Drop on Demand Inkjet Tutorial

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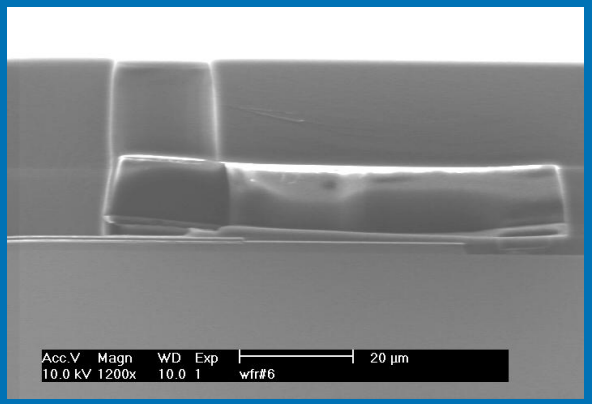


TAPPI
people resources solutions

PaperCon 09

Inkjet Technology History

Inkjet Printer Product Lines

- Solutions evolved from desktop into business and industrial applications

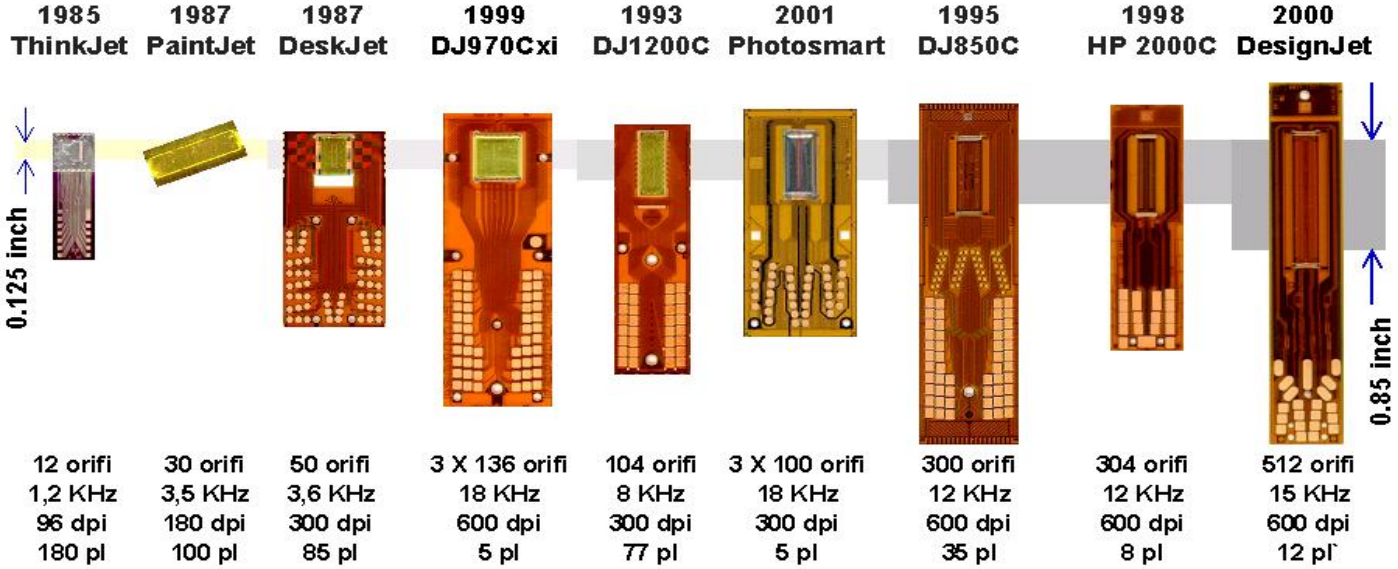
Industrial Print Engines
>1 page per second

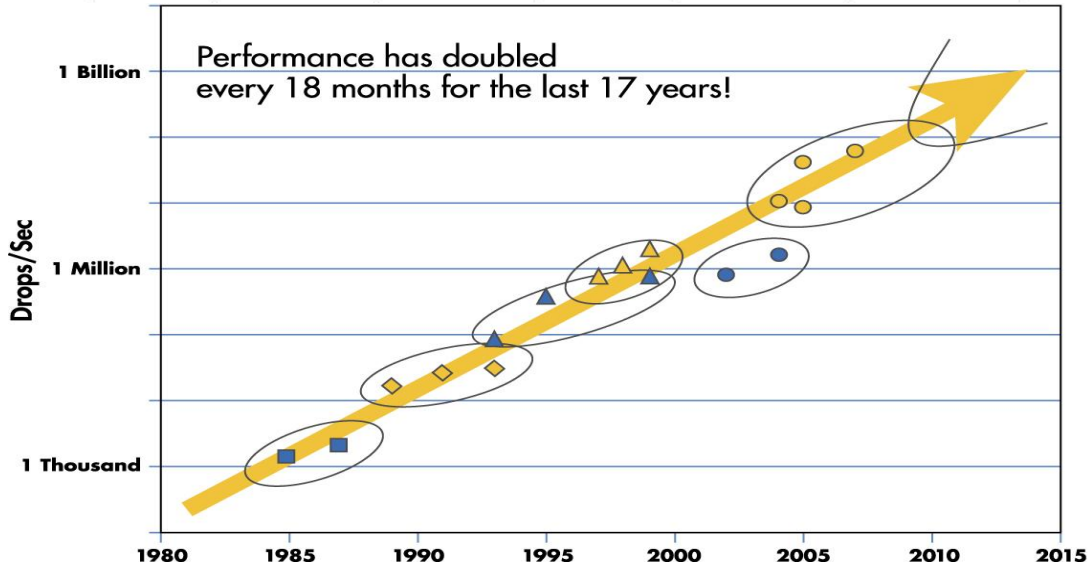
- Modular, expandable systems
- Precision dispense
- Drop on demand
- Multiple fluids
- High flux capacities

