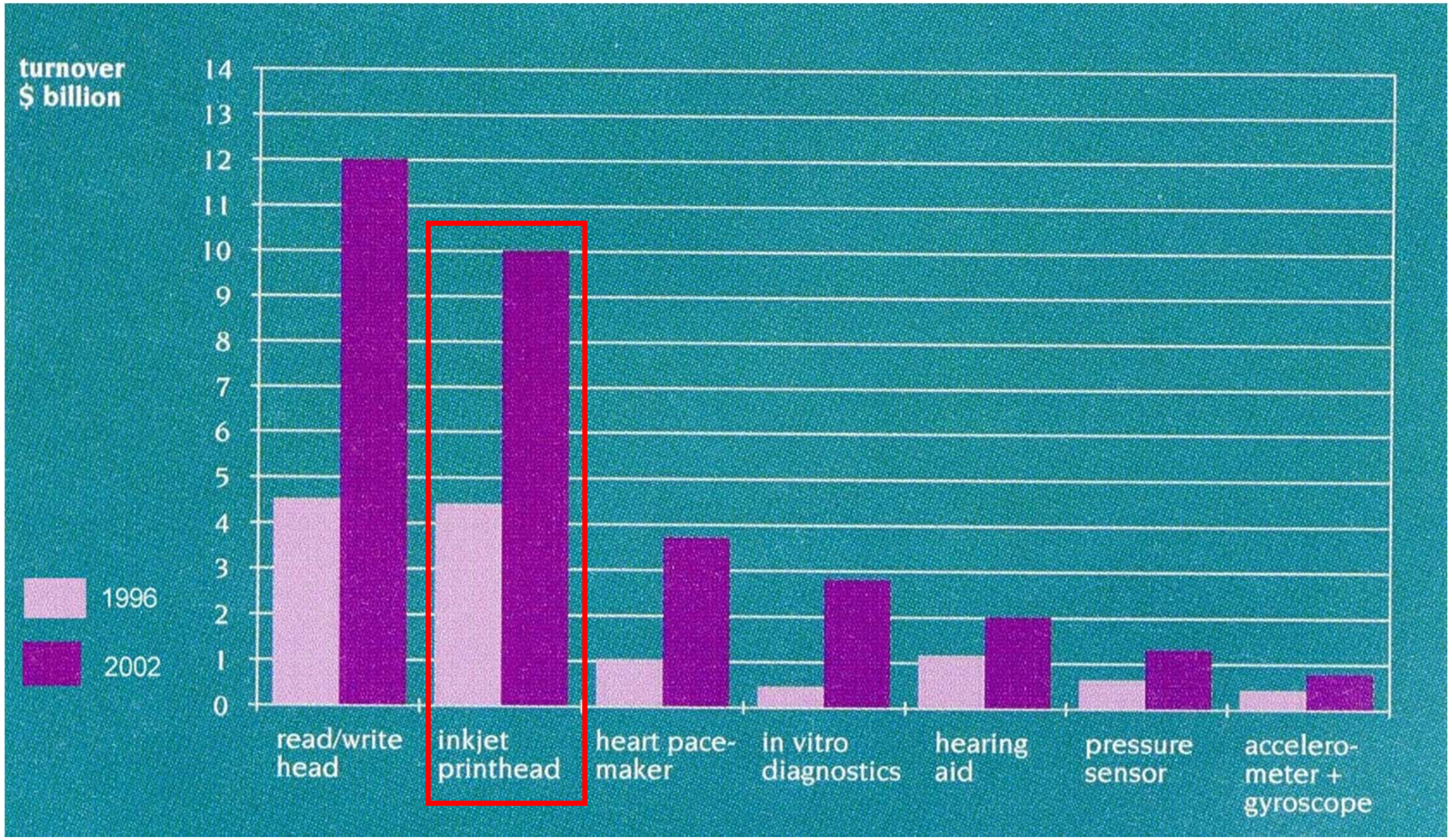
# Contents

# Ink-Jet: Definition

The ink-jet technology is a **contact free dot matrix** printing procedure. **Ink** is issued from a **small aperture** directly onto a **specific position** on a **medium**.

***Quelle:*** **Hue P. Le, Journal of Imaging Science and Technology · Volume 42, Number 1, January/February 1998**

# MST-Market Study



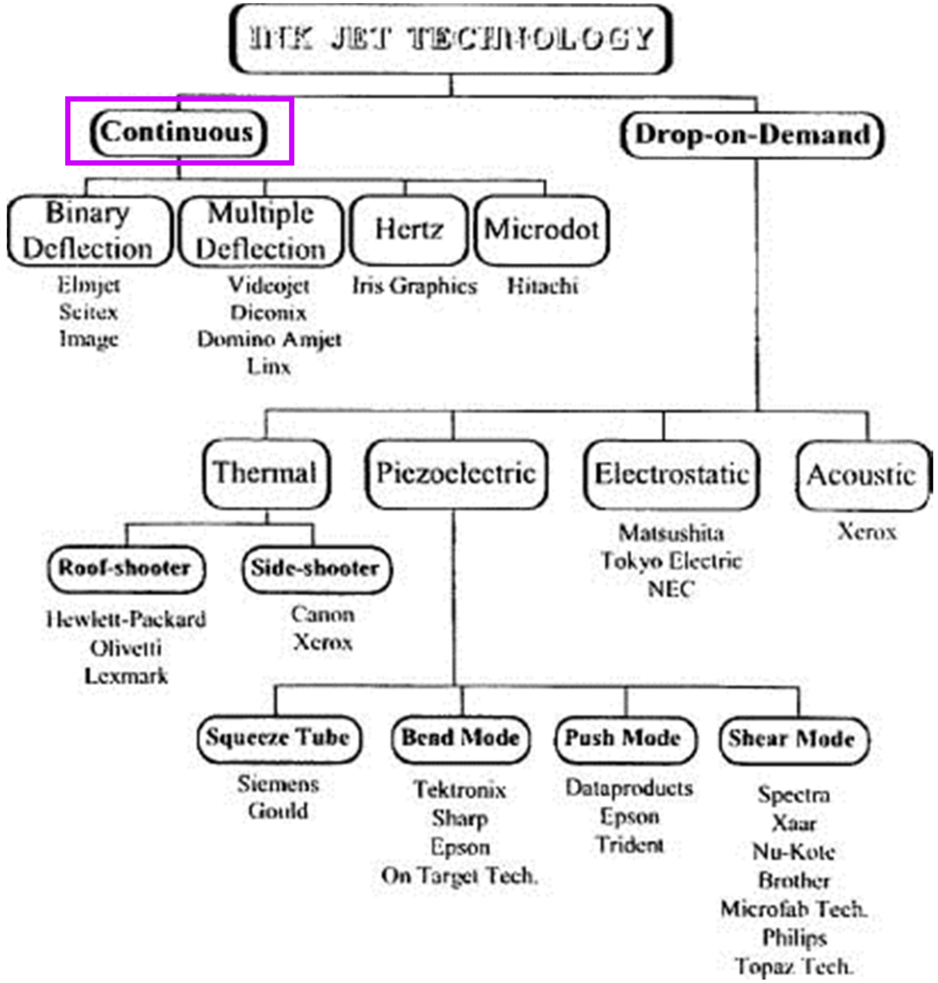

**NEXUS**

**Market analysis for microsystems 1996 - 2002**

# Commercial Engagement

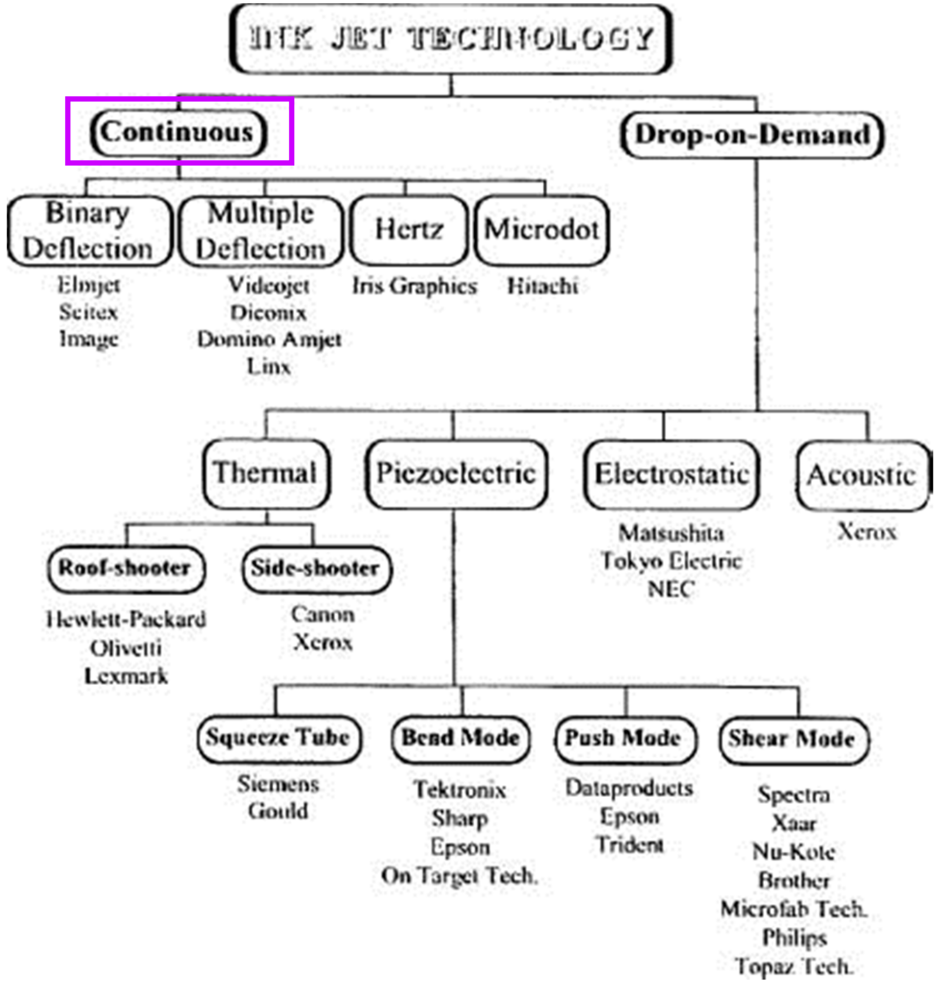
# 8. Ink-Jet Technology

1. Continuous Inkjet Technology (cIJ)
2. On-Demand Technology
3. Inkjet Ink Technology



# 8.1. Continuous Inkjet Technology (cIJ)

1. Background
2. Droplet Delivery
3. Hertz-Type Inkjet
4. Applications



# 8.1.1. Ink-Jet Technology: History (1)

- 1878: Lord Rayleigh
  - Breaking of liquid jets into individual droplets
  - [On the instability of jets, in Proc. London Math. Soc. 10 (4), 4–13 (1878)]
  - Surface-tension related stable minimum of energy

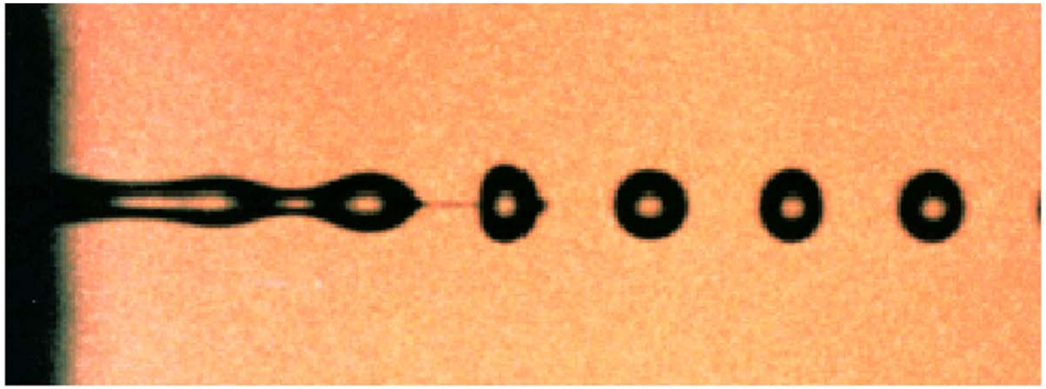


**Fig. 8.1.** Rayleigh instability in a liquid jet issued by a continuous inkjet printer at 10 kHz. The orifice diameter and the initial jet measures 50 µm, after the break off the droplets possess about twice the diameter of the orifice

# 8.1.1. Minimum of Surface Energy

- Liquid surface
  - Sphere (droplet)
  - Radius *r*
  - Surface area *A*

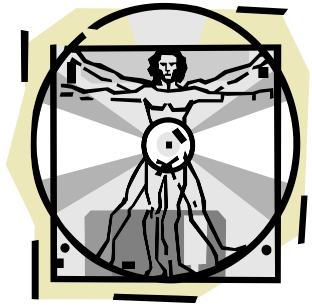
$$E = \sigma A = 4\pi r^2 \sigma = 4\pi \left( \frac{3}{4\pi} \right)^{2/3} \sigma V^{2/3}$$

- Surface energy of *N* droplet of same overall volume

$$E_{\text{droplets}} = N E_{\text{drop}} = N^{1/3} E_{\text{jet}} \overset{N>1}{<} E_{\text{jet}}^{\text{sphere}}$$

- Hydrodynamic stability / metastability?
  - Perturbations

# 8.1.1. Ink-Jet Technology: History (2)



- 1951: Elmqvist from Siemens files first patent for device based on  Rayleigh principle
  - „Measuring instrument of the recording type“, U.S. Patent 2566443 (1951)
  - Mingograph: first ink-jet based writer for recording analogue voltage signals

- Early 1960s: Sweet (Stanford University)
  - Distinct pressure wave patterns
  - Applied to orifice of liquid column
  - Jet breaks up into equally spaced droplets of same volume

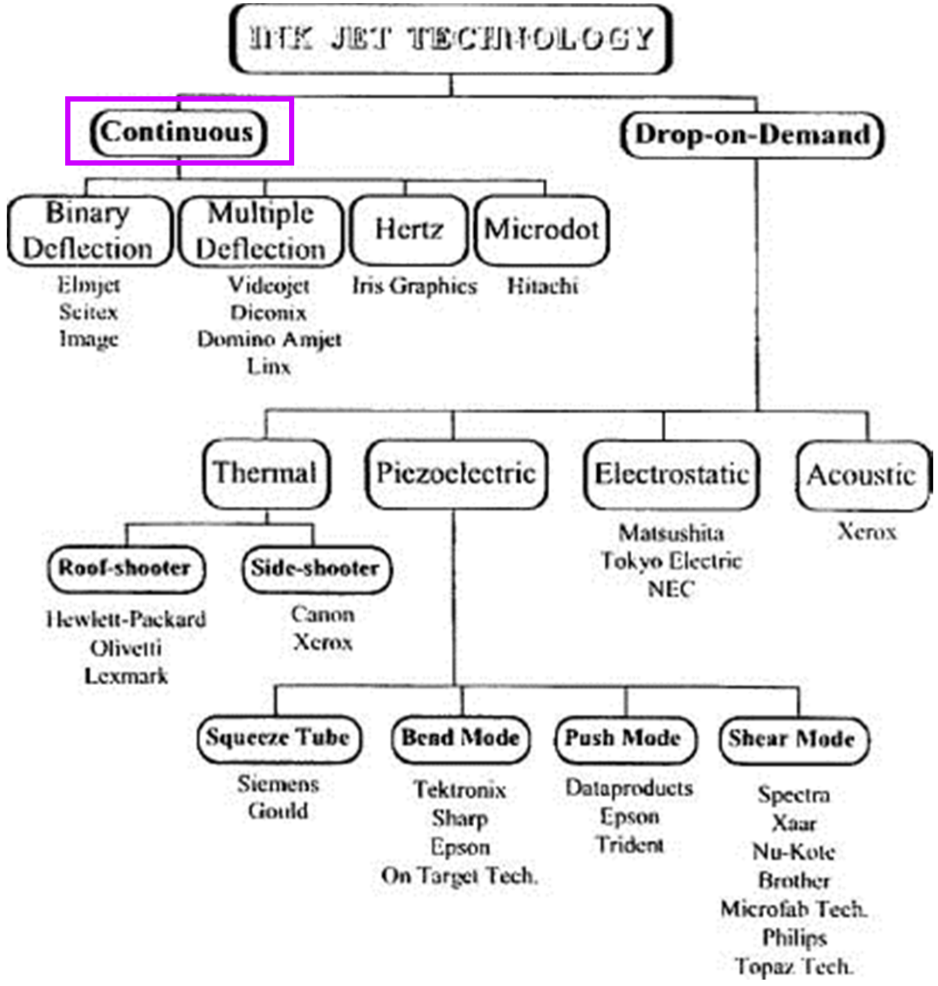
# 8.1.1. Ink-Jet Technology: History (3)

- Continuous Ink-Jet Technology (cIJ):
  - ➢ Dedicated charging of droplets
  - ➢ Recirculation by deflection in transversal electrical field
  - ➢ Products: A. B. Dick VideoJet und Mead DIJIT

- 1970s: IBM licenses continuous ink-jet technology
  - ➢ Massive development efforts at IBM to establish ink-jet technology for their printers
  - ➢ 1976: IBM 4640 (Word-Processing Hardcopy-Output application)

