Advances in Ink Jet Printhead Development for Digital Textile Applications

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Introduction

Advances in digital color printing technology in the past decade have given designers as well as consumers more creativity in their applications. For printed textile designers, this more creative trend means more designs must be created in a shorter time and printed in smaller batch sizes at lower cost. One of the major digital color technologies contributing to this trend is the ink jet printing. Ink jet printing has become popular in home and office applications and has begun to make significant inroads into industrial printing applications. Ink Jet's potential in reducing sampling cost and time to market for the printed textile market has led many companies into the implementation of ink jet printing on textile. The recent introductions of textile ink jet printers such as Robustelli's Monna Lisa, Reggiani's DReAM, and Dupont's Artistri are some examples.

Despite major developments in the recent years, barriers such as printhead life, cost and limited ink chemistry flexibility have prevented the wide spread adaptation of ink jet printing by textile printing markets. This paper presents PicoJet's recent manufacturing technology developments using ultrasonic bonding techniques to produce a significantly more durable (and hence providing a lower operating cost) all stainless steel, piezoelectric, drop-on-demand printhead featuring large ink droplets specifically designed for textile printing. Because of the all metal construction of the device, the printheads can jet a wide variety of ink chemistries. Inks such as UV curable, water, solvent, and oil based solutions have been successfully tested. This flexibility in ink chemistry allows PicoJet printhead's to adapt more easily in applications using digital printing on textile.

Printhead Design

PicoJet printheads use the bend mode design for deformation of the piezoelectric material. In this design the piezoceramic plates are bonded to a diaphragm forming an array of bilaminar electromechanical transducers used to eject ink droplets. As an electrical field is applied to the piezoceramic, the piezoceramic expands and contracts. This action forces the diaphragm to which the piezoceramic is bonded to buckle in and out creating a pressure pulse that ejects an ink droplet from a small nozzle. Figure 1 describes the bend mode piezoelectric printhead design.

Stainless Steel Plate Fabrication

PicoJet printheads are assembled using multiple stainless steel laminates each having a unique design which when bonded together form the inner fluidic architecture of the printhead. By applying ultrasonic energy, temperature, and pressure to the stainless steel laminates; a highly durable weld is created without allowing the bonding alloy to spread into the printhead's fluid channels. This fluxless and very precise bonding process allows for the creation of a printhead stack containing all metal ink channels within 15 seconds. A photograph of the stainless steel plates is shown in Figure 2. The stainless steel diaphragm, up to 15 layers of stainless steel ink channel and manifold plates, and a stainless steel nozzle plate are ultrasonically bonded together at a same time to form the basic fluidic structure of the printhead. Figure 3 presents a SEM photograph of a cross sectioned printhead stack.

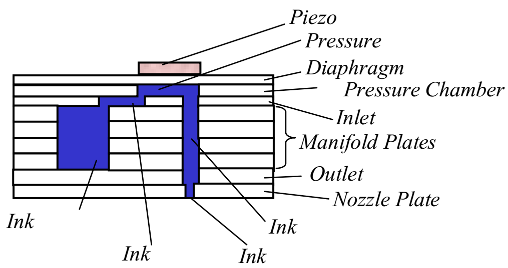

Figure 1. Bend mode printhead design

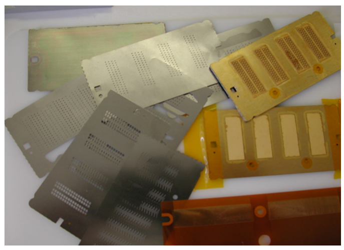

Figure 2. Stainless steel plates

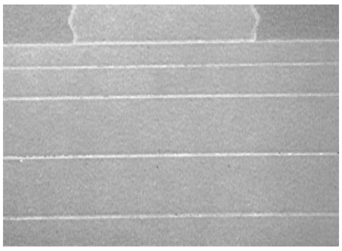

Figure 3. Jet Stack cross section

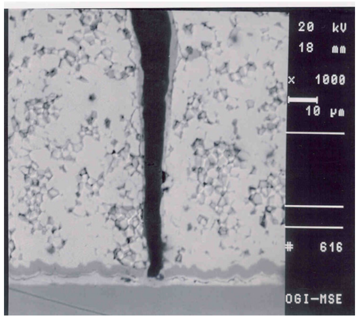

Figure 4. Piezoceramic cross section

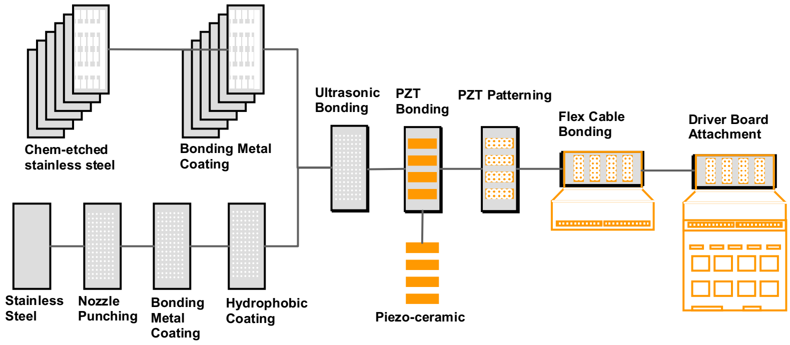

Figure 5. PicoJet's printhead manufacturing processes flow

Piezoceramic Bonding

The next step in the printhead fabrication process is piezoceramic bonding. In a bend mode printhead design, for the jet-to-jet performance uniformity, the piezoceramic plates not only have to be strongly bonded to the stainless steel diaphragm, but also need to be precisely aligned with the ink chambers below. A high speed and high resolution diode-pumped laser is used to align and cut the piezoceramic plates. In a few minutes, 256 individual piezoceramic pieces can be patterned uniformly in size and shape and in direct alignment above the 256 ink chambers located below. A SEM photograph of a cross section of the patterned piezoceramic on a stainless steel diaphragm is shown in Figure 4.

Manufacturing Process Flow

PicoJet's overall printhead manufacturing processes flow is presented in Figure 5. A fully automated fabrication plan for these manufacturing processes can be built to significantly reduce the cost of manufacturing the printhead.

Conclusion

The recent advances in PicoJet's printhead manufacturing technology allow for the production of a more robust printheads. As a result of the use of all metal printhead construction materials, a wide variety of inks have been successfully tested in the laboratory. PicoJet's printhead technology advances including more robust jetting capability, greater flexibility in ink chemistry, and potential for fully automated production will remove the existing printhead barriers so that ink jet printing for textile markets can be widely used in the near future.

Biography

Hue Le is the CEO/President of PicoJet, Inc., Hillsboro, OR (www.picojet.com) which designs, manufacturers and markets fluid jetting devices for industrial printing, as well as micro-dispensing systems for electronic materials, biotechnology equipment and drug delivery applications. He has over 23 years of experience in developing and commercializing ink jet products in the digital color printing industries. Hue Le holds 18 US patents in the field of ink jet printing technology. Prior to forming PicoJet, Inc. in 1997, Hue held the position of Director of Technology Development for Tektronix, Inc.'s Printing and Imaging Division (1990-1996) where he was responsible for technology development that has been commercialized in Tektronix and Xerox Phaser Color Ink Jet printers.