuators From 2005 Through 2009
International Overview of U.S. Patent Activity in Piezoelectric Operated Actuators/ultrasonic Motors
Table 25 U.S. Patents Granted by Assigned Country/region for Ultrasonic Motors and Piezoelectric Actuators From January 2005 to 2009

COMPANY PROFILES

ADVANCED CERAMETRICS, INC.
APC INTERNATIONAL, LTD.
AUSTRIAMICROSYSTEMS USA, INC.
CEDRAT TECHNOLOGIES SA
CERAMTEC AG
CERATEC, INC.
CONTINENTAL AUTOMOTIVE GMBH
DELPHI WORLD AND NORTH AMERICAN HEADQUARTERS
DENSO CORPORATION
DISCOVERY TECHNOLOGY INTERNATIONAL
EDO CORPORATION, ELECTRO-CERAMIC PRODUCTS DIV
FAULHABER GROUP
FEINMESS DRESDEN GMBH
GALIL MOTION CONTROL
HEASON TECHNOLOGY LTD

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MAD CITY LABS INC.
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MICROMO ELECTRONICS, INC
MIDE TECHNOLOGY CORPORATION
MORGAN ELECTROCERAMICS LTD.
NPOINT
NANOMOTION LTD.
NEC TOKIN CORPORATION
NEW SCALE TECHNOLOGIES, INC.
NOLIAC A/S
PI CERAMIC GMBH
PIEZO SYSTEMS, INC.
PHYSIK INSTRUMENTE (PI)
PIEZOMOTOR AB
PIEZOSYSTEM JENA GMBH
PIEZOMECHANIK GMBH
PRIOR SCIENTIFIC, LTD.
QTECH NANOSYSTELS PTE LTD
ROBERT BOSCH LLC
SAMSUNG ELECTRO-MECHANICS CO., LTD.
SMART MATERIALS GMBH
SHINSEI CORPORATION
SEIKO INSTRUMENTS INC. (SII)
STAR MICRONICS
TEXAS INSTRUMENTS
TDK-EPC CORPORATION
ZYVEX

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List Of Tables

LIST OF TABLES

Summary Table Global Market Size/percentage Share for Piezoelectric Actuators and Motors by Application, Through 2014
Table 1 Continued
Table 2 General Piezo Symbols
Table 2 Cotinued
Table 3 Formulas Used in Piezoelectric Technology
Table 3 Continued
Table 4 Material Constants of Piezoceramic Materials Used in Piezoelectric-driven Actuators and Motors
Table 4 Continued
Table 5 Materials Used for Fabricating Basic Piezo Electric Actuators
Table 5 Continued
Table 5 Continued
Table 6 Typical Materials Used in Pzt-based Mems Devices
Table 7 Amplifiers and Controllers Used for Ultra-small Scale Motion of Piezoelectric Actuators
Table 8 Market Segments Employing Ultra-small Scale Motion Piezoelectric Actuators
Table 8 Continued
Table 8 Continued
Table 9 Types of Basic Piezo Electric Actuators for Ultra Small Scale Precision Motion
Table 9 Continued
Table 9 Continued
Table 9 Continued
Table 10 Typical Shape Variants and Brands of Piezoelectric Actuators Commercialized for Small Scale Precision Motion
Table 10 Continued
Table 10 Continued
Table 10 Continued
Table 10 Continued
Table 10 Continued
Table 11 Types of Piezoelectric Motors
Table 11 Continued
Table 11 Continued
Table 11 Continued
Table 11 Continued

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Table 12 Microvalve Actuators and Piezo ink Cartridges
Table 12 Continued
Table 12 Continued
Table 12 Continued
Table 13 Piezo Micro-mirrors, Micro-pumps and Micro-blowers
Table 13 Continued
Table 13 Continued
Table 13 Continued
Table 14 Representative Characteristics of Fabrication Technologies for Piezo Actuators
Table 15 Piezo Micro Surgery Tools, Micro-grippers and Minirobots
Table 15 Continued
Table 16 Types of Piezo Unit Injectors
Table 16 Continued
Table 17 Typical Prices for Piezoelectric Actuators for Ultrasmall Scale Precision Motions
Table 18 Price Structure Variation for Piezoelectric Actuators / Motors for Five Other Market Segments
Table 18 Continued
Table 19 Typical Price Patterns of Electronic Controls of High Volume, low Cost Piezoelectric Motors for Auto-focus and Zoom Functions in Phone Cameras
Table 20 Acquisition Deals Among Manufacturers of Piezoelectric Motors and Actuators From 2004 to 2009
Table 21 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Application From 2009 to 2014
Table 22 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Material Used From 2009 to 2014
Table 23 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Region From 2009 to 2014
Table 24 Number of U.S. Patents Granted to Companies in the Ultrasonic Motors and Piezoelectric Actuator Markets From 2005 Through 2009
Table 25 U.s. Patents Granted by Assigned Country/region for Ultrasonic Motors and Piezoelectric Actuators From January 2005 to 2009

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List Of Figures

LIST OF FIGURES

Summary Figure Global Share for Piezoelectric Actuators and Motors by Application, 2009 and 2014 ($ Millions)
Figure 1 Designation of the Axes and Directions of Deformation
Figure 2 pzt Elementary Cell Before and After Poling (dc Field Applied)
Figure 3 Electrical Dipole Moments in Weiss Domains
Figure 4 Standing Wave Ultrasonic Motor
Figure 5 Hysteresis Behavior of Piezoelectric Material
Figure 6 Process Followed in Co-fired Piezoelectric Material
Figure 7 Piezo Electric Nano Manupulator
Figure 8 Typical Optical Zoom Using two Squiggle® Motors
Figure 9 Surgical Micromanipulator With two Fingers Operated by Piezo Actuators
Figure 10 Mobile Phone Camera Auto-focus Module Using a Piezo Motor
Figure 11 Global Market Share for Piezoelectric Motors and Actuators by Application From 2009 to 2014
Figure 11 Continued
Figure 12 Global Market Share for Piezoelectric Motors and Actuators by Material Used From 2009 to 2014
Figure 13 Global Market Size/percentage Share for Piezoelectric Motors and Actuators by Region From 2009 to 2014
Figure 14 top Companies Granted U.s. Patents for Ultrasonic Motors and Piezoelectric Actuators From 2005 Through 2009

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