# 8.1. Continuous Inkjet Technology (cIJ)

1. Background
2. Droplet Delivery
3. Hertz-Type Inkjet
4. Applications



# 8.1.2. cIJ: Setup

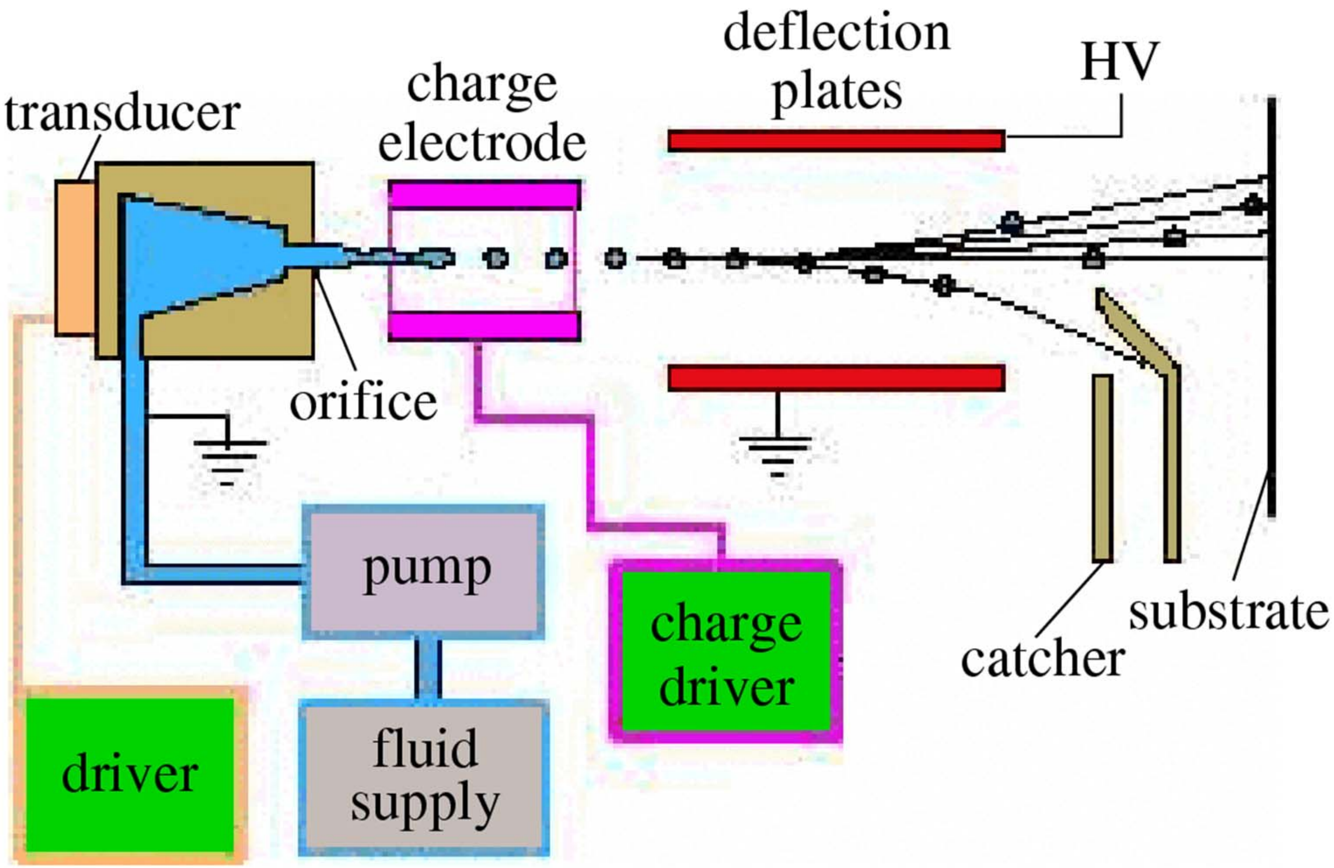
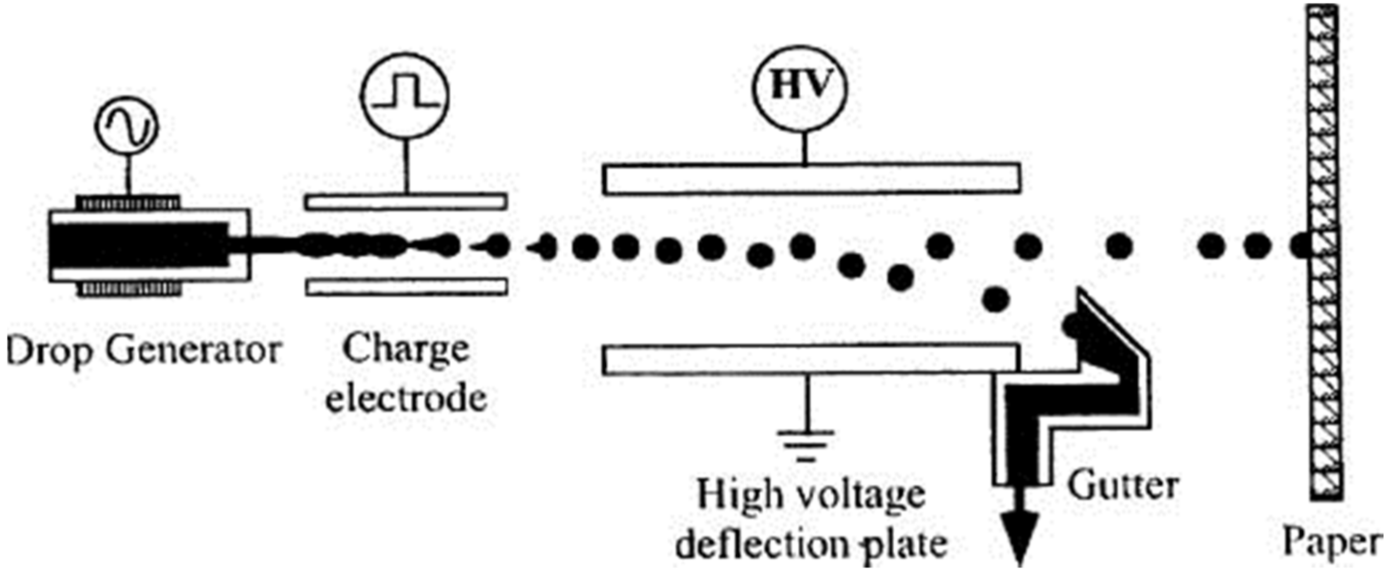


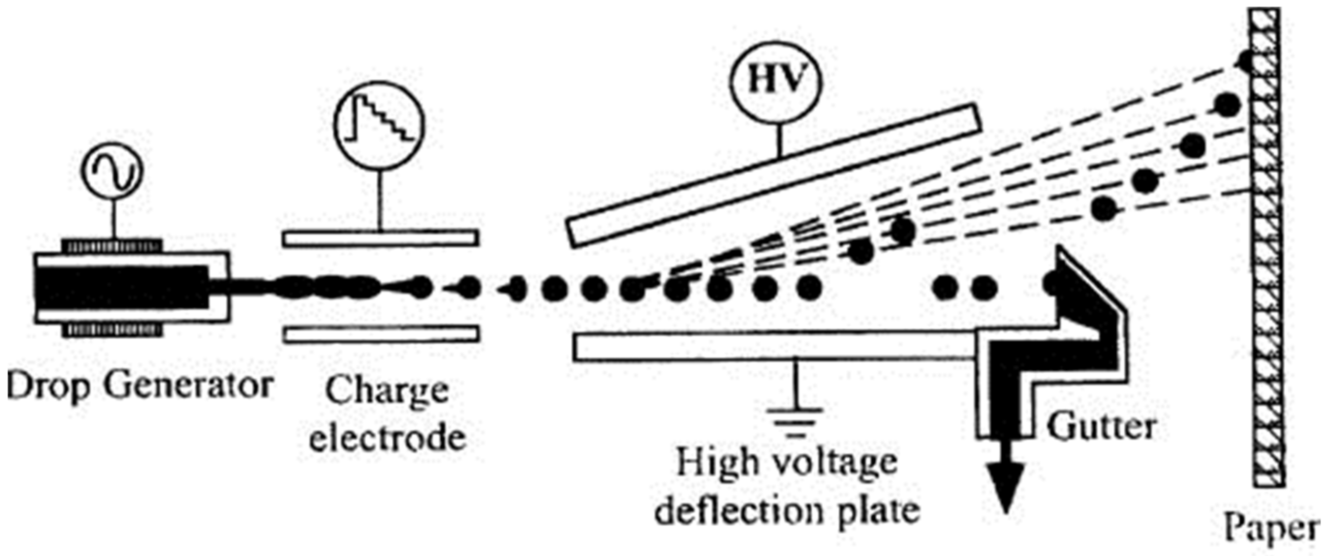

**Fig. 8.2.** Setup of a continuous inkjet printer (cIJ). The substrate moved into the paper plane

# 8.1.2. cIJ: Binary Deflection




- Uncharged droplets dispensed on substrate
- Charged droplets recirculate

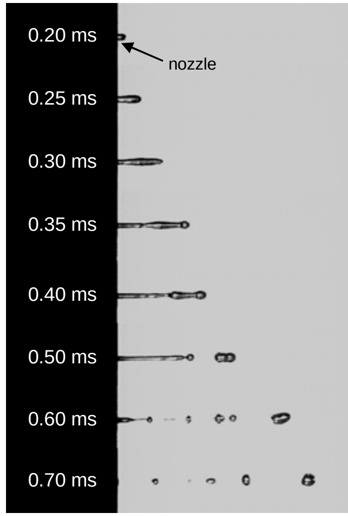
# 8.1.2. cIJ: Multiple Deflection

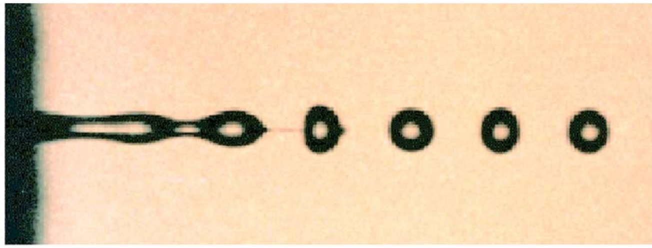



- Uncharged droplets recirculated by gutter
- Charged droplets deflected according to *q* / *m*-ratio
- 2-dimensional writing of small areas with single nozzle

# 8.1.2. Droplet Delivery

- Droplet formation
  - Emission of cylindrical plug from orifice
  - Varicosity
    - Sectioning into thinner and thicker zones
  - Ligaments break
    - Electrical connection to print head cut
- Stimulated break-off
  - cIJ: disintegration induced by regular wave patterns applied to orifice
  - Growth of perturbations
  - Predetermined breaking points
  - Critical parameters



Weber number

$$We = \frac{\varrho v^2 l}{\sigma}$$

$E_{kin}$

surface tension

Reynolds number

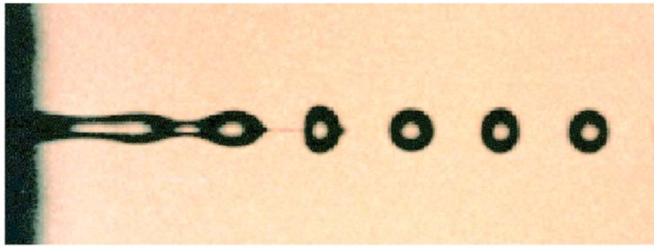
$$Re = \frac{\varrho_\infty \tilde{v} \tilde{l}}{\eta} = \frac{\tilde{v} \tilde{l}}{\upsilon}$$

$E_{kin}$

viscosity

# 8.1.2. Droplet Delivery

- Droplet sizes and rates
  - Orifice diameter typically 50 µm to 80 µm
  - Droplet diameter roughly exceeds orifice diameter by factor of two
  - Droplet sizes below 150 µm common
    - Volumes between 4 fl and 1 pl
  - Droplet frequencies in order of 100 kHz
  - Special devices up to 1 MHz
- Satellite droplets
  - Frequently formed
  - High *q* / *m* ratio
    - Large deflection
  - Erroneous droplets



- Droplet deflection
  - Charging by passing electric field
  - Ring or tunnel electrode

# 8.1. Continuous Inkjet Technology (cIJ)

1. Background
2. Droplet Delivery
3. Hertz-Type Inkjet
4. Applications

# 8.1.3. Hertz-Type Inkjet

- History
  - Separate branch of cIJ technology
  - Developments at Lund Institute (S) in late 1960s
  - ~1976: device by Hertz et al.
  - cIJ-procedure with gray-scale capability
  - License for Iris Graphics and Stork which develop color ink-jet
  - Later licensed by Iris Graphics and Stork
- Working principle of gray-scaling
  - Multiple droplets dispensed on same spot
  - Control of number of droplets forming single drop
  - Differential charging of continuous droplet stream
  - Mutual repulsion of droplets
  - Further downstream, plate catches deflected droplets
  - Drawback: slightly gray background surrounding dots
  - High droplet rates
  - Continuous half-tone scheme

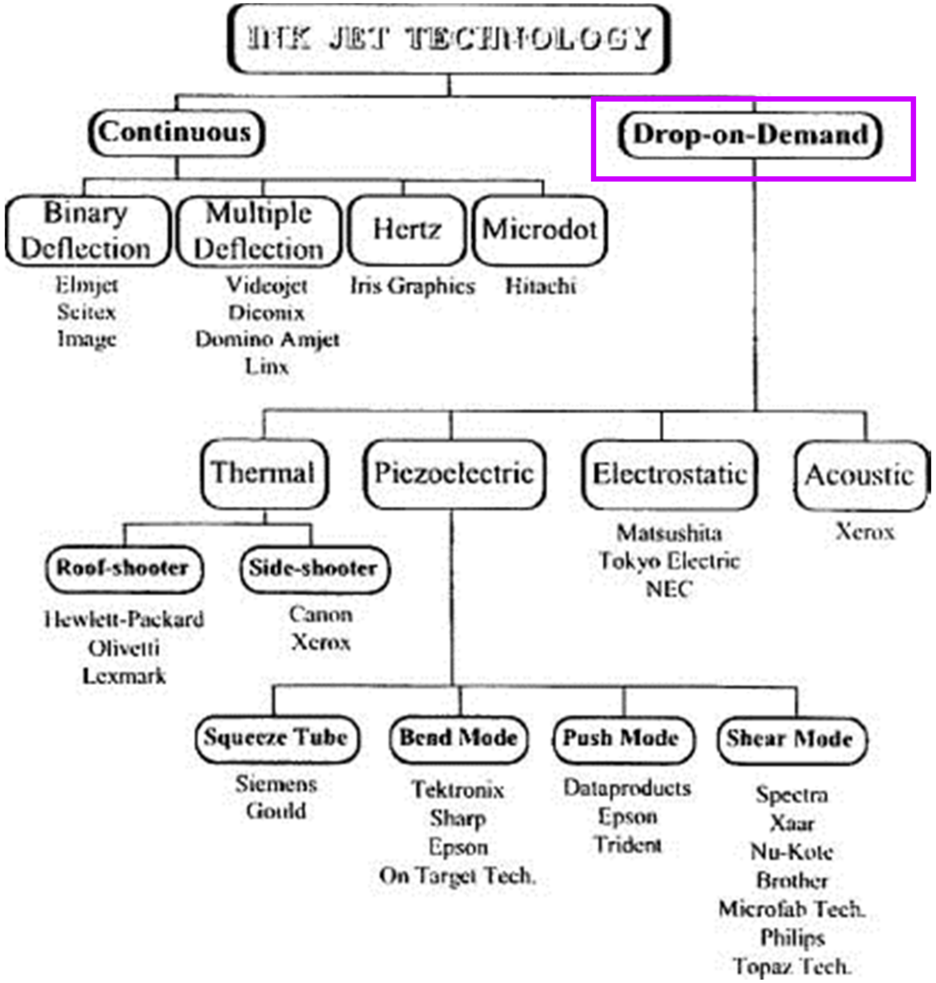
# 8.1. Continuous Inkjet Technology (cIJ)

# 8.1.4. Applications

- Drawbacks
  - ➢ Complex recirculation
    - Prone to errors
    - Expensive
  - ➢ Deflection according to charge-to-mass ratio
    - Limited accuracy
  - ➢ Necessity of charging
    - Restriction to conducting ink formulas
- Summary
  - ➢ High-speed printing
  - ➢ Low quality
  - ➢ Rather expensive systems
- Applications
  - ➢ Industrial small-character printing (SCP)
    - High throughput
    - Low resolution

# 8. Ink-Jet Technology

1. Continuous Inkjet Technology (cIJ)
2. On-Demand Technology
3. Inkjet Ink Technology



# 8.2. On-Demand Technology

1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet Nozzleplate by Microparts

# 8.2.1. Ink-Jet Technology: History (4)

- 1970s: On-Demand (DoD) Technology
  - ➢ Advantage: error-prone charging and recirculation obsolete
  - ➢ Pressure generated by voltage pulse applied to piezo element
  - ➢ Pioneering work
    - By Zoltan, Kyser und Sears
  - ➢ Products
    - Siemens (PT-80 serial character printer,1977)
    - Silonics (1978)

- Up to early 1980s: problems of IJ-technology
  - ➢ Clogging of nozzles
  - ➢ Inconsistencies in printing quality

# 8.2.1. Ink-Jet Technology: History (5)

- 1979: Canon invents bubble-jet (BJ) technology
  - ➢ Pressure built up by expanding vapor bubble above small heat element
  - ➢ High precision due to microtechnological fabrication
- ~1979: Hewlett-Packard
  - ➢ (Independently) develops on-demand impulse method
  - ➢ Termed „thermal Ink-Jet“
- 1984: ThinkJet by Hewlett Packard
  - ➢ First commercially successful low-lost printer based on BJ-principle
  - ➢ Disposable cartridges elegantly eliminate reliability problem
- Late 1980s: IJ-technology replaces dot-matrix pin printers to conquer low-cost market of rapidly expanding PC industry
- 1990s: low-cost color ink-jet printer become standard equipment in home and office solutions

# 8.2.1. Impulse Methods

- Mechanism of droplet formation
  - Thermal
  - Piezo-electric
  - Electrostatic
  - Acoustic

- Thermal and piezo-electrical principles primarily used

- Electro-static and acoustic principles under development
  - Many patents
  - Few commercial products

# 8.2.1. Impulse Method: Setup

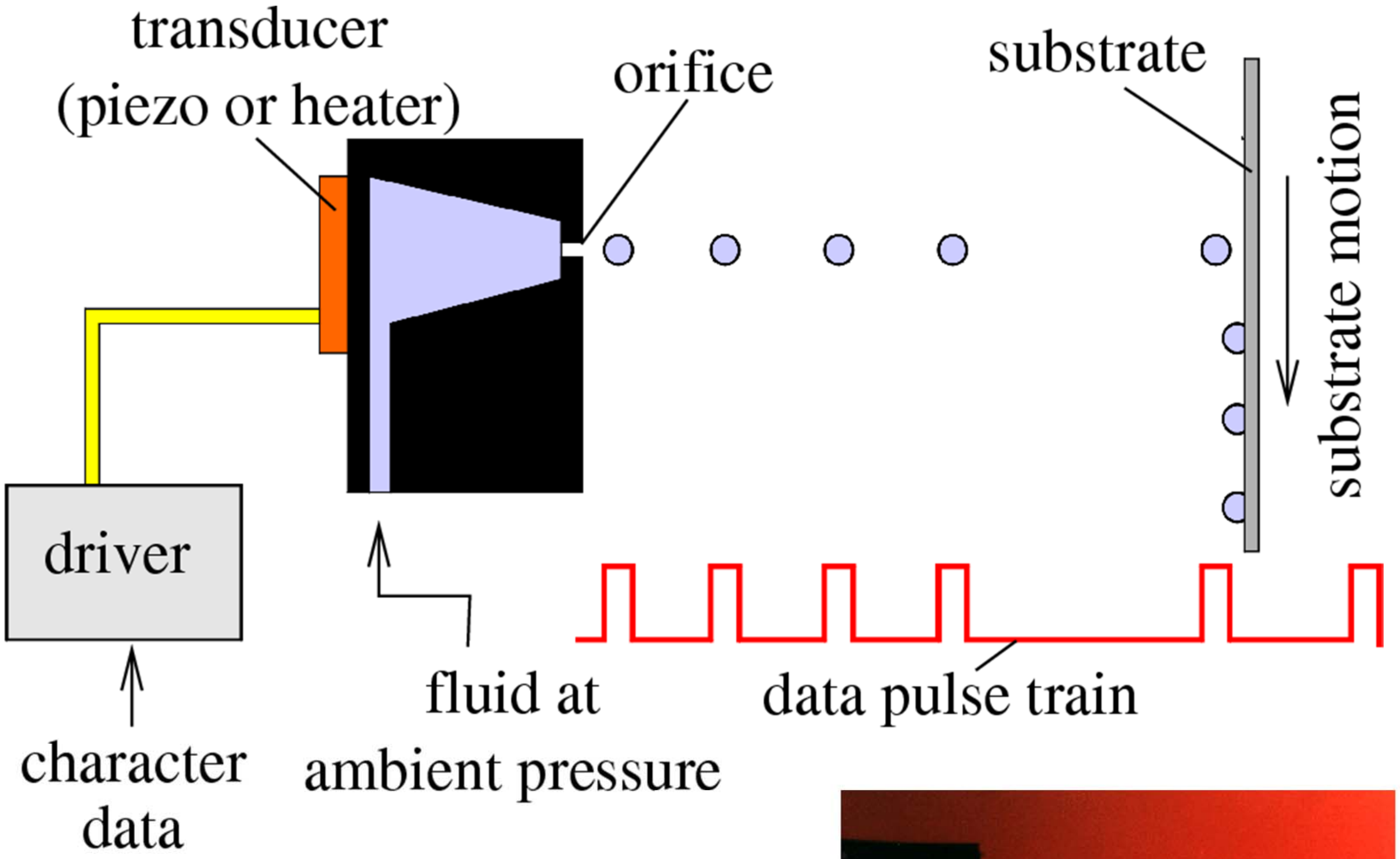



**Fig. 8.3.** Impulse technology

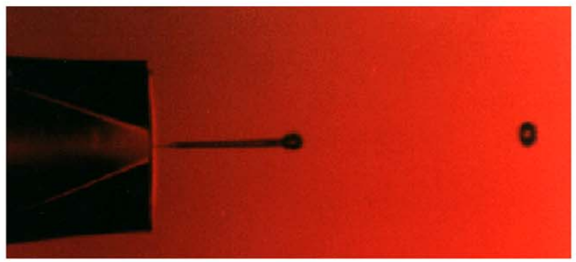


**Fig. 8.4.** Droplet formation in impulse-type devices. The 50-μm droplets are issued from an orifice of the same diameter at a frequency of 2 kHz