HP Thinkjet <1 page per minute

Increasing Performance

Inkjet Generations
Continuous Innovation Increases Performance



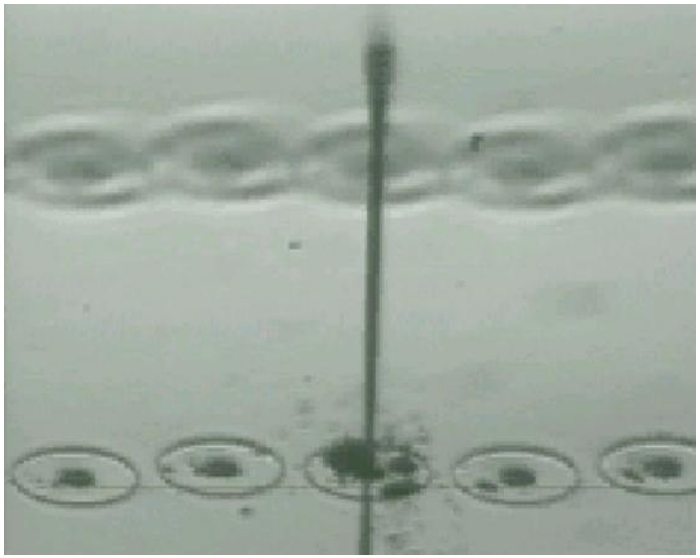


Drop weights decrease

picoliters	86	50	32	10	4	0.01
relative drop size	70µm	45µm	40µm	26µm	19µm	3µm
year	1991	1995	1996	1997	1999	2002

relative drop sizes in picoliters (trillionths of liters)

(3 micron, 10 fl)



