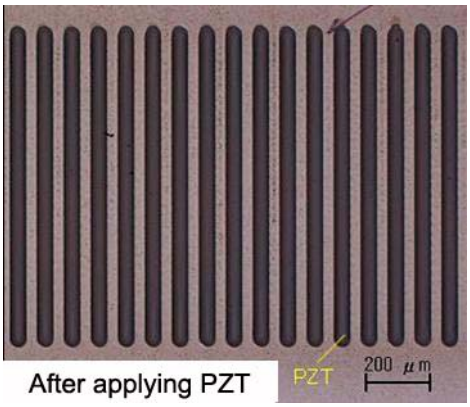
News Release

Ricoh Simultaneously Succeeded in Developing a PZT Thin Film Actuator by Ink-Jet Printing Method and a Lead-free Piezoelectric Material

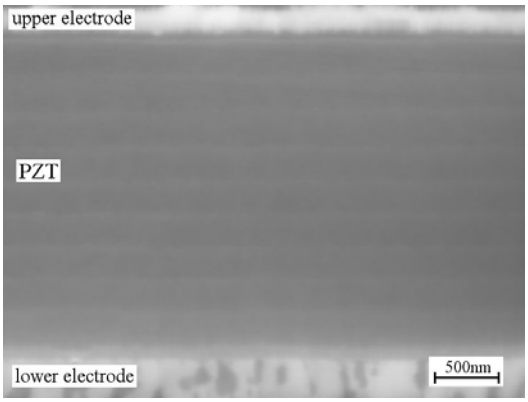
Tokyo, May 21, 2012 – Ricoh Company, Ltd. (President & CEO: Shiro Kondo) has succeeded in developing a unique ink-jet printing (IJP) technique that can produce PZT (lead zirconate titanate) (*1) in a voluntary pattern shape at 2 μ m-film thickness. The company demonstrated its functionality with an actuator (*2) created by this method. Further, Ricoh has simultaneously developed a lead-free piezoelectric material, bearing the same deformation properties as the PZT material on a silicon substrate. Both are world firsts. Combining both technologies will allow us to manufacture a lead-free piezoelectric device (*3), bearing functionality equivalent to PZT, on a silicon substrate using the IJP method at low cost and with low environmental impact.

The IJP method using ink-jet printing techniques in the manufacturing process of electronic devices has attracted much attention in recent years. It has many advantages over conventional semiconductor manufacturing processes. These include the efficient use of materials, fewer man-hours, reduced environmental impact, sharply reduced manufacturing costs, and the ability to respond to small-lot production of diverse products.

Ricoh has made PZT material, currently used extensively for piezoelectric elements, into an ink with a specific technology, and has succeeded in molding a piezoelectric pattern. The pattern demonstrates mechanical deformation properties as an actuator at 2 μ m film thickness. This thickness is about 50 times that of the film formed with the usual IJP method. This was not possible without the integration of technologies for controlling ink ejection in drawing precise patterns, modifying hydrophilicity and hydrophobicity (*4) of a substrate surface, and even, eliminating discards during firing thick film. Further, there are unique devisals on the nature of a solvent and drying speed control, which are needed to prepar film at a uniform thickness.



Actual sample of thin film formed by IJP method
The black portion is PZT. A uniform pattern is formed without line overflows.



Cross sectional image of PZT film formed at 2 μ m thickness
Layers are formed at almost regular intervals and good quality film results without voids or other internal flaws.

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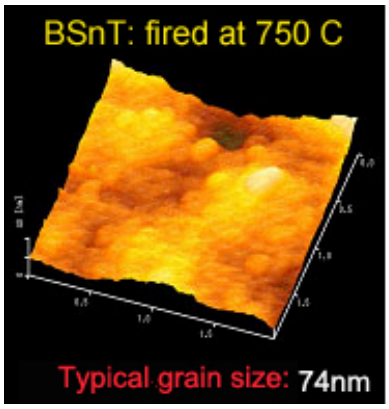
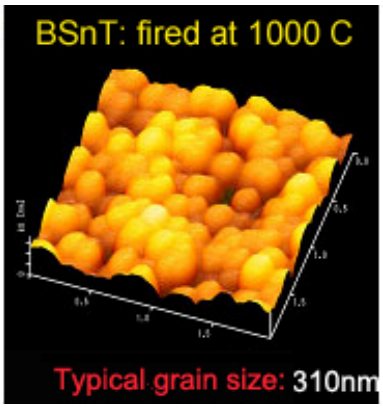
PZT has unique piezoelectric properties (*5) and ferroelectric properties. It is used in sensors or actuators such as car-navigation systems and high precision positioning devices. Although PZT contains lead, which is designated a controlled substance by the RoHS Directive (*6), PZT is exempted and often used, as there is no alternative material that matches its properties. Accordingly, although the development of lead-free materials is advancing in every direction, a practical-application level has not yet been reached.