# 8.2. On-Demand Technology

1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet Nozzleplate by Microparts

# 8.2.2. pIJ: Droplet Formation

- Acoustic pressure wave
  - Pressure drop due to viscosity
  - Pressure drop due to surface tension
- Dynamic pressure (kinetic energy)

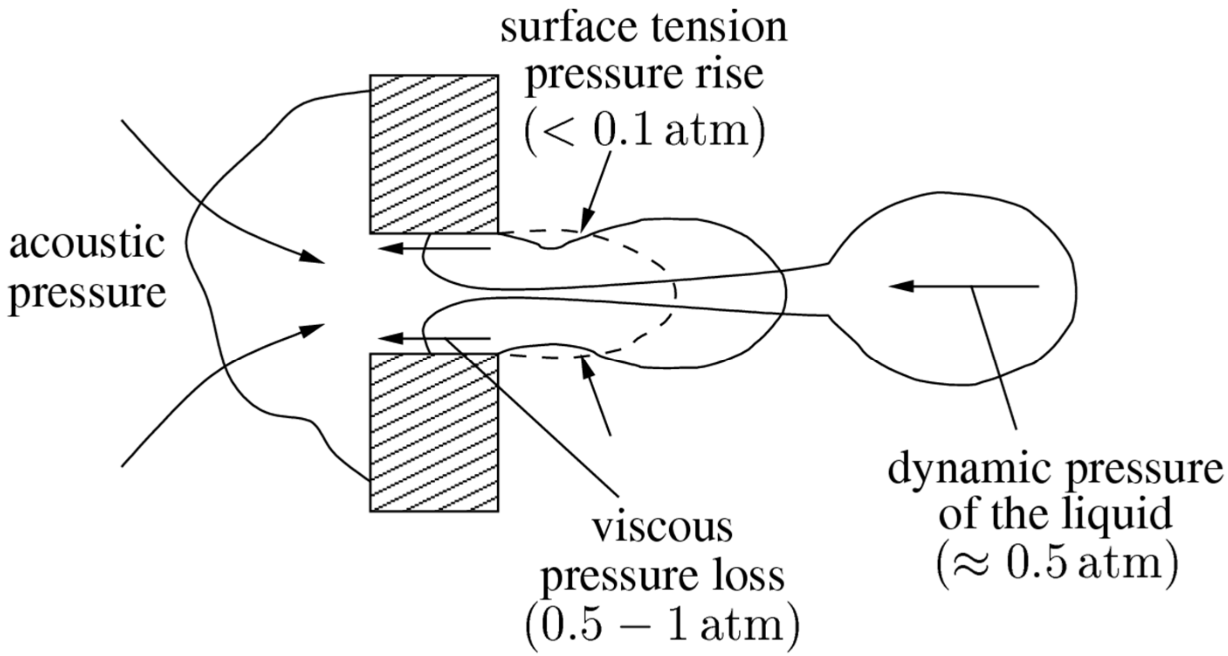


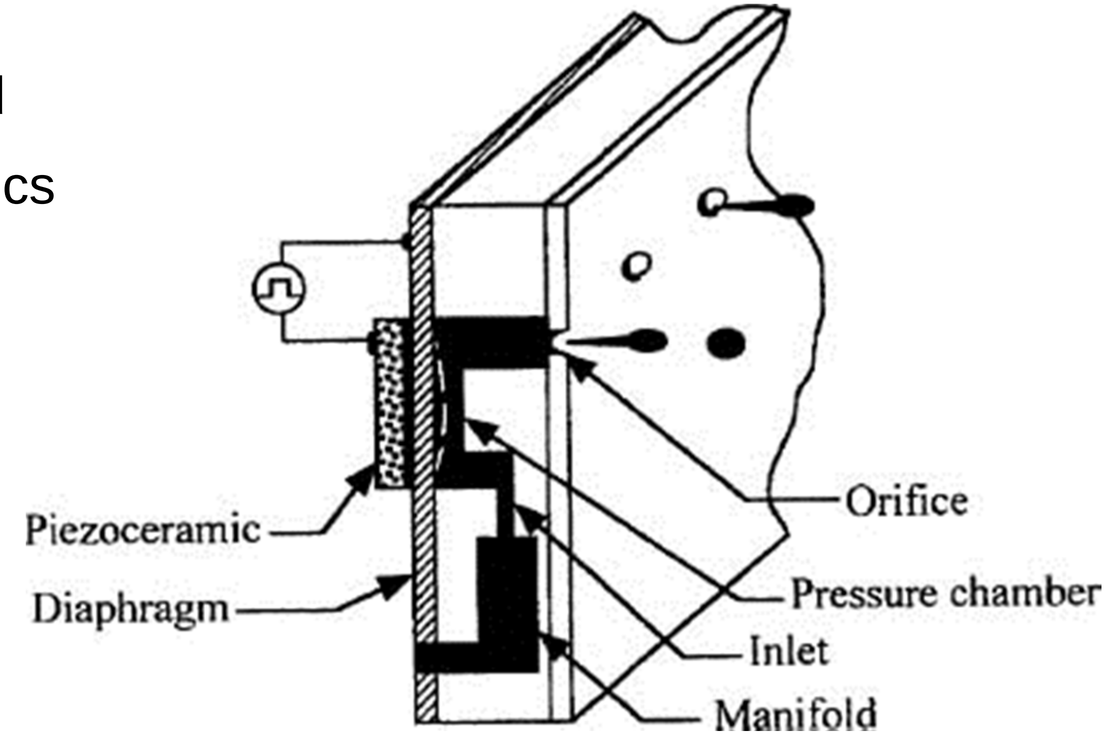

**Fig. 8.5.** Pressures governing the ejection dynamics of a liquid jet out of a nozzle

# 8.2. On-Demand Technology

1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet Nozzleplate by Microparts

# 8.2.3. Piezo-Electric IJ: Principle

- On-demand impulse method
- Deformation of piezo-ceramics
- Change in volume
- Pressure wave propagates to nozzle




- Problem of pIJ-Technology
  - Deflection of piezo-ceramics in sub-µm range
  - Piezo-element has to be much larger than orifice
  - Main problem: miniaturization

# 8.2.3. pIJ: Modes of Deformation for Piezo-Ceramic Plate

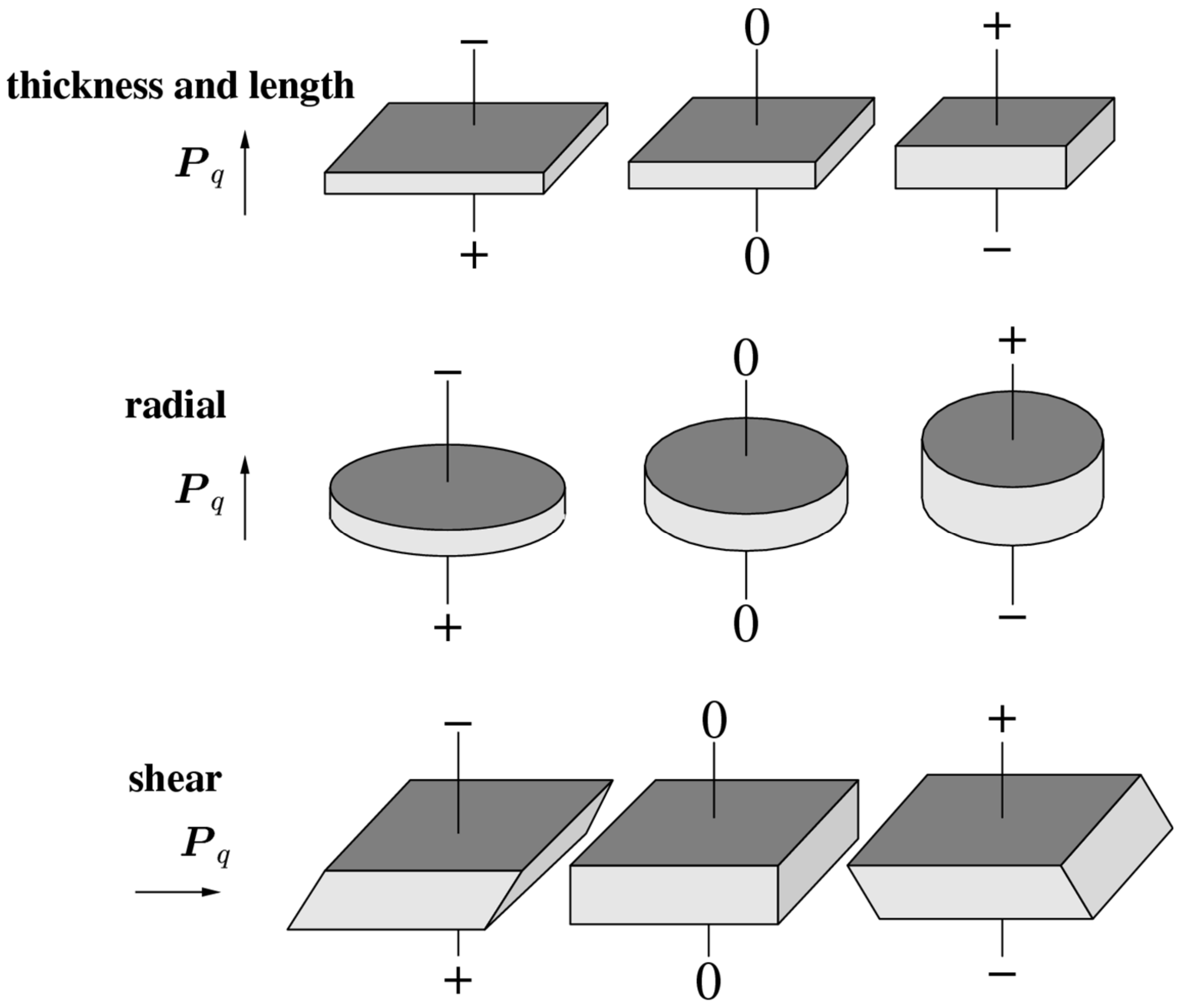



**Fig. 5.20.** Basic deformation modes of piezo-actuators

# 8.2.3. pIJ: Types

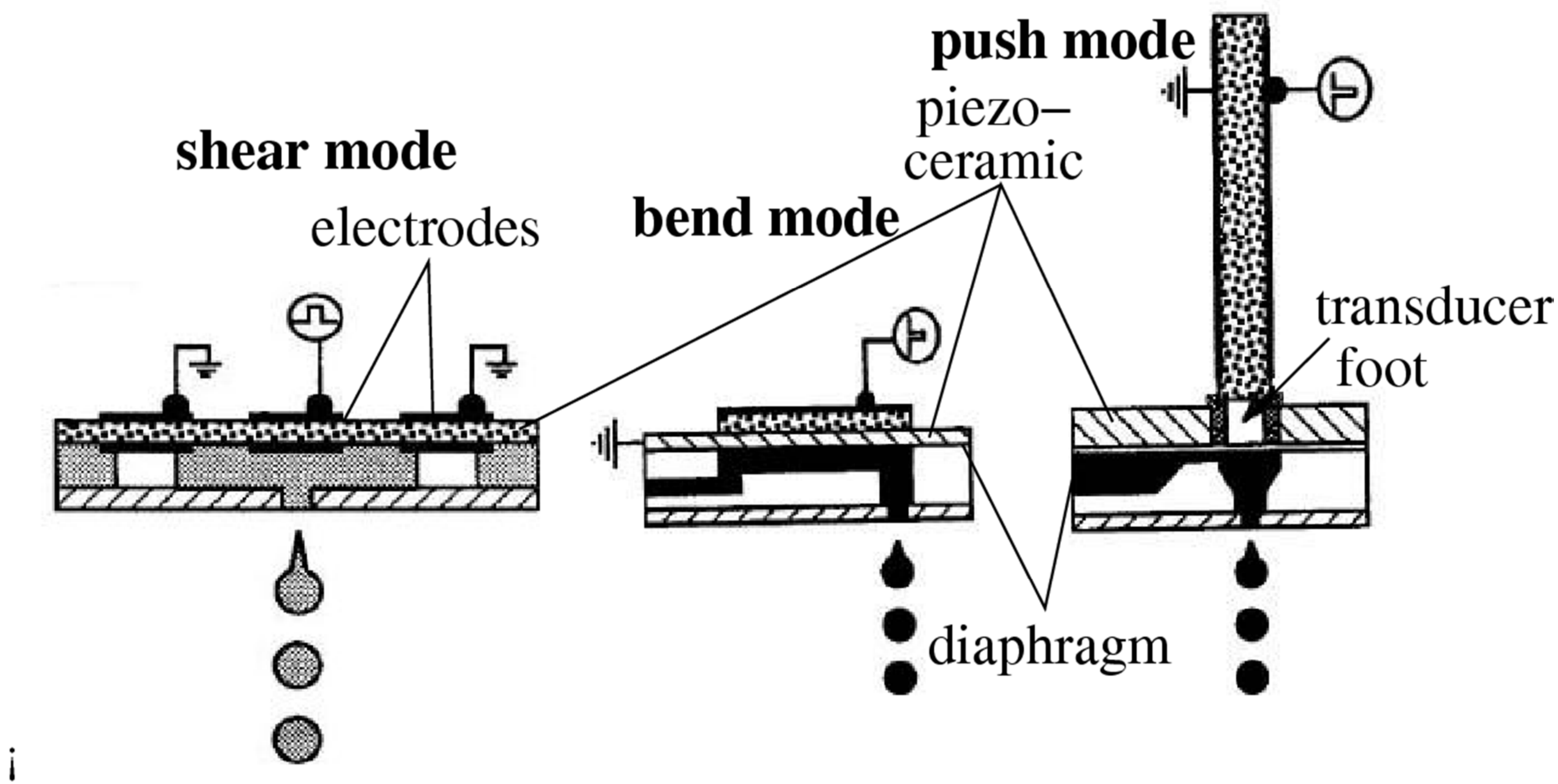



**Fig. 8.6.** Piezo-modes in inkjet printheads

# 8.2.3. pIJ: Squeeze-Mode

- Thin piezo-ceramic tube surrounds glass nozzle
  - Gould´s Impulse-Ink-Jet

- Piezo-ceramic tube cast in plastics surrounds ink channel
  - Siemens PT-80 (1977)
    - Matrix composed of 12 nozzles
    - Innovative service station
    - First truly successful office ink-jet printer
  - Development of 32-nozzle follow-up printhead failed due to problems with nozzle-to-nozzle uniformity

# 8.2.3. pIJ: Bend-Mode

- Piezo-ceramic platelet bonded to diaphragm
  - Bi-laminar electro-mechanical transducer
- Voltage pulse (E || P) generates droplet
- Tektronix Phaser 300 and 350 and
  Epson Color Stylus 400, 600, 800

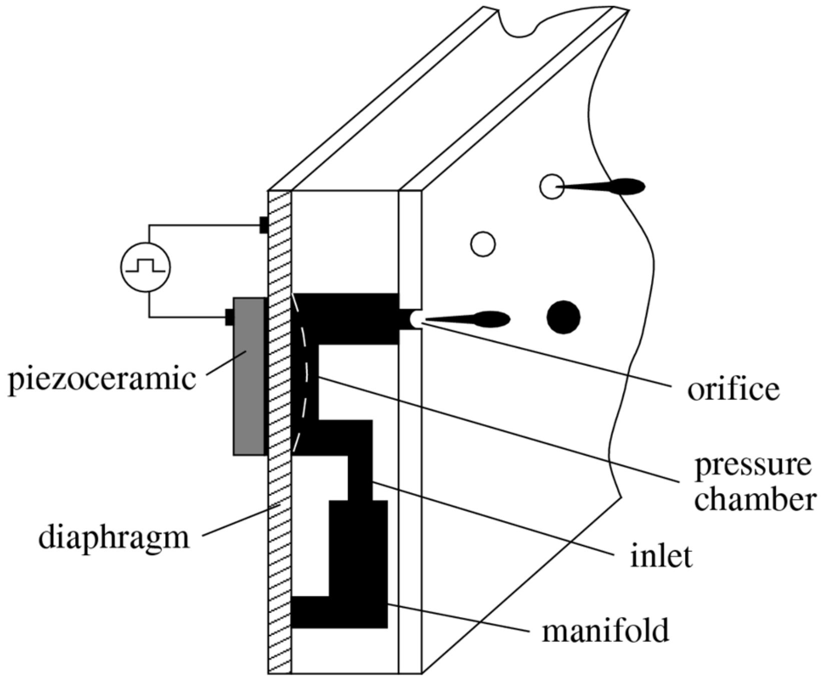


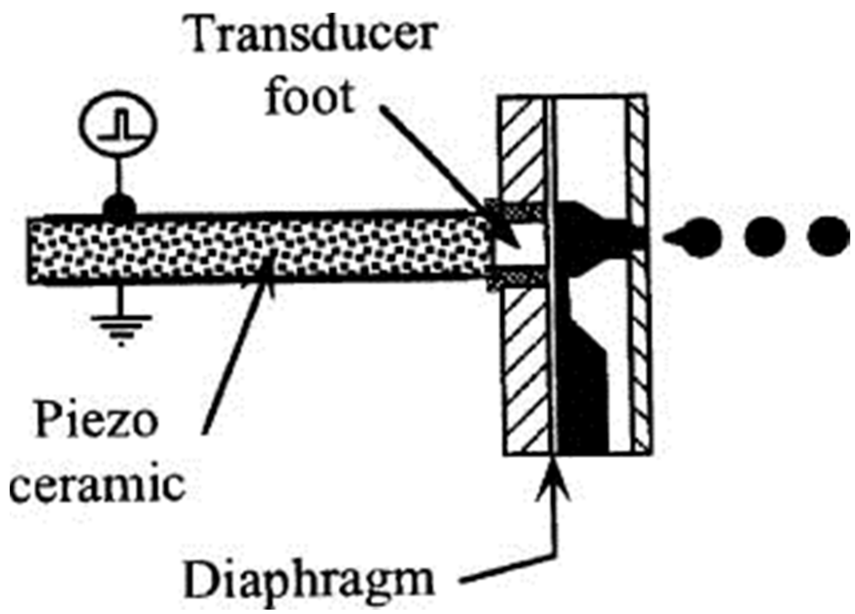

**Fig. 8.7.** Basic configuration of a bend-mode piezo-electric printhead

EPSON

Tektronix

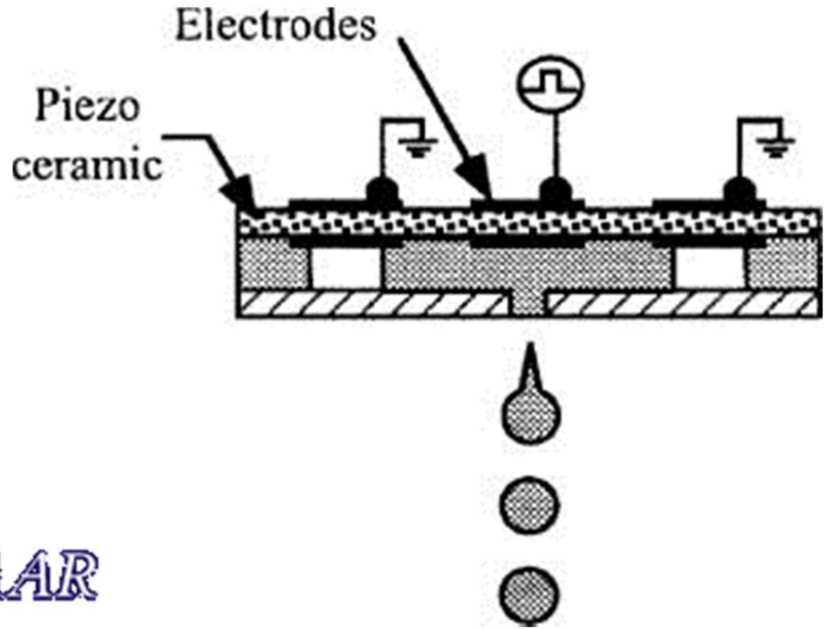
# 8.2.3. pIJ: Push-Mode

- Piezo-ceramic rod (E || P) pushes against ink nozzle
- Diaphragm protects piezo-ceramics against reaction with ink
- Commercial products: Dataproducts, Trident and Epson



