Piezoelectric and Other Drop Ejection Technologies for Drop-On-Demand Inkjet

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Abstract

Drop-on-demand (DOD), or impulse, inkjet has been in practical use as a printing and deposition technology for over thirty years. The popularity and growth of this technology can be attributed to evolutionary improvements in the physics of operation, materials, and ink or fluid chemistry. In addition to traditional desktop printing, DOD inkjet is finding acceptance in the areas of industrial printing and digital fabrication. In general, most applications of DOD inkjet technology have centered on thermal and piezoelectric technology as actuators for drop ejection. However, other types of actuators such as thermal membrane, electrostatic membrane and electrostatic inkjet may provide advantages in a more specific range of applications. Although this paper will focus on piezoelectric actuators, a review of the history, physical principles, and current state of each type of inkjet actuator is presented. Thermal inkjet made DOD technology and color graphics available to millions of users on the desktop as well as many other printing applications. Low cost piezoelectric technology entered the marketplace just prior to the rising wave of digital fabrication and materials deposition applications. The wider materials compatibility has led to broader use of piezoelectric inkjet in industrial applications. The physics of the piezoelectric inkjet drivers and the efficacy of the technology for printing applications are also reviewed. Links are drawn between the deformation modes and the varieties of actuation chamber design. Simple one dimensional acoustic theory can be used to model the propagation of pressure waves induced by piezoelectric actuation. The use of multi-pulse waveforms for the control of drop formation is discussed. Free boundary fluid models describe the interaction of pressure wave energy and surface tension that leads to an ejection of a small volume of fluid. Two-phase fluid models describe the dynamics of drop flight, including the formation of satellites and the consequences of drop size modulation techniques. A model of drop placement accuracy is presented. The techniques and tools of piezoelectric inkjet characterization are reviewed, including advances in imaging techniques and the emerging use of modeling and simulation as a primary tool in an iterative design-simulate-prototype-test printhead development process. These explicit models have allowed the successful development of miniaturized piezoelectric designs fabricated with MEMS techniques, which represent the state-of-the-art and future of piezoelectric inkjet. Lastly, the paper will view these significant milestones and technological advances in light of how inkjet technology might influence the future.

Biography

Ross N. Mills is currently Chairman of the Board of Directors and Chief Technical Officer of imaging Technology international (iTi) Corporation. He received his Ph.D. and M.S. Degrees in Engineering Science from the University of California Berkeley and his B.S. Degree in Aerospace Engineering with Honors from the University of Texas at Austin. Since 1978 he has worked on digital printers for IBM, Lexmark International, and Topaz Technologies as well as iTi. In 1992, he founded iTi Corporation in Boulder, Colorado for advanced applications of ink jet in digital fabrication. Dr. Mills has twelve patents in this field and he is the inventor of iTi's proprietary ESIJET™ technology.

Philip Branning is lead software engineer for development tools at iTi. He received his B.S. degree in Computer Science and Mathematics from Vanderbilt University School of Engineering in 2003, and since has worked in the fields of human vision research, modeling and simulation, and machine vision.