2.4.4 INK-JET PRINTING

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1. INTRODUCTION

Microprinting involves the delivering of a small volume of a fluid material, typically in the pico- to nanoliter range, onto a solid target. The technologies for spotting such fluids onto a substrate fall into two distinct categories: contact and non-contact dispensing [1].

Contact printing includes solid pins, capillary tubes or microspotting devices. The pin tools are dipped into a sample solution resulting in a transfer of a small amount of fluid onto a flat or a concave bottom tip of the pins. The pins are then brought in contact with the substrate and leave a spot when moved away with a size as small as about 75 μm.

Non-contact dispensing involves the ejection of droplets from a dispenser, the most common systems using ink-jet printing technologies derived from devices used for printing inks onto a paper. A recent review of this technology was given by Le [2]. Several systems are available. The most versatile one includes a piezoelectric ceramic transducer positioned around a glass capillary connected to a fluid reservoir. By applying a voltage pulse, the transducer is deformed and squeezes the capillary which ejects a small amount of fluid from its tip, typically of the order of hundreds of picoliter. Several thousand drops can be delivered every second (drop-on-demand technology). Figure 1 shows a scheme of the process as well as a stroboscopic picture of drops ejected by the nozzle.

Systems using a stream of a liquid which breaks up into uniform drops by the application of capillary waves induced onto the jet by an electromechanical device are also available. These drops can be electrostatically charged so that their trajectory can be deflected by another electrostatic field. Such systems are referred as "continuous" because the drops are continuously produced with size as small as 6 μm and as large as 1 mm.

Other systems use a syringe-solenoid technology. A well determined amount of a fluid is delivered by a pressurized syringe connected to fast micro-solenoid valves. The minimum amount of liquid dispensed is larger (a few nL) and the throughput is slower but, given the positive displacement nature of the mechanism, the reliability of the system is higher.

In all systems, xy arrays of drops can be precisely dispensed by for instance moving the substrate below the nozzle by a fast xyz positioning stage in combi-
nation or not with a multinozzle system. Some commercial dispensers can be also slightly heated so that low melting point metals or polymers drops can be delivered [3] (hot melt ink-jet deposition).

Figure 1. Scheme of the drop-on-demand ink-jet printer (left) and stroboscopic picture of drops ejected from the tip of a Microdrop nozzle (size of the drops about 200 pL for a 65 μm diameter).

These microprinting techniques find today many applications [4] to print for instance array of very small spots of DNA [1], polymeric or organic light emitting diodes [5], for solid free body forming [6], for combinatorial approach in the search or in property adjusting of materials [7], for microlens fabrication [8-10], for ceramic decor fabrication [11-16], for the fabrication of transistor circuits [17], for printing micropads and vertical interconnects [18], etc.


2. SOL-GEL INKS

The sol-gel process is a potentially interesting method to produce inks. Typical inks to be used with a piezoelectric demand-mode device require a viscosity of 0.5 - 40 cp and a surface tension of 20-70 dyne/cm. A Newtonian behavior is not strictly required but the fluid properties at the orifice of the nozzle must be in the above range. Viscoelastic behavior causes significant problems. The use of ink containing particles or agglomerates are acceptable as long as their size does not exceed 5% of the orifice diameter as instability in the drop generation will occur. Sols which have a high tendency to gel must be avoided as they will rapidly block the thin nozzles.