# 8.2.3. pIJ: Shear-Mode

- Polarization of piezo-ceramics perpendicular to *E*-field
- Piezoceramics as active wall in direct touch with ink
  - ➢ Stiction of ink on wall crucial parameter
- Shear-motion generates droplet
- Pioneers: Spectra and Xaar



# 8.2.3. Thick-Film PZT Actor

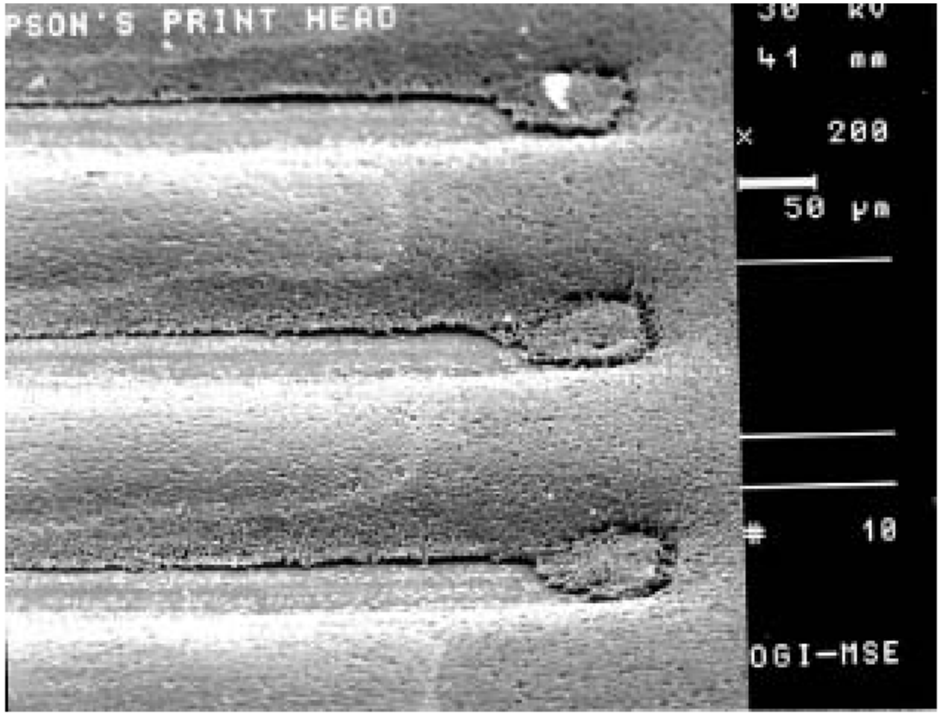



**Fig. 8.8.** SEM photograph of the thick film PZT on the zirconia diaphragm in the Epson Color Stylus 800 printhead

- Epson Color Stylus 800 printhead

# 8.2.3. pIJ: Shear Mode

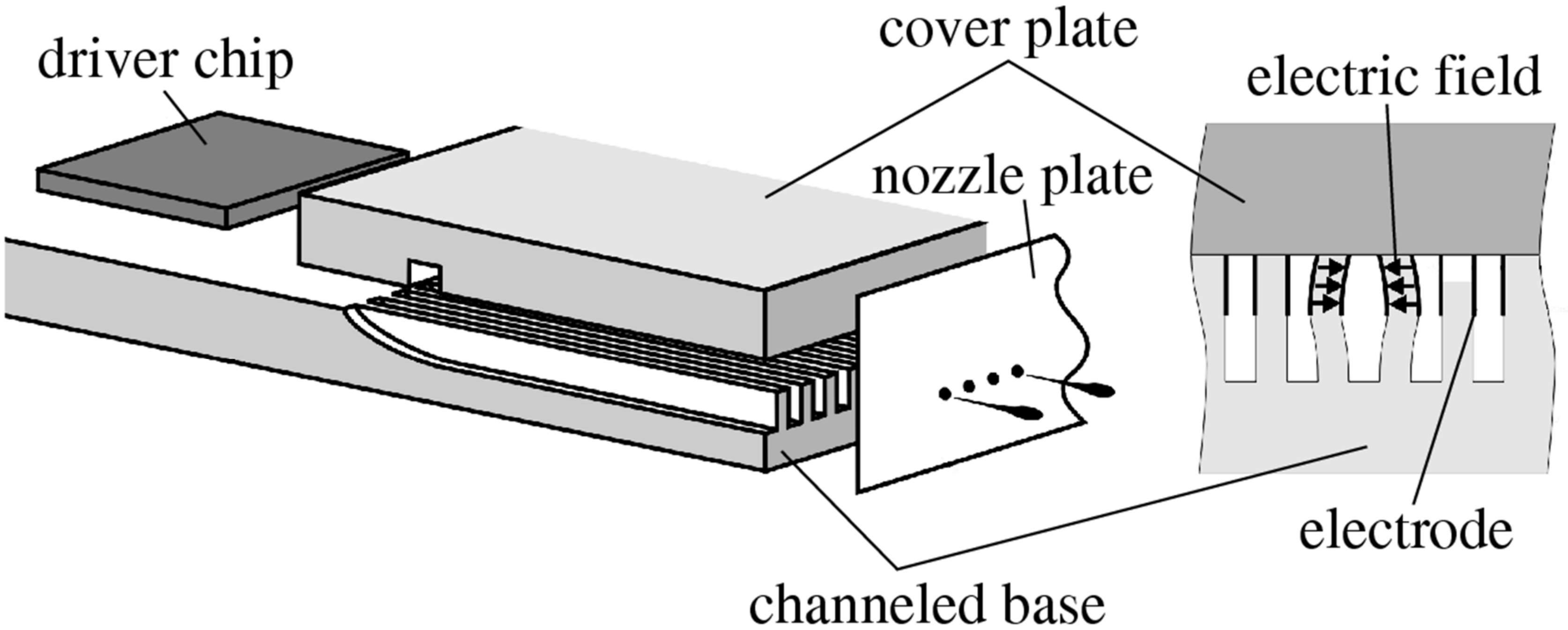



**Fig. 8.9.** Shear-mode technology by Xaar

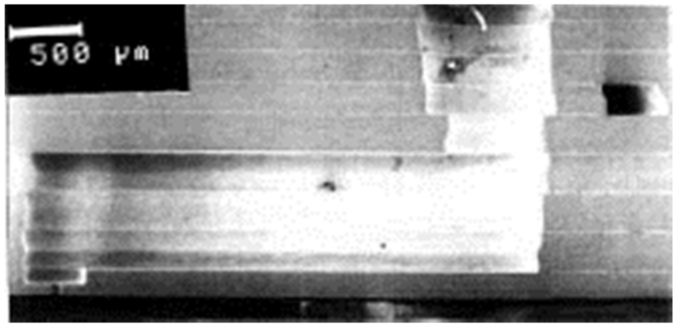
XAAR

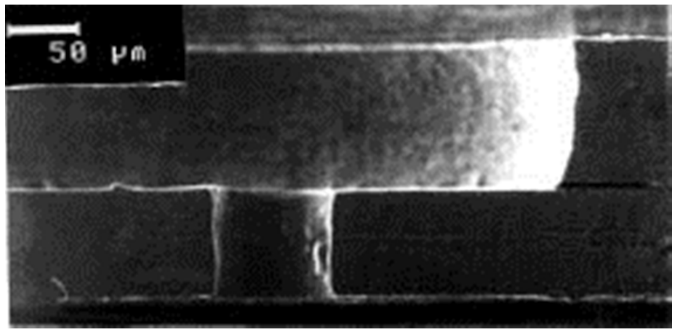
# 8.2.3. pIJ: Fabrication by Stacking

- Several photochemically structured layers of stainless steel
- Intermetal bonding by layer of Au or Ni at high temperature
- Uniform thickness of layer
  - ➢ Uniform performance of channels
  - ➢ Hermetic sealing of channels
- Printheads by Tektronix (352 nozzles, below) and Sharp (48 nozzles)

Tektronix

SHARP

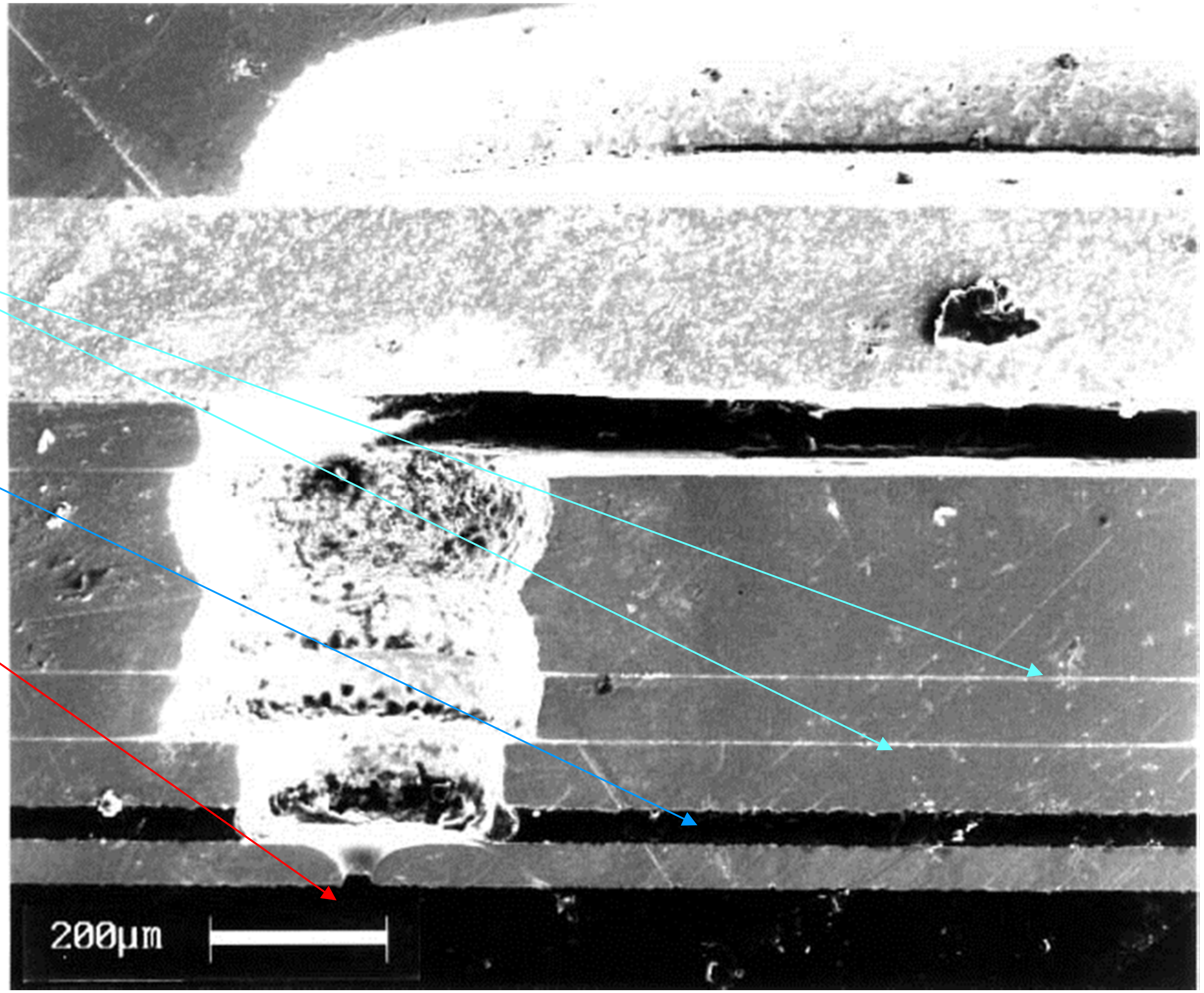



SEM-images of steel-laminated printhead by Tektronix

# 8.2.3. pIJ: Alternative Bonding

- Spectra
  - Soldering
  - Epoxy
  - Electro-plated Ni-orifice



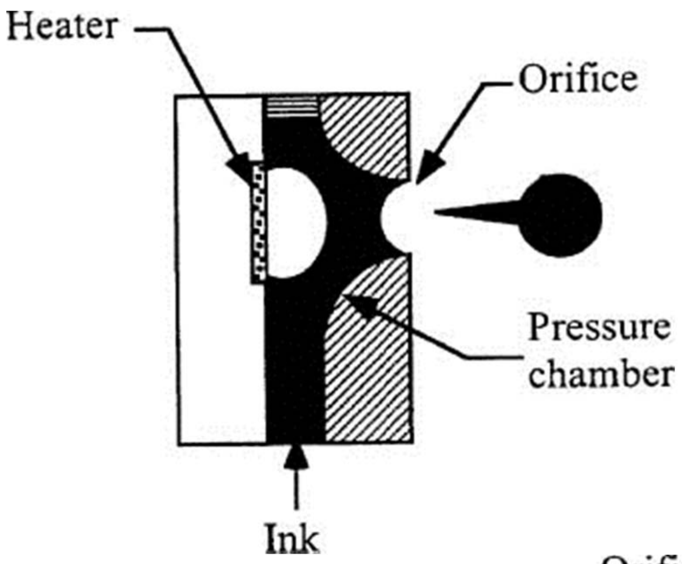
# 8.2. On-Demand Technology

1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet nozzleplate by Microparts

# 8.2.4. Thermal Ink-Jet Technology

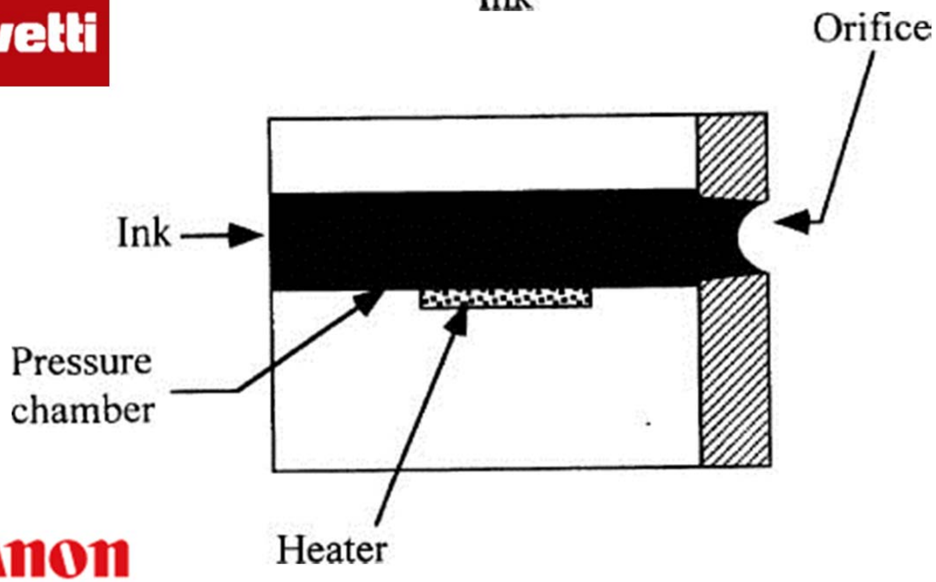
- Commercially most successful

- Variant 1: roof shooter
  - Heater above orifice
  - Hewlett-Packard, Lexmark and Olivetti




hp LEXMARK Passion for printing ideas. olivetti

- Variant 2: side-shooter
  - Heater lateral to orifice
  - Canon and Xerox




THE DOCUMENT COMPANY XEROX Canon

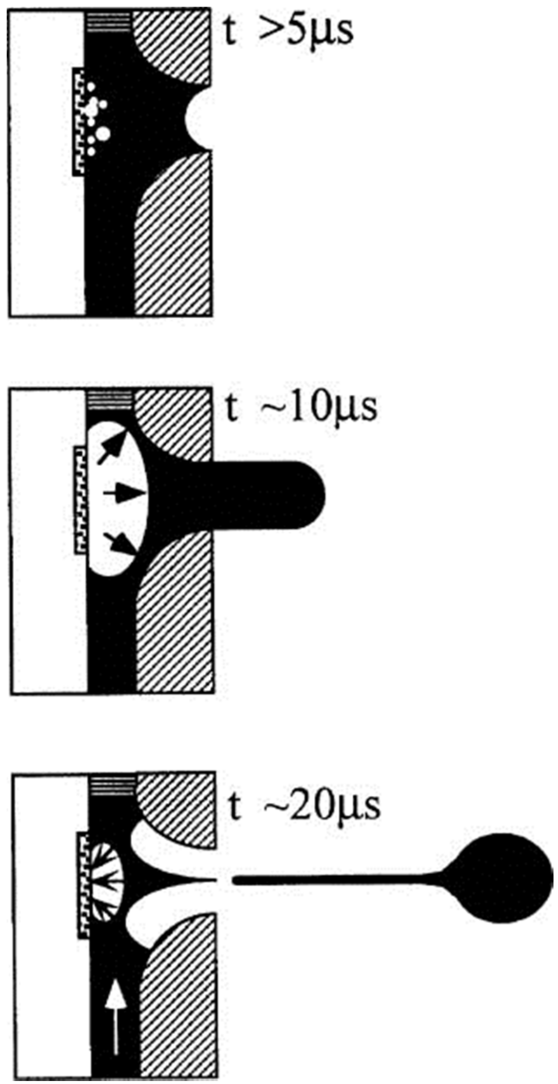
# 8.2.4. tIJ: Phases of Droplet Formation

- Heating (some µs)
  - Overheated ink
  - At 300°C: nucleation of bubble

- Expansion
  - Ejection of ink
  - Parallel to bubble expansion
  - Bubble pressure (empirical)

$$p[T(t)] = (p_{\text{nuc}} - p_{\text{vap}}) \exp\left[-\left(\frac{t}{\tau}\right)^{0.5}\right] + p_{\text{vap}}$$

- Droplet formation
  - Collapsing vapor bubble
  - Retraction of bulk ink
  - Refilling of cavity (80-200 µs)
    - -Speed-critical step