With this project, Ricoh developed a material having about the same deformation properties (deformation amount when applied voltage) as PZT. It could be used to replace PZT. This was done in a system of materials (BSnT material) of lead-free barium titanate with tin added. This material needs to be fired at high temperature to form a high quality film. To do so, Ricoh raised the thermal stability of the under layer (electrode layer provided under the piezoelectric material) of the substrate and enabled film formation of BSnT with properties at a practical level on the silicon substrate. This enabled application as a microelectromechanical system (MEMS) and enabled modularization. The application area was significantly extended. Further, Ricoh has adopted a method to use the precursor of BSnT in liquid form, unlike the conventional powder method. Doing so allowed adoption of the IJP method to form piezoelectric film, resulting in cost and environmental advantages.





Surface morphology of the BSnT films fired at different temperatures.
(The one on the right fired at higher temperature shows larger grain size, indicating better film properties.)

Piezoelectric material has been used very broadly. We believe that combining these two technologies makes it possible to substitute the piezoelectric element of the conventional PZT, from both the material (lead-free material) and the manufacturing process (IJP method). It has both environmental and cost advantages. Ricoh will first manufacture a prototype of an actuator, then work on technical solutions, targeting commercialization.

In addition, Ricoh will announce both technologies at "The 29th Meeting on Ferroelectric Materials and Their Applications (FMA29)," a well-known conference, to be held in Kyoto May 23 to 26.

*1 **PZT (lead zirconate titanate):** A solid solution ceramic of lead zirconate and lead titanate; it is used for the piezoelectric ignition element in household gas appliances, ultrasonic transducers, piezoelectric buzzers, etc. This piezoelectric material presently has the highest versatility.

*2 **Actuator:** A mechanism to convert input energy into physical movement. An actuator, generally called, is a device to convert electrical energy into movement and is widely used for household appliances, in the aeronautics industry and in the research of artificial muscles.

*3 **Piezoelectric device:** An element expanded and contracted by applying a voltage. Further, the phenomena of deformation when a voltage is applied or of being charged when external force is applied are also called the piezoelectric effect. This is used in explaining earthquakes as well as in IT or the industrial-commodity field. Some ink jet printers adopt the piezo-electric system to produce jets of ink using expansion and contraction of this piezoelectric element. It is further applied in piezoelectric loudspeakers, which use the piezoelectric element to convert electrical signals into acoustic pressure, and in various precision instruments, such as scanners.

*4 **Hydrophilicity and hydrophobicity control:** The technology to create a hydrophilic region (area easily damped) and hydrophobic region (area hard to damp) intentionally and to mold the targeted functionalized layer only in a hydrophilic region.

*5 **Piezoelectric properties:** The property of the material deformed in the direction of the applied voltage.

*6 **RoHS Directive:** The "EU Directive on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment. It is an EU Directive to restrict the use of specific chemical substances (lead, cadmium, hexavalent chrome, etc.) in electronic equipment.

| About Ricoh |

Ricoh is a global technology company specializing in office imaging equipment, production print solutions, document management systems and IT services. Headquartered in Tokyo, Ricoh Group operates in more than 200 countries and regions. In the financial year ending March 2012, Ricoh Group had worldwide sales of 1,903 billion yen (approx. 23 billion USD).

The majority of the company's revenue comes from products, solutions and services that improve the interaction between people and information. Ricoh also produces award-winning digital cameras and specialized industrial products. It is known for the quality of its technology, the exceptional standard of its customer service and sustainability initiatives.

Under its corporate tagline, *imagine. change.* Ricoh helps companies transform the way they work and harness the collective imagination of their employees.

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