# 8.2.4. tIJ: Droplet Formation

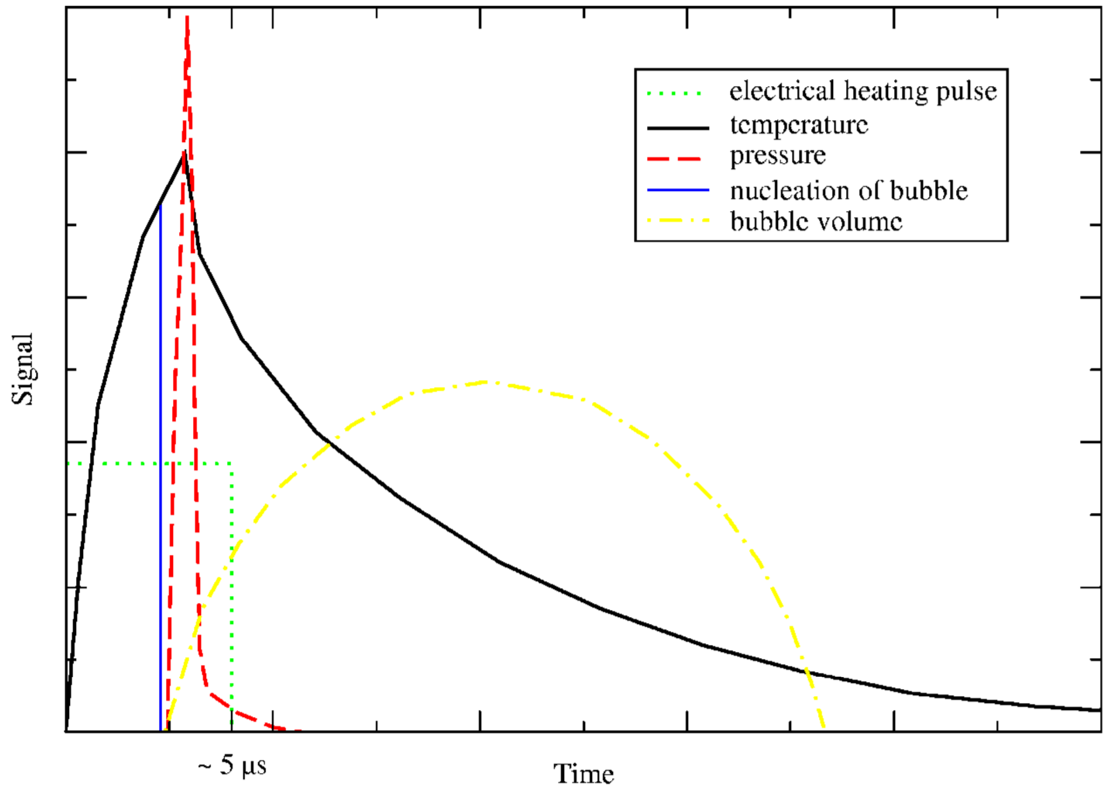
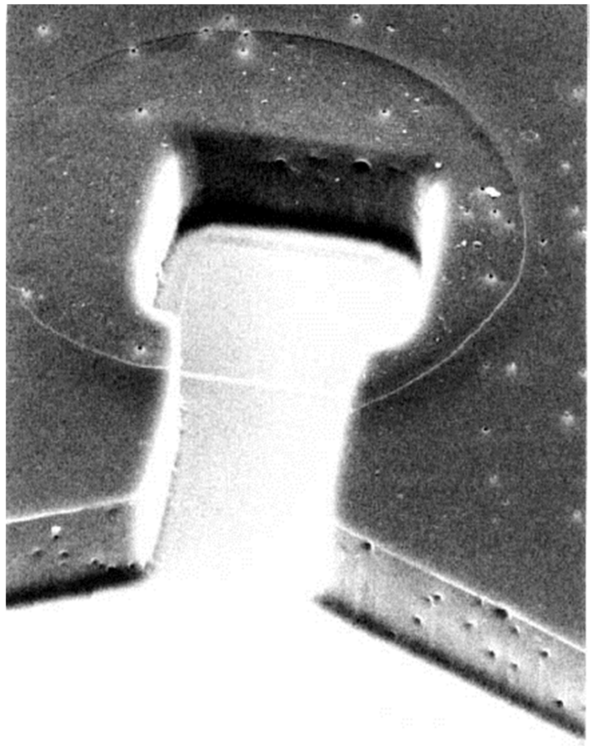



**Fig. 8.13.** Bubble formation process in thermal inkjet printers. An electric pulse ramps up the temperature above the heating element. At the point of bubble nucleation after about 5 μs , the pressure in the cavity swiftly increases prompting the bubble to expand and deliver a droplet

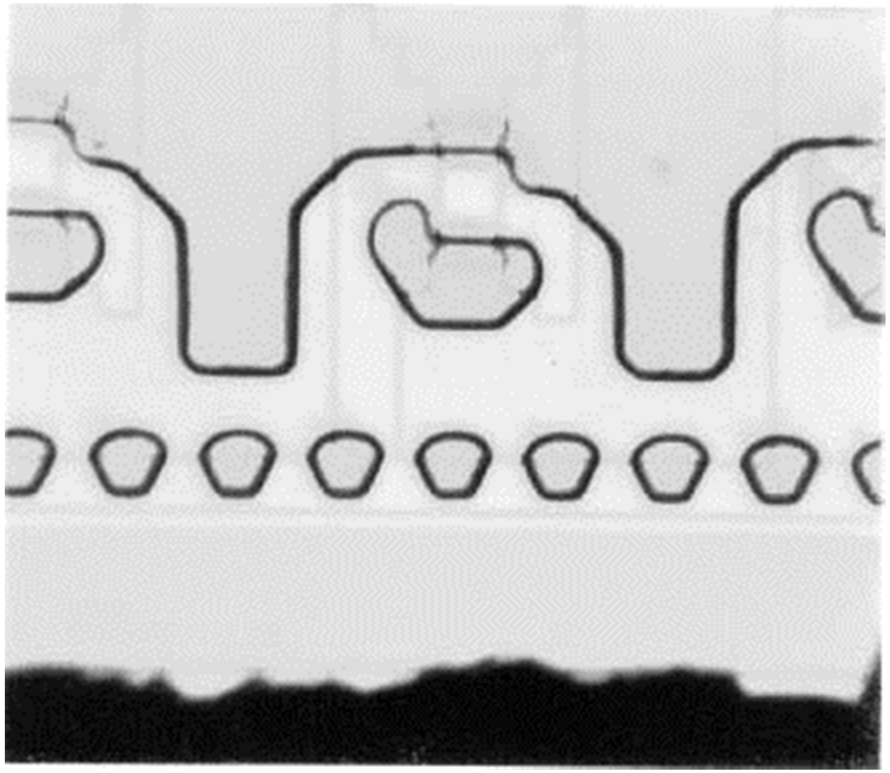
# 8.2.4. tIJ: Nozzle of DJ 850C Color printhead

- Heater (roof shooter, aperture plate removed)
- 6000 droplets à 32 pl per second
  - Cycle time 170 µs
- Width and height of ink channel on µm range
- Critical production parameters
  - Dimensional stability
  - Precision
  - Uniformity of nozzles
- Drop performance
  - Frequency
  - Volume
  - Speed



# 8.2.4. tIJ: Trends

- Enhancement of frequencies
  - Speed of printing
- Reduction of volume
  - Quality of printing
- Cost reduction



➡ Further miniaturization
  - Problem: reliability
- Example: HP 890C (roof shooter)
  - 192 nozzles (3 colors)
  - 12000 droplets at 10 pl / second
  - Heater surface 1 mm²
  - Series of small openings to avoid clogging by particles

# 8.2.4. tIJ: Further Trends

- Canon BJC 7000
  - 480 nozzles in single printhead
  - Largest density in small-office arena
  - 6 colors, hence 80 nozzles per color

- Market need for low-cost printheads
  - Larger ink containers
  - Permanent or semi-permanent printheads

# 8.2. On-Demand Technology

# 8.2.5. Valve-Jet

- Non-contact principle
- Drop-on-demand
  - Often confused with impulse jet

- Working principle
  - Ink held under pressure
  - Dynamic opening of valve
    - Micro-electromechanical
  - Spraying of fine jet

# 8.2. On-Demand Technology

1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet Nozzleplate by Microparts

# 8.2.6. Ultrasonic Droplet Generation

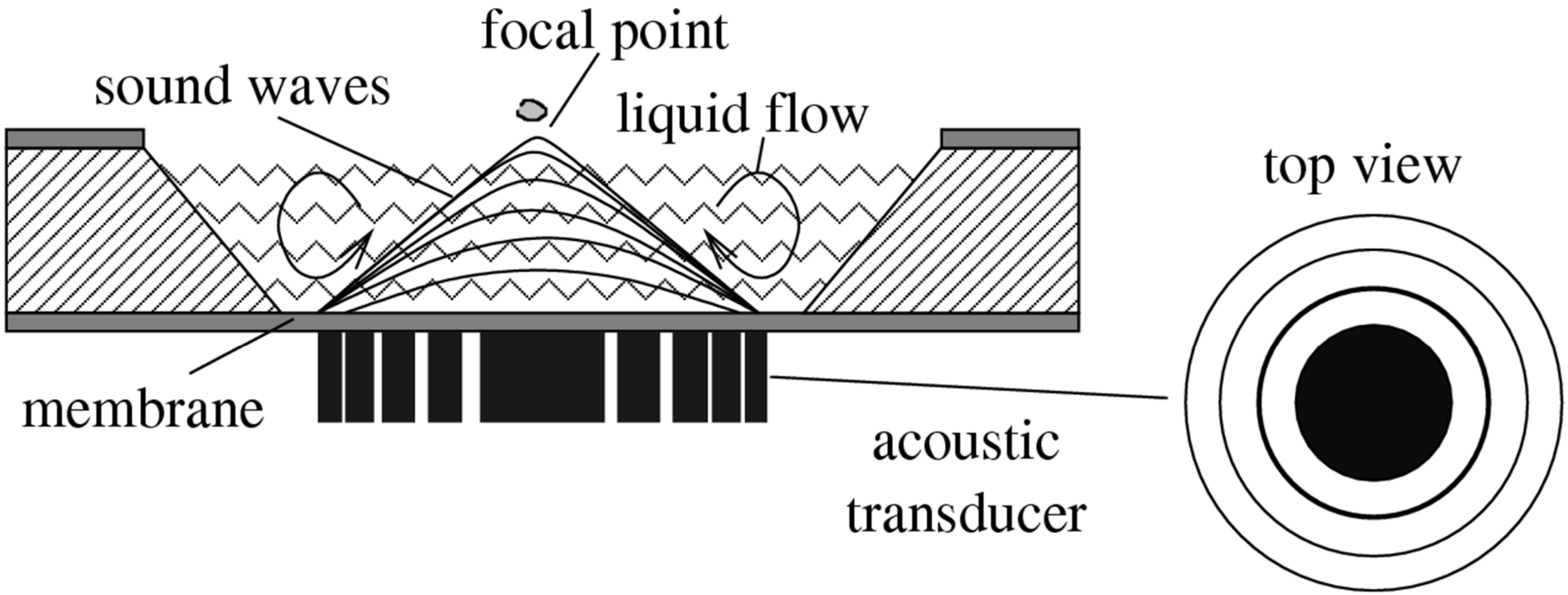


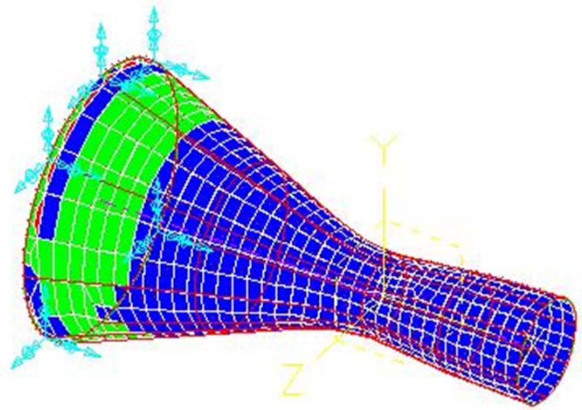

**Fig. 8.16.** Acoustic ejector

- Acoustic transducer
- Constructive interference of waves
  - Similar to Fresnel lens

# 8.2. On-Demand Technology

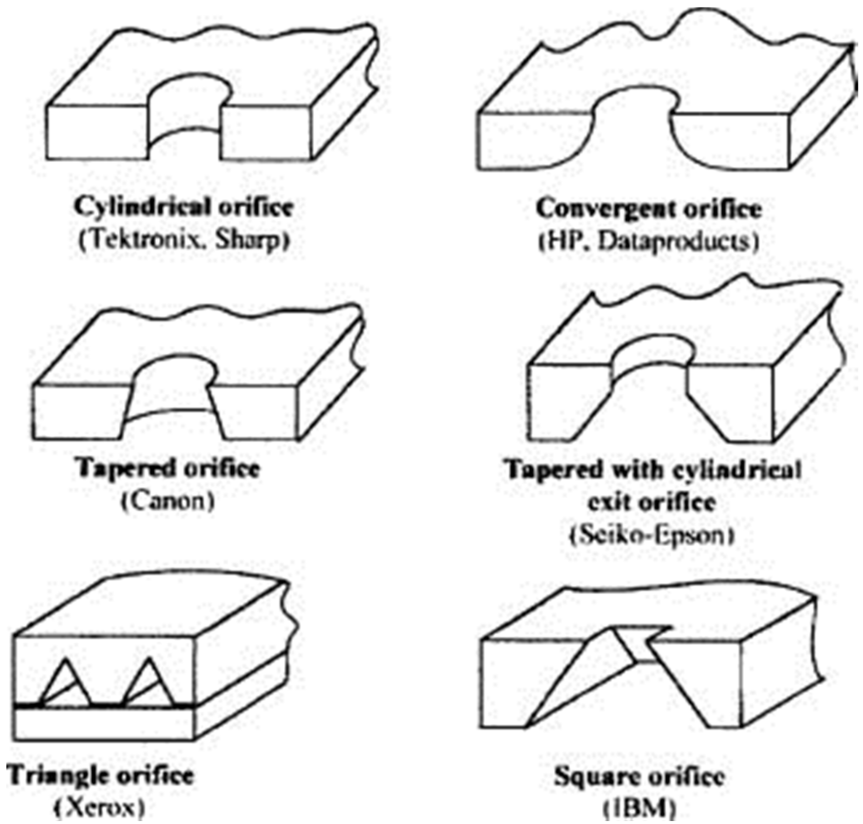
1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet Nozzleplate by Microparts

# 8.2.7. IJ-Technology: Nozzle Design (1)

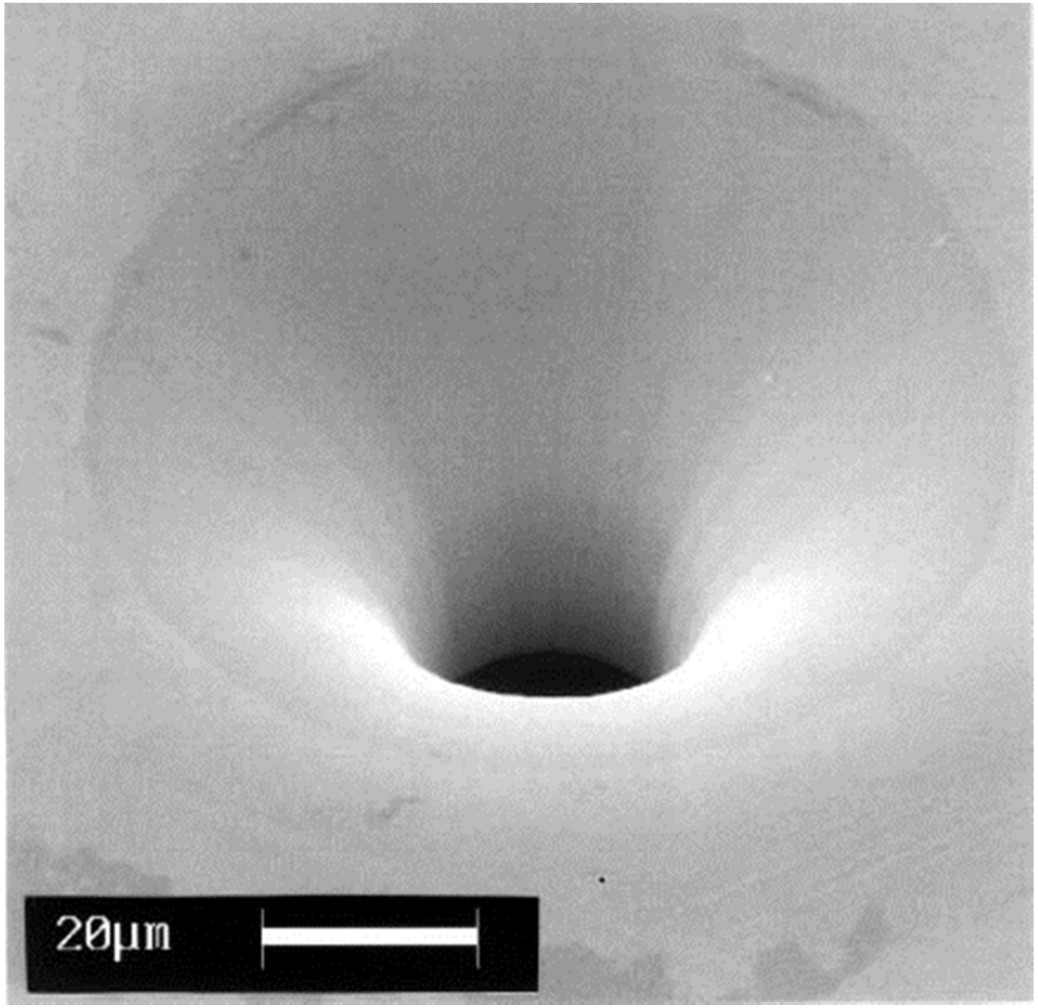



- Geometry parameters of nozzle
  - Diameter
  - Depth
- Effect on droplets
  - Volume
  - Speed
  - Deflection angle
- Effect on ink supply (refilling)
  - Capillary forces
- Fabrication tolerances limit picture quality
- Fabrication of orifice plates
  - Laser-ablation in polyimide, especially for small nozzles (10 pl, 20 µm)
  - Nickel-electroplating
  - Electro-discharge machining (EDM)
  - Micro-punching
  - Micro-pressing

# 8.2.7. IJ-Technology: Nozzle Design (2)

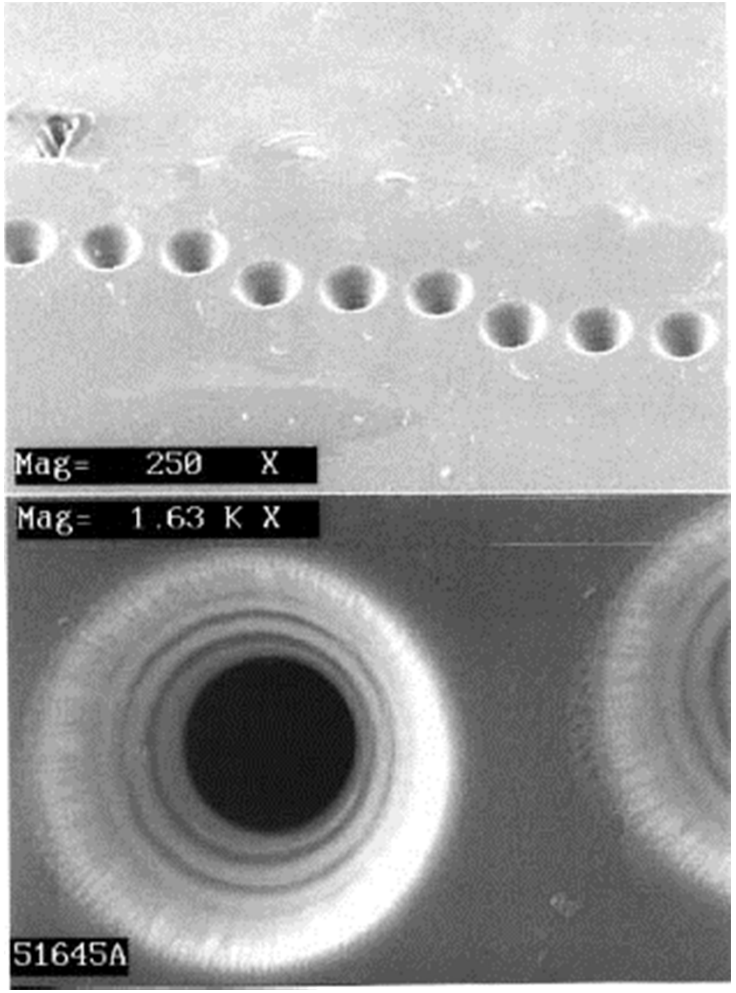


# 8.2.7. IJ-Technology: Nozzle Design (3)



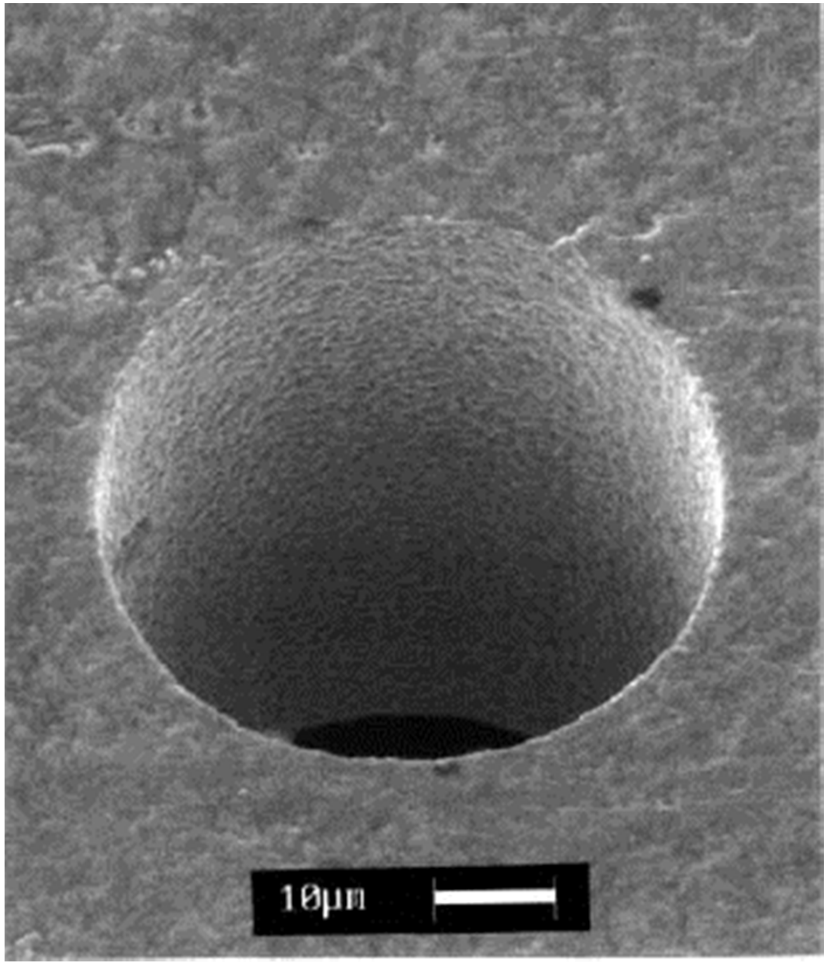

Electroplated Ni-nozzle

# 8.2.7. IJ-Technology: Nozzle Design (4)




Nozzle plate formed by laser ablation in polyimide

# 8.2.7. IJ-Technology: Nozzle Design (5)




Stainless-steel nozzle (Electro-Discharge Machining)

# 8.2. On-Demand Technology

1. Impulse Printing
2. Droplet Dynamics
3. Piezo-Actuation
4. Thermal Inkjets
5. Valve-Jet
6. Ultrasonic Droplet Generation
7. Orifice Plates
8. Inkjet Nozzleplate by Microparts

# 8.2.8. Inkjet Nozzleplate by Microparts

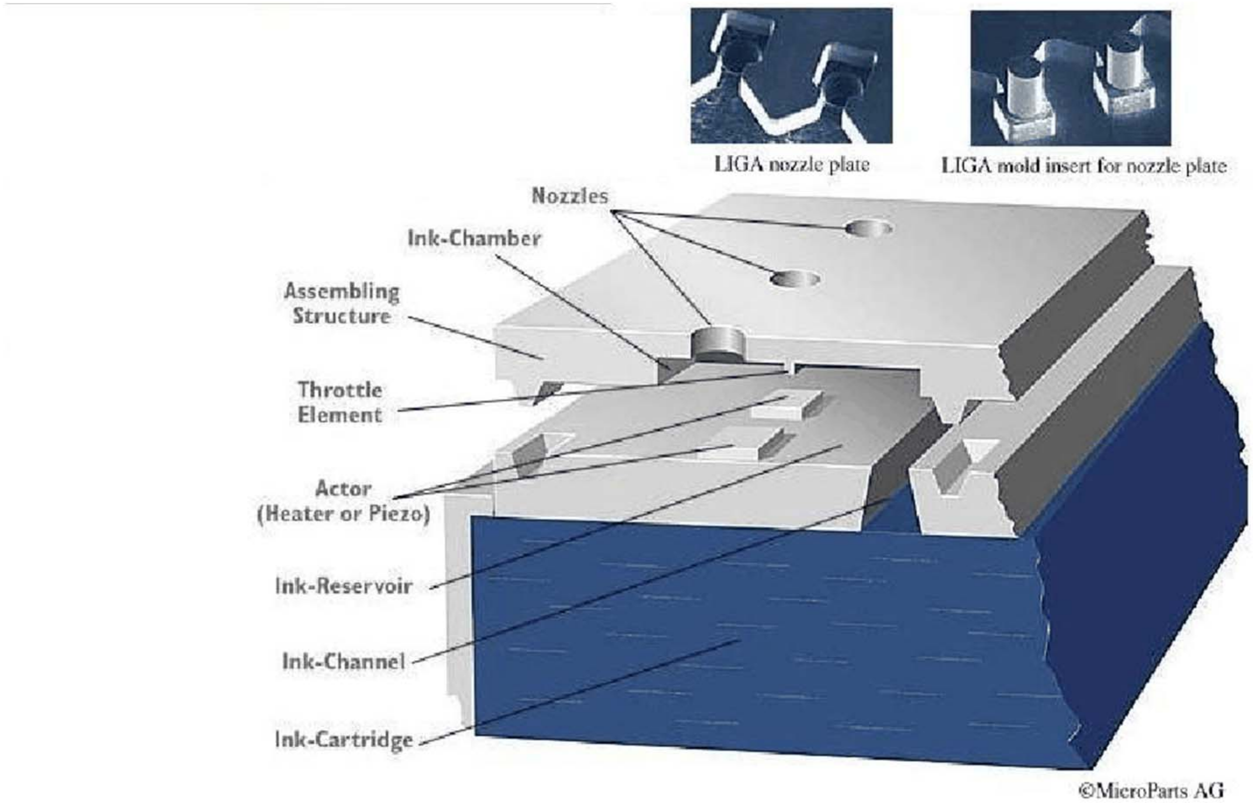



**Fig. 8.20.** A nozzle plate fabricated by STEAG Microparts AG

# 8. Ink-Jet Technology

1. Continuous Inkjet Technology (cIJ)
2. On-Demand Technology
3. Inkjet Ink Technology

# 8.3. Ink-Jet Technology: Media

- High-quality color prints require special inks and media
  - ➢ Capillary forces make ink follow pores and fibers
  - ➢ Ink penetrates paper too slow to allow absorption of multiple droplets at same spot
  - ➢ Consequences: intercolor-bleeding und ink-spreading
- Special coatings of substrates
- Designated ink bases
- Designated colorants
- Design parameters for ink-substrate combination
  - ➢ Droplet volume
  - ➢ Rate of evaporation
  - ➢ Time of penetration
  - ➢ Thickness of coating
  - ➢ Porosity, etc.

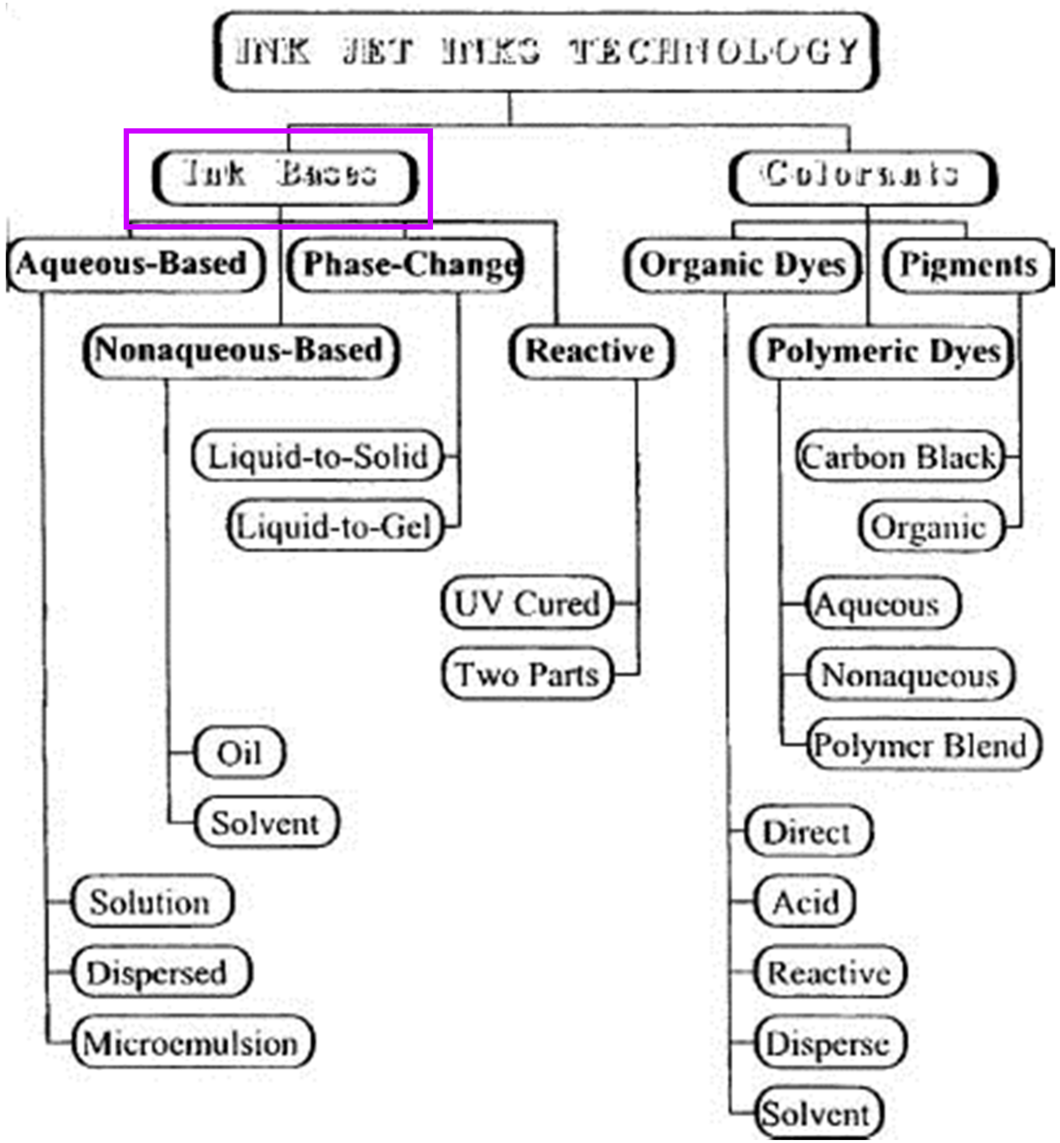

Canon

THE DOCUMENT COMPANY
XEROX

3M

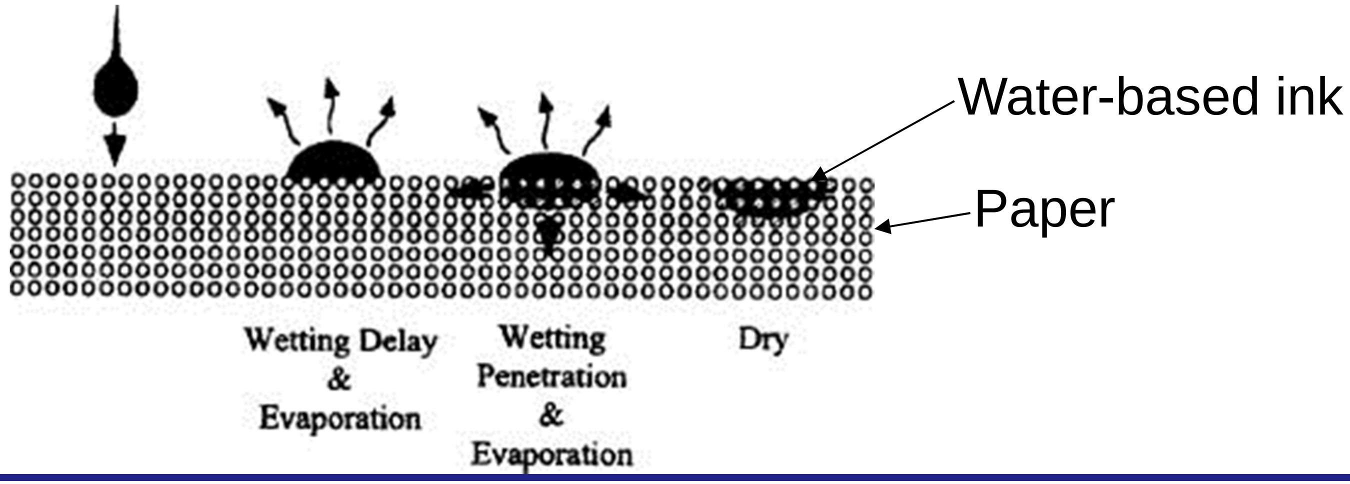
# 8.3. Inkjet Ink Technology

1. Types of Ink
2. Colorants
3. Inkjet Print Media



# 8.3.1. Chemistry of Ink-Jet Ink

- Critical component of IJ-technology
  - Quality of printing
  - Dynamics of droplet formation
  - Reliability
- Frequently: water-based inks
  - tIJ: vapor bubble
  - Hewlett-Packard DeskJet, Canon BJC and Epson Color Stylus Series
  - Viscosity range between 2 x $10^{-2}$ and 8 x $10^{-2}$ Pa s
  - Drying comparatively slow, penetration prevails
  - Water-absorbing layer enhances printing quality

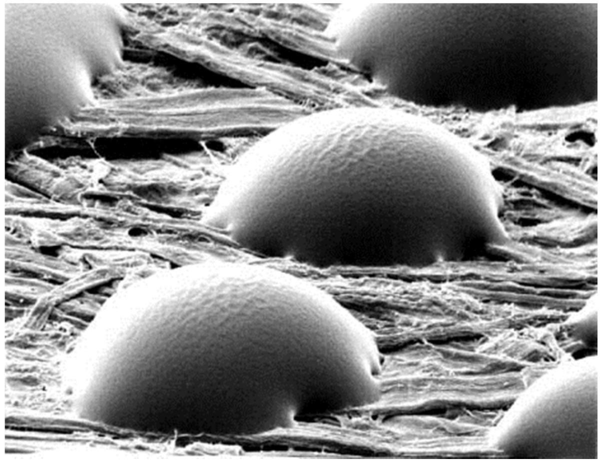


# 8.3.1. Constituents of Water-Based Ink

| Component | Purpose | Concentration [%] |
|---|---|---|
| DI-water | Aqueous carrier medium | 60-90 |
| Water-soluble solvent | Wetting, control of viscosity | 5-30 |
| Color or pigment | Coloring | 1-10 |
| Tensides | Wetting, penetration | 0.1-10 |
| Biocide | Avoids biological growth | 0.05-1 |
| Buffer | Stabilizes pH-value of ink | 0.1-0.5 |
| Others | Chelator, anti-foam, ... | <1 |

# 8.3.1. Ink-Jet Technology: Media

- Alternative: solid ink
  - Also hot-melt or phase change
  - Solidification at contact with medium
  - Widely independent from properties of substrate
  - Few spreading on substrate
  - Brilliant colors

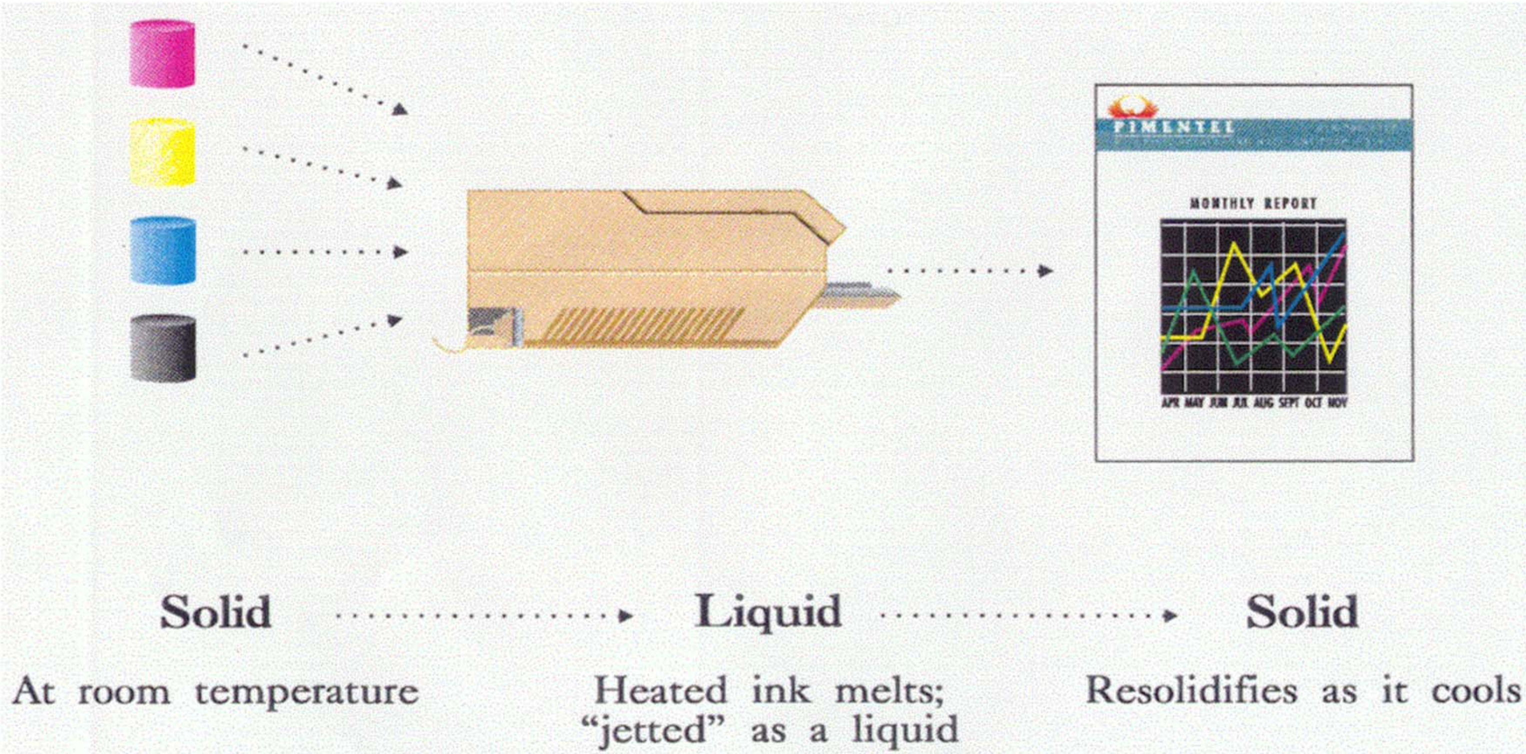


- Pioneering work at Teletype with electrostatic cIJ
- First DoD devices by
  - Exxon and Howtek
- Recent activities
  - Tektronix
  - Dataproducts, Spectra and Brother

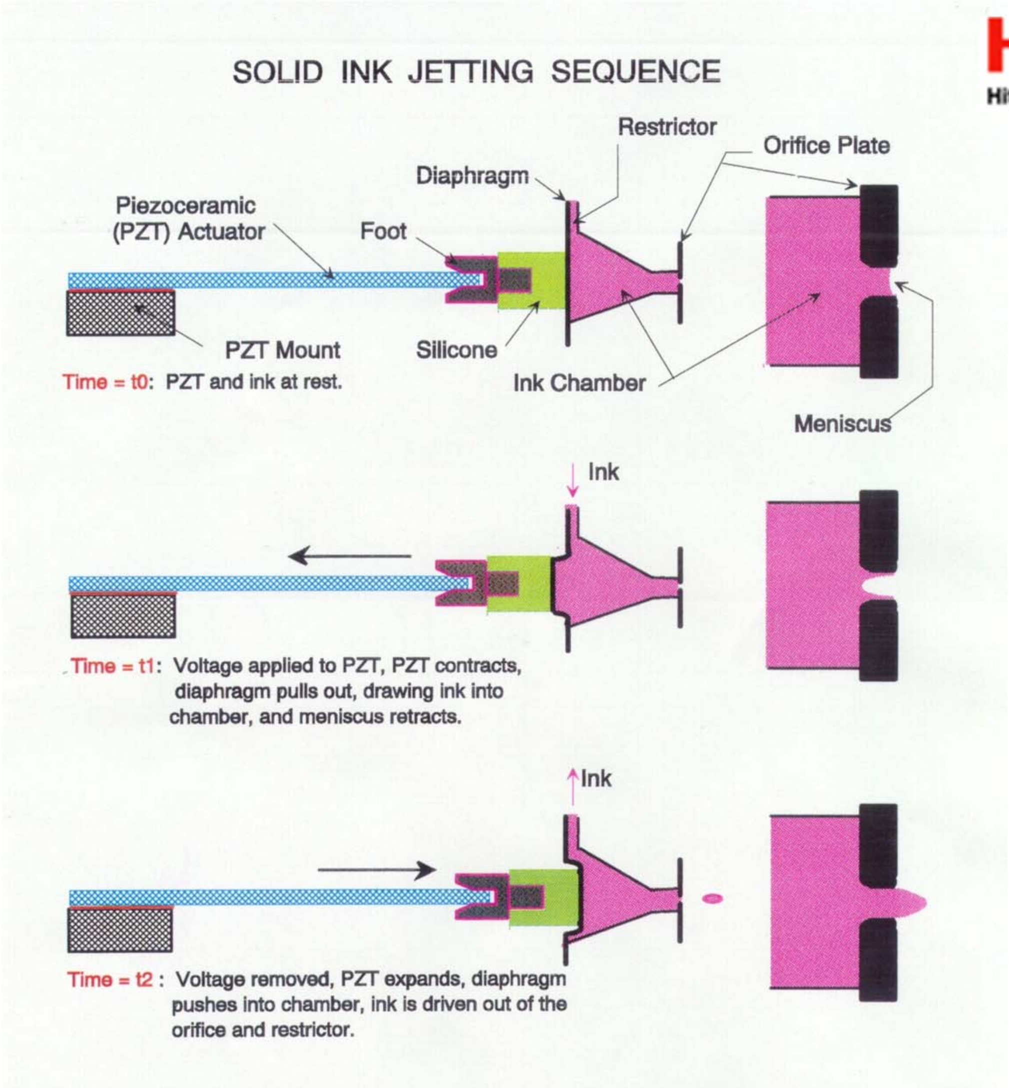
# 8.3.1. Phase-Change Ink

- Often based on wax
- Solid at room temperature
- Typical temperatures: 120-140°C
- Typical viscosities: 8-15 x $10^{-2}$ Pa s
  - Compare: water ~ 1 x $10^{-3}$ Pa s
- Nozzle of printhead ejects hot melt
- Instantaneous solidification upon contact avoids spreading
- Print results widely independent from substrate
- High speed of printing: 6 pages per min (Tektronix Phaser 350)

# 8.3.1. Solid-Ink: Phases



# 8.3.1. Solid-Ink Technology: Mechanisms



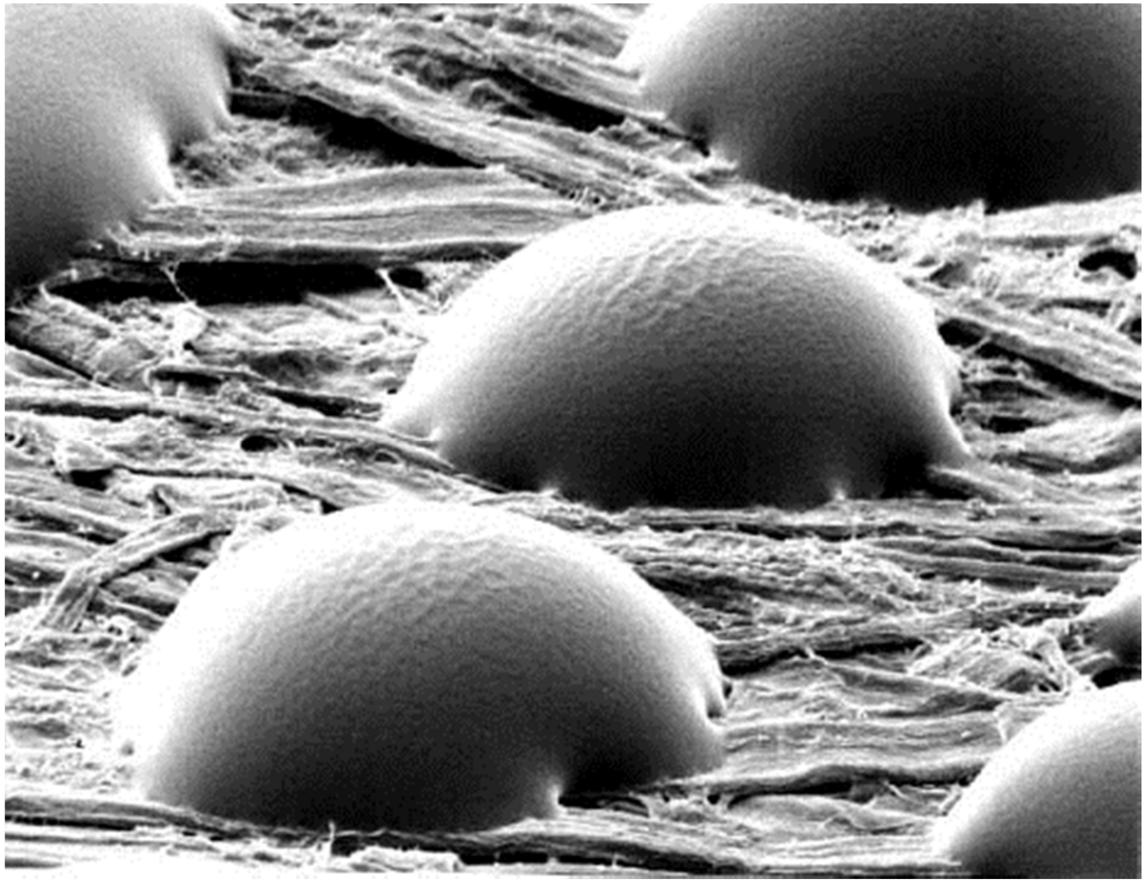

HITACHI
Hitachi Koki Imaging Solutions, Inc.

# 8.3.1. Phase-Change Ink: Constituents

| Component | Purpose | Concentration [%] |
|---|---|---|
| Mixture of wax | Ink-vehicle | 40-70 |
| Viscosity modifier | Reduction of viscosity | 5-20 |
| Adhesive | Adhesion on substrate | 1-15 |
| Plasticizer | Flexibility | 1-15 |
| Dye / pigment | Color | 1-10 |
| Antioxidant | Heat resistance | 0.05-2 |

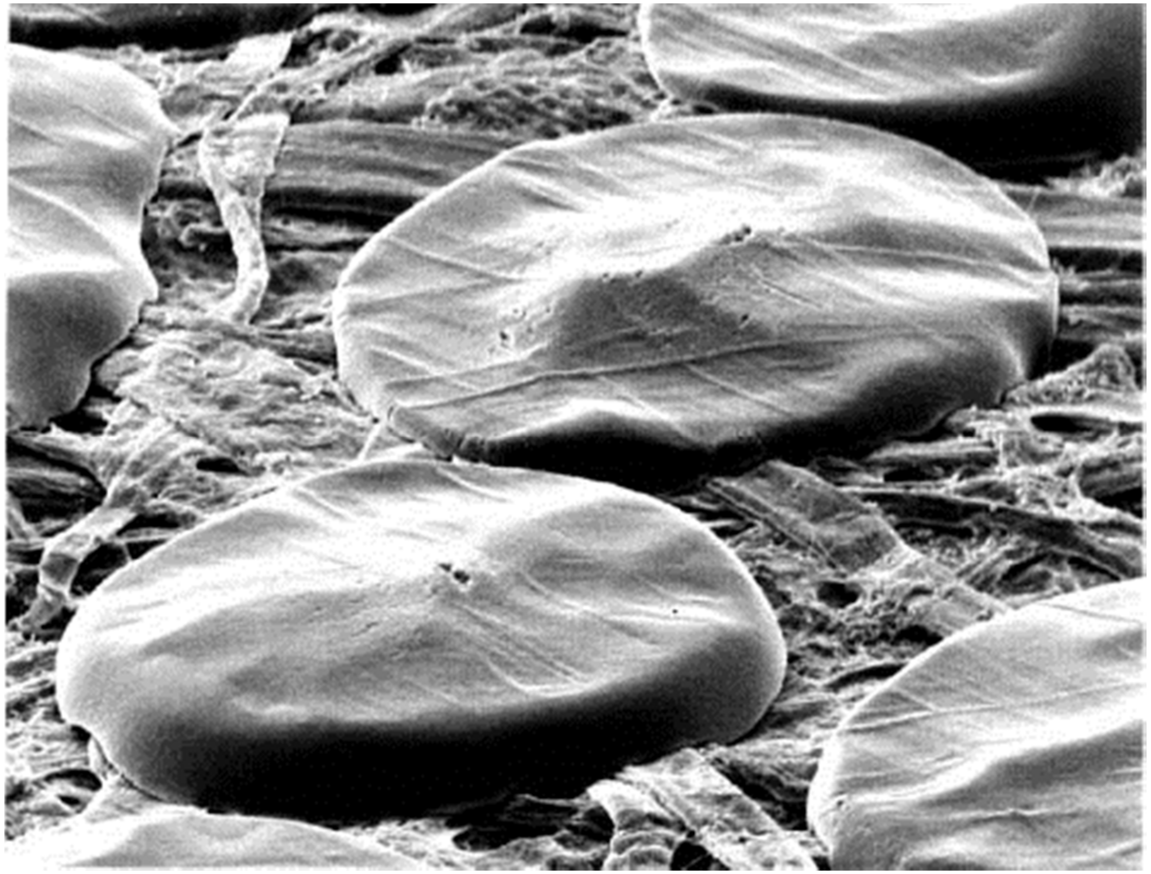
# 8.3.1. Phase-Change Ink

- Solidified ink on Xerox 4024 Paper
- Hemispherical dots, no spreading



# 8.3.1. Phase-Change Ink: Fusion

- In practice: solidified ink needs further adhesion
- Tektronix Phaser 300: pressing of droplets with roller

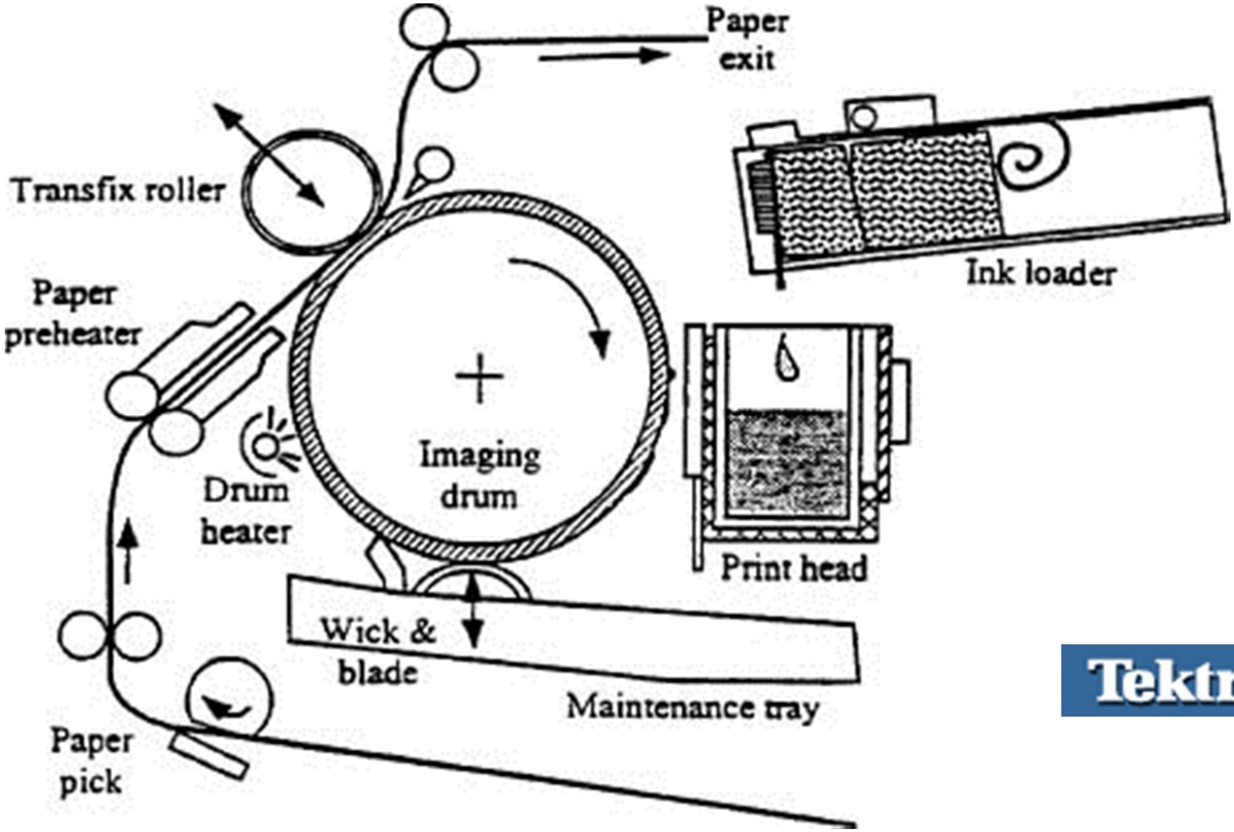


Tektronix

# 8.3.1. Phase-Change Ink: Offset Printing

Tektronix Phaser 350 color ink-jet printer

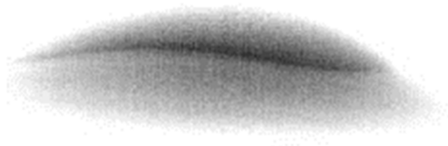
- Printhead writes on thin Si film attached to warm Al drum
- Pattern transferred by transfix roller onto preheated paper



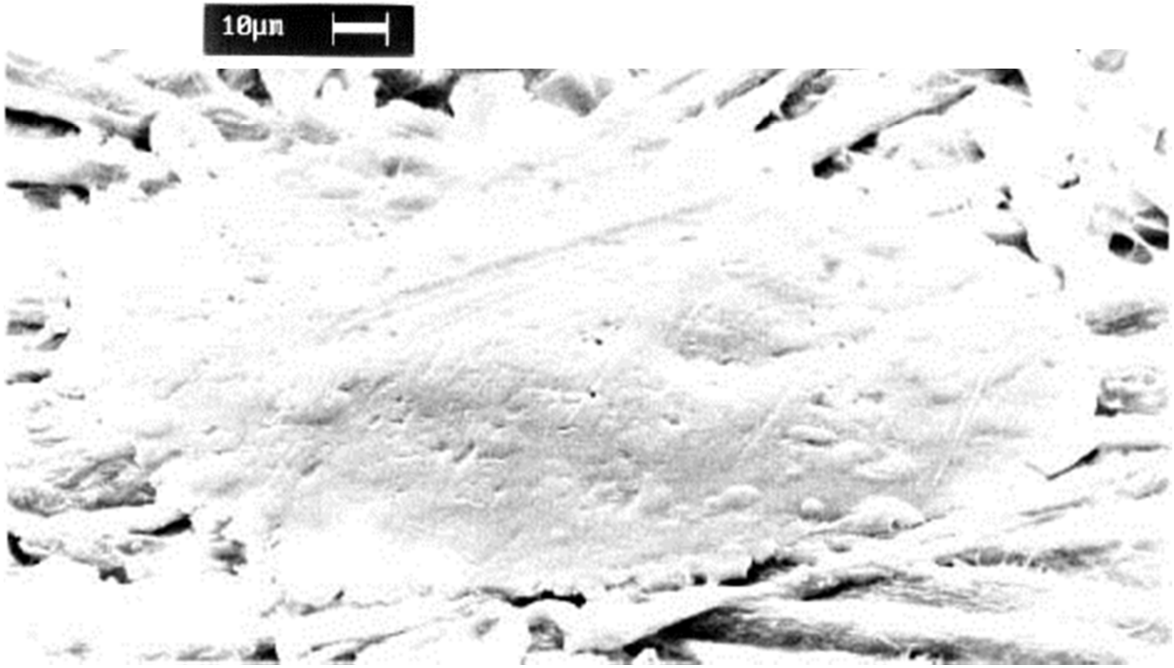

Tektronix

# 8.3.1. Phase-Change Offset Printer: Print Result

Al-substrate



Paper



# 8.3.1. Further Types of Ink

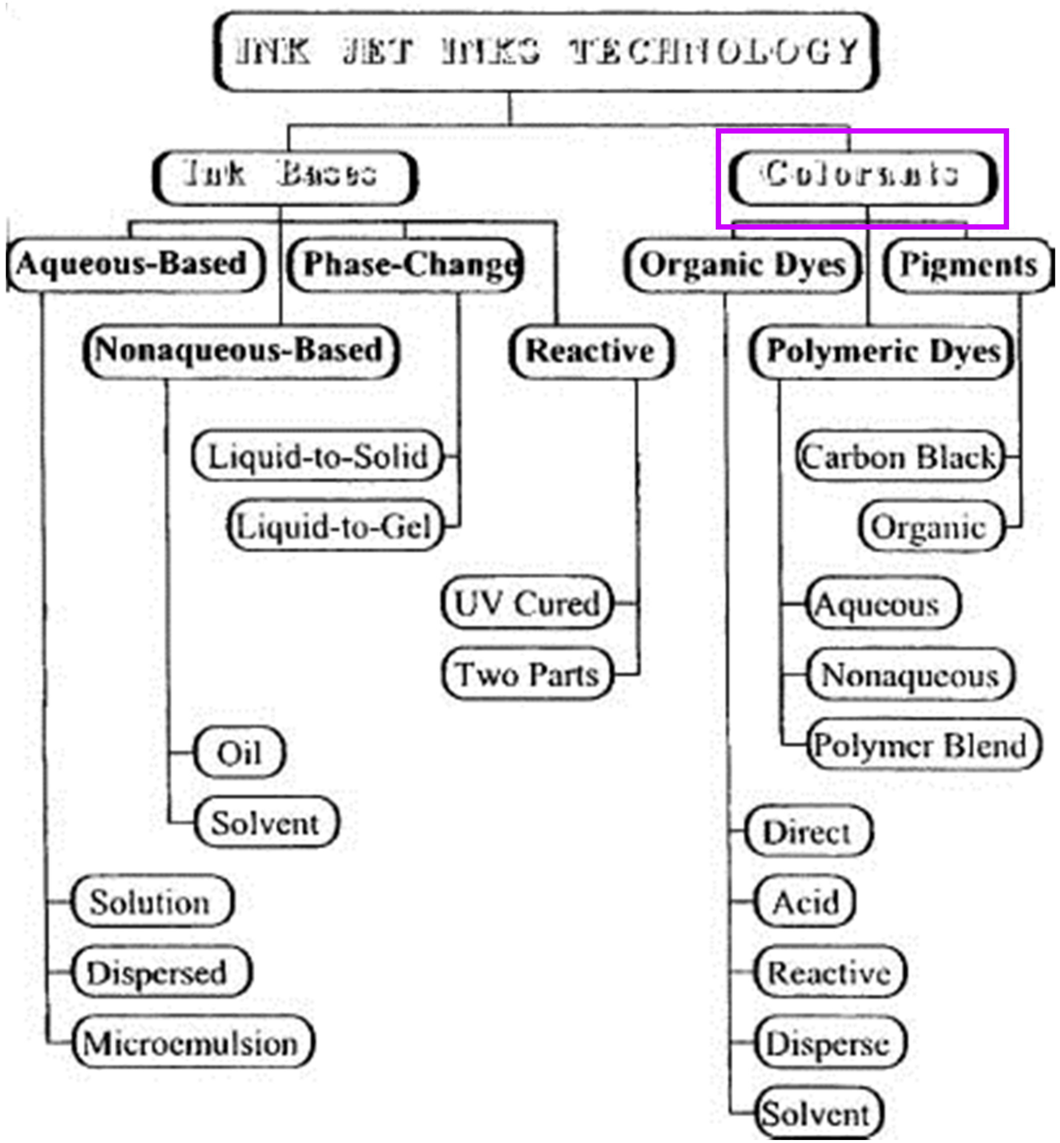
- Oil-based Ink
  - For large-format printers (Raster Graphics PiezoPrint 5000, Xerox ColorgrafX)
  - Both printers based on Nu-Kote piezo shear-mode printheads
  - Unpolar oil minimizes negative effects of *E*-fields on ink and printhead
  - Zeneca: faster evaporation, high-quality printing
- UV-curable inks
  - Non-absorbing substrates like glasses, metals and plastics
  - UV photo-initiators, monomers and oligomers available
  - Market entry expected

THE DOCUMENT COMPANY
XEROX

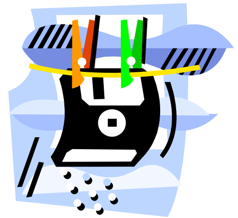
AstraZeneca
International

# 8.3. Inkjet Ink Technology

1. Types of Ink
2. Colorants
3. Inkjet Print Media



# 8.3.1. Mechanisms of Drying



| Type of Ink | Printhead | Mechanism of Drying |
|---|---|---|
| Aqueous | tIJ and pIJ | Continuous absorption, penetration, evaporation |
| Oil | cIJ with piezo | Absorption, penetration |
| Solvent-based | cIJ with piezo | Evaporation |
| Hot-melt | Piezo | Phase change<br>liquid $\Rightarrow$ solid |
| UV curable | cIJ with piezo | Polymerization |
| Reactive | cIJ with piezo | Oxidation, Polymerization |

# 8.3.2. Drying of Water-Based Ink

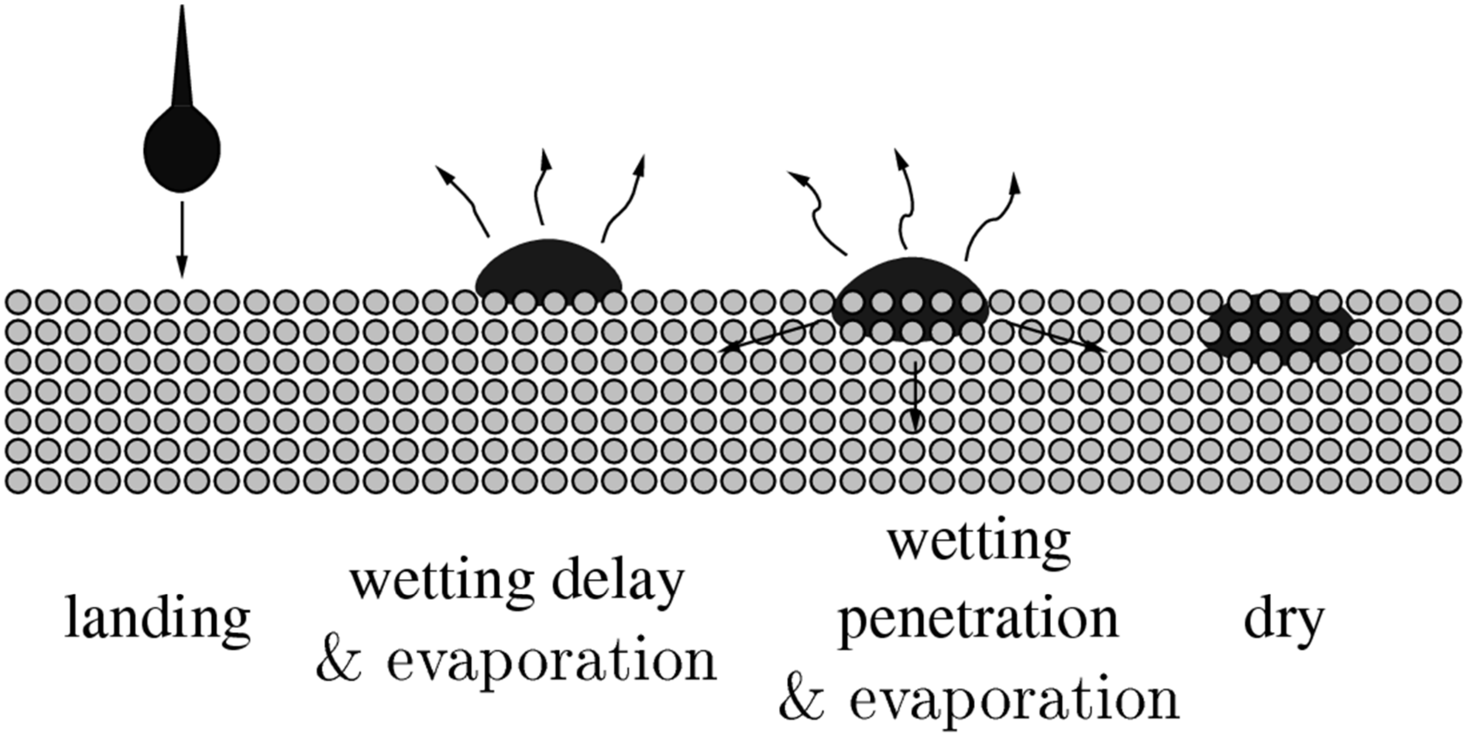
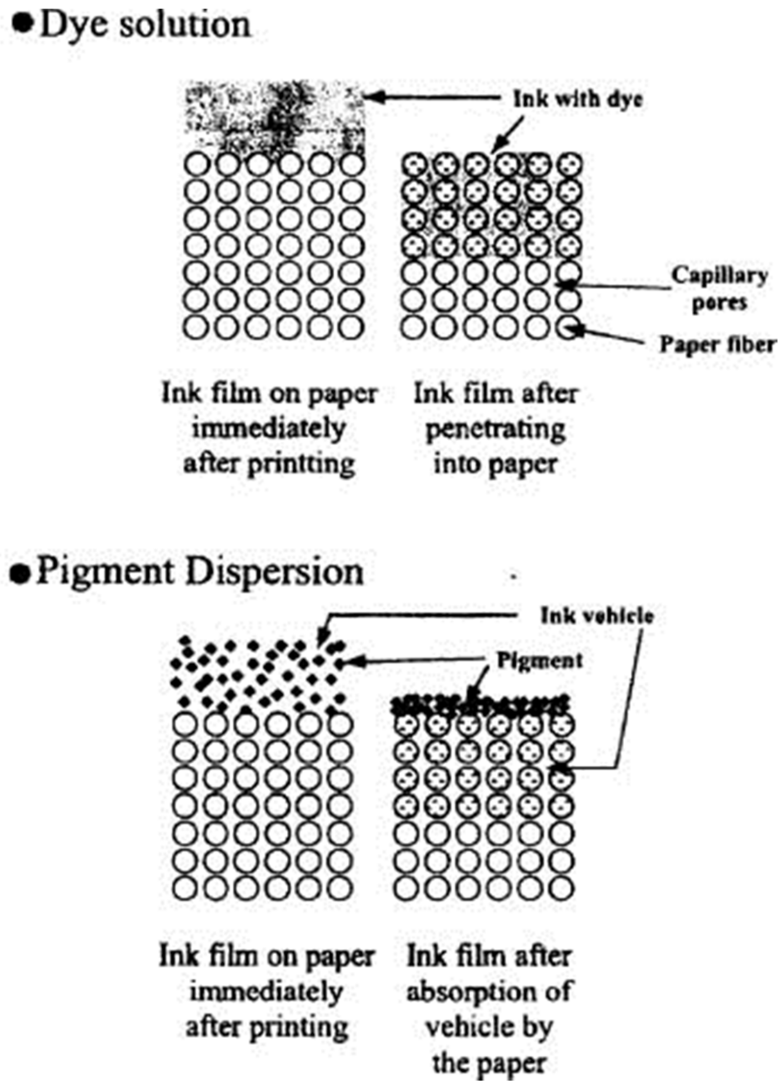


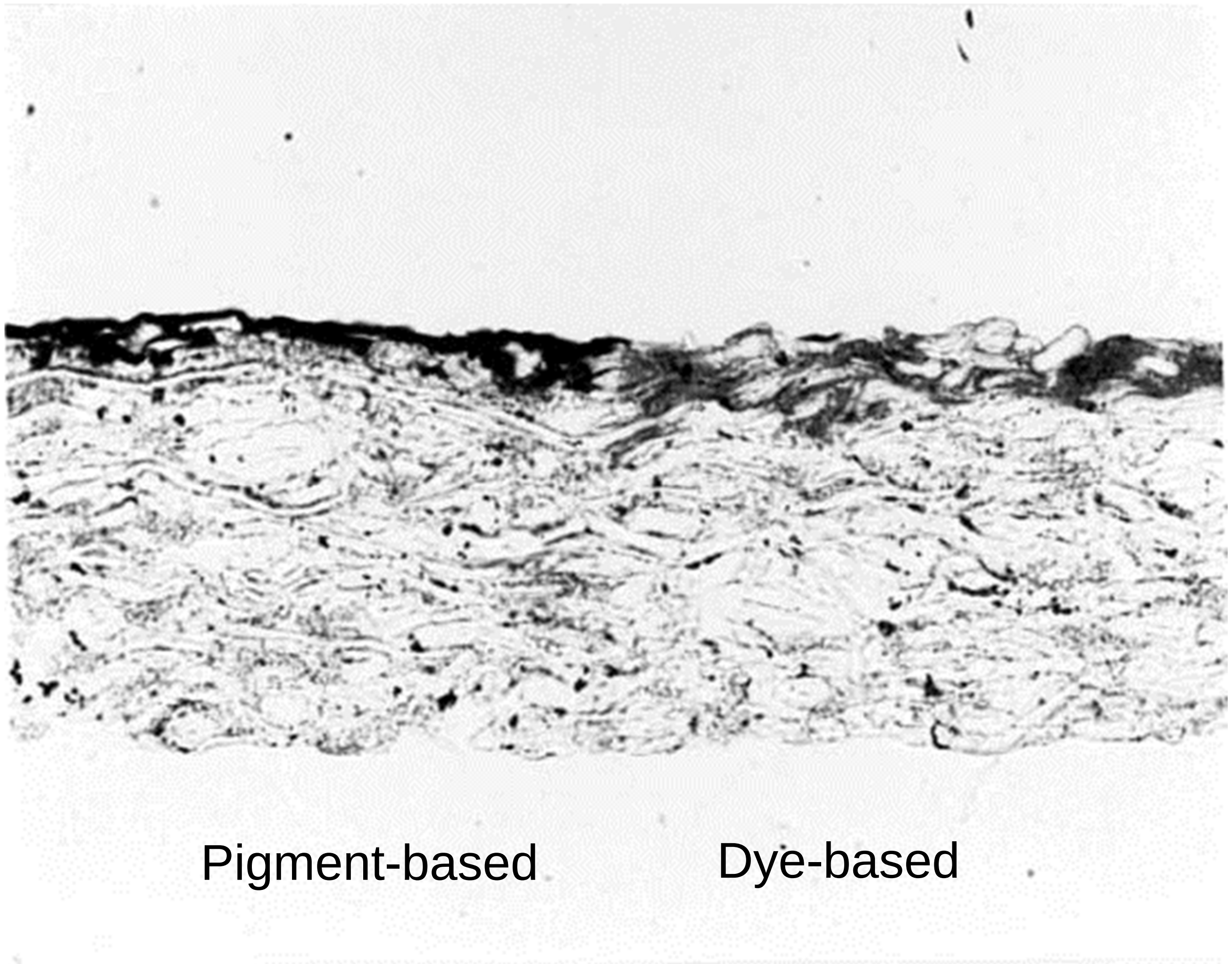

**Fig. 8.21.** Wetting, evaporation and penetration sequence of a water-based ink droplet landing on a plain, uncoated paper substrate

# 8.3.2. Pigment-Based Ink

- Particle dispersion
  - Dye: solution
- Advantages in terms of
  - Picture quality
  - Stability of color
    - Time and weathering
  - Reliability of jetting
  - Costs
- Disadvantages
  - Faster clogging of nozzles
- Companies: 3M, Dupont and Kodak



# 8.3.2. Comparison between Inks based on Dye and Pigments



# 8.3. Inkjet Ink Technology

1. Types of Ink
2. Colorants
3. Inkjet Print Media

# 8.3.3. Inkjet Print Media

- Fibers in paper act as pores
  - Capillary forces
  - Spreading of ink dots
  - Insufficient on-site mixing
  - Intercolor bleeding
  - Drying process depends on paper quality

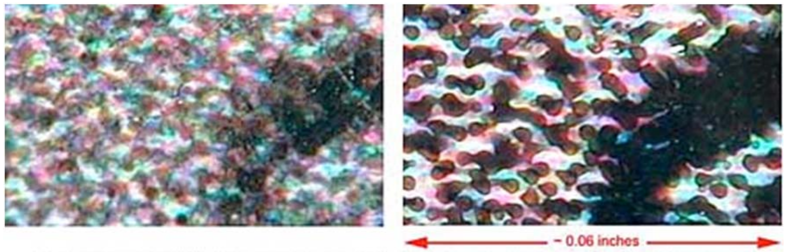
- Early 1980s: Jujo Paper and Mitsubishi Paper Mills
  - Development of glossy paper types for ink jet printouts

- Nowadays: Canon, Xerox, Asahi Glass, Arkwright, Folex, 3M and Imation

# 8.3.3. Effects from User‘s Point of View

- Ink clumping
  - Areas of heavy ink coverage
  - Surface tension „clumps“ ink in globs
  - Orange peel („crackle“) effect
  - Improvement
    - Improved wetting of paper by ink

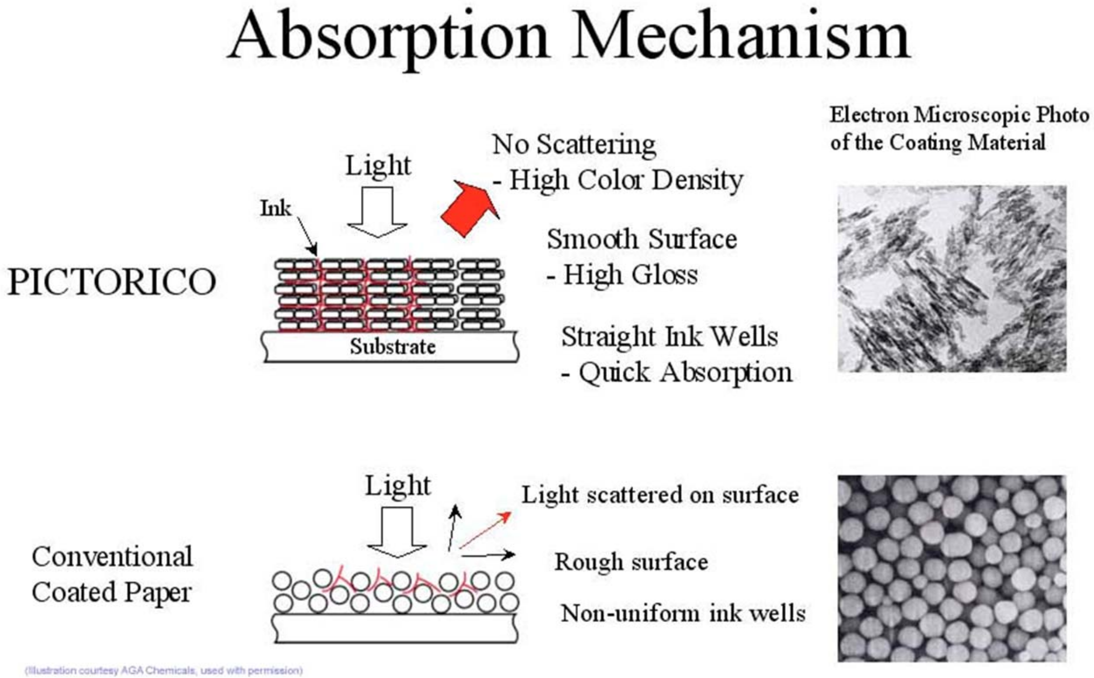
- Muddy colors
  - „Intercolor bleeding“
  - Wicking of ink along fibers
  - Photo from same printer, but on different media

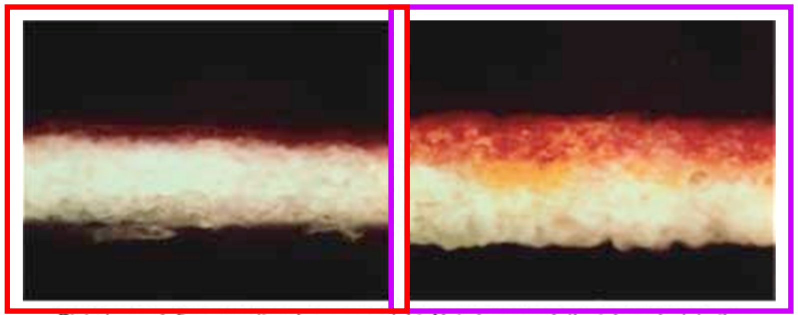



Photomicrographs of the identical area of a print, produced by an HP 970Cse printer, on generic "house brand" gloss inkjet paper and Pictorico Gloss Film. (No, they're both in focus! - Observe the small white flecks and paper fibers in the houes-brand print: It's the dots that are fuzzy, not the overall image!) © 2000, Imaging Resource

- Poor surface texture
  - Absorption of ink
  - Grainy „sandpaper“ surface
  - Feels not good for sharing photos with your friends
- Waterfastness
  - Inkjet prints will run at least hint of moisture
  - Solution: e.g. chemical bond between ink and paper

# 8.3.3. Pictorio Paper

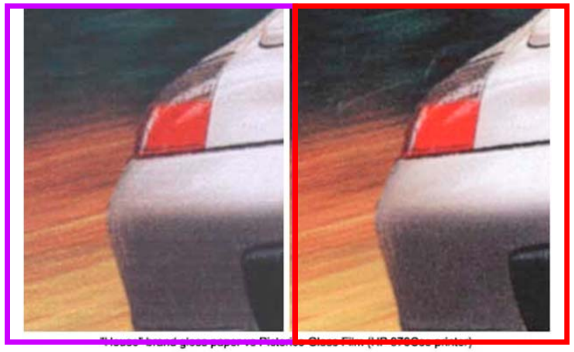


Pictorico on left, conventional paper on right. Note how much the ink soaks into the conventional paper: Ink that's buried inside the paper doesn't contribute to the final image. Colors will be less intense. (Images courtesy AGA Chemicals, used with permission)

House brand

Pictorio

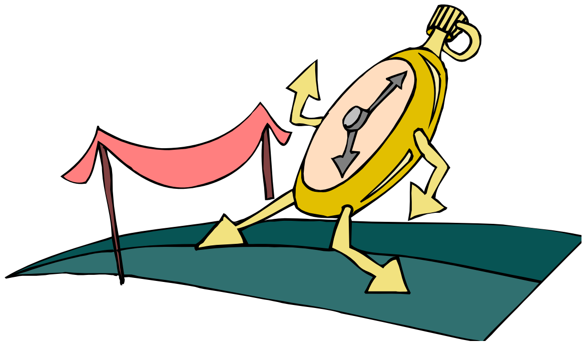


# 8.3.3. Plain Paper Optimized Printing (P-POP)

- Canon BJC-7000 series
- Black printhead
  - Preparation of substrate with jet some milliseconds prior to ink
  - Coupling  to dye which is instantaneously fixed on paper
- Water-resistant
- Similar results as on coated glossy paper
- In case reliability can be demonstrated:
  - Technological breakthrough of IJ-Ink technology (!?)

# 8. Summary

- Ink-jet technology
  - Continuous Ink-Jet
  - Thermal ink-jet (bubble jet)
  - Piezo-electrical ink-jet
- IJ-technology most mature discipline of microfluidics
- Strong commercial involvement, few pure academic research
- Technological solutions for
  - Miniaturization
  - Reliability
    - Clogging
    - Variations in droplet volume
  - Speed
  - Fabrication technology, often without Si
  - Chemistry of ink-jet ink
  - Costs



- Typical problems of microfluidics
  - Extremely application-specific solutions
  - Interdisciplinary R&D
  - Broad range of applications, e.g. office printers, biotechnology