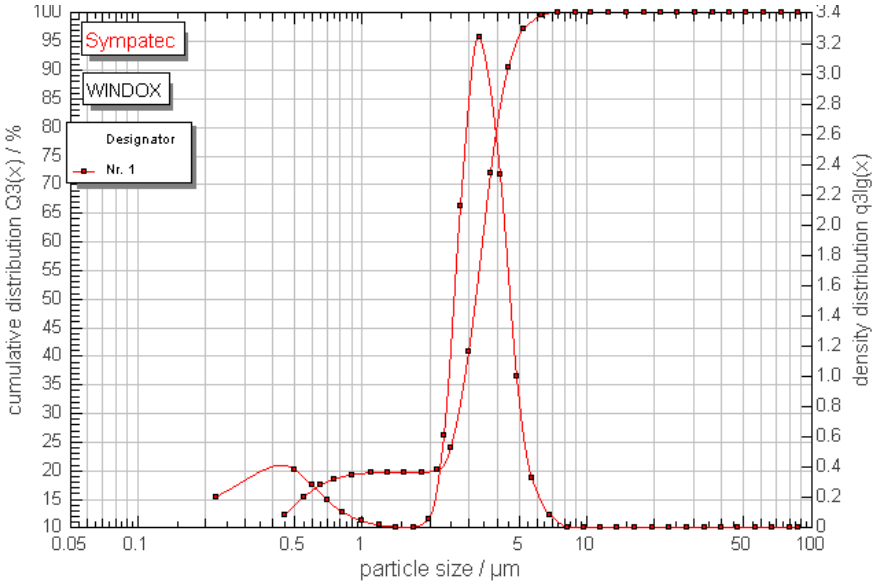
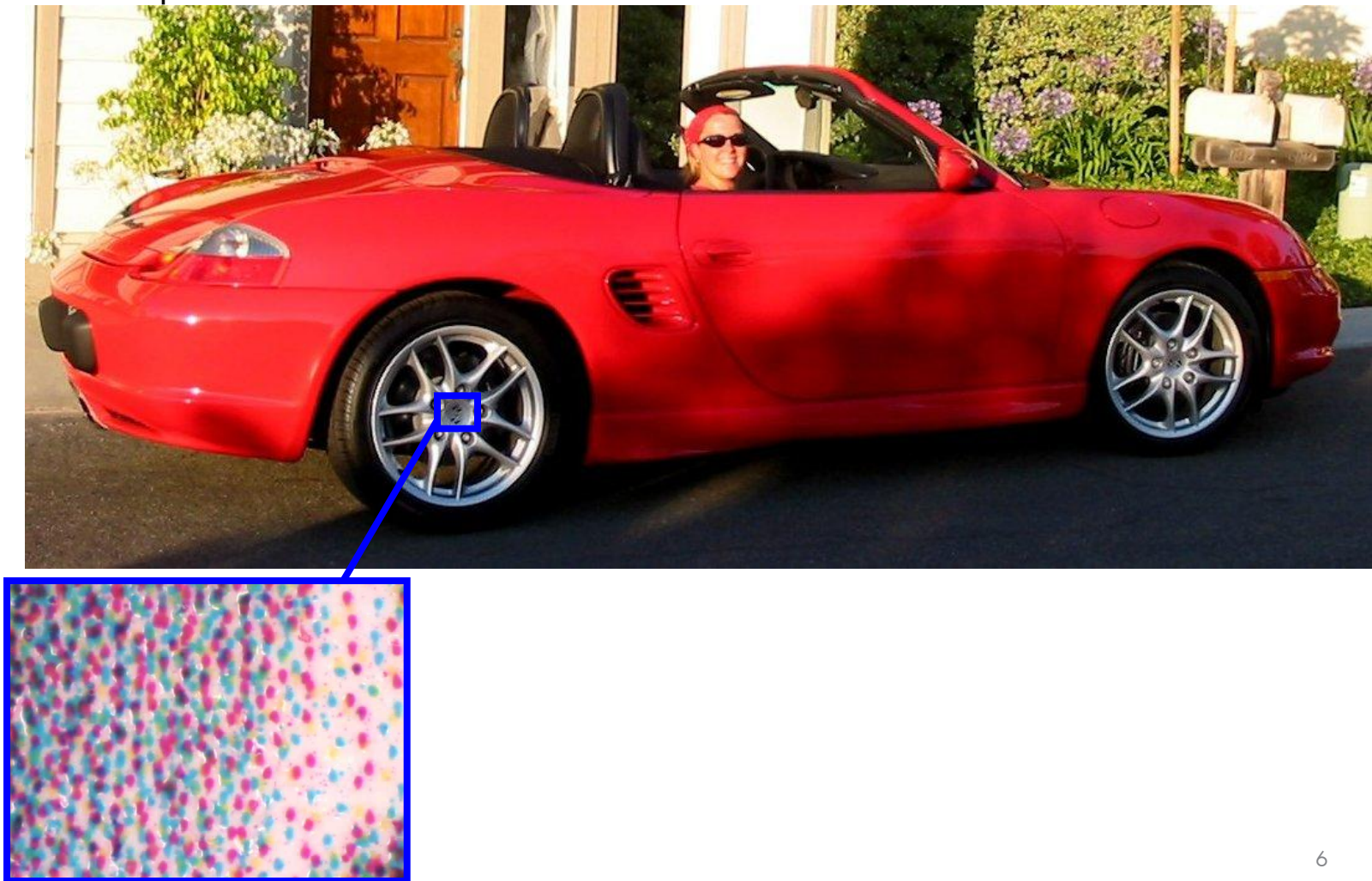


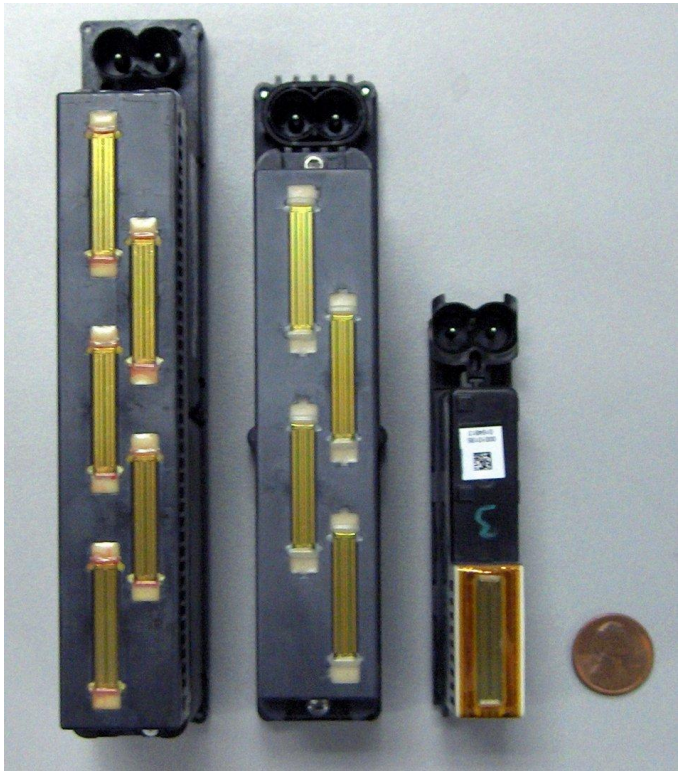
Photo Printing
precise color placement is the key

- Photo quality images are formed through precise placement of colored dots
  - ~5um radial placement error



Modularity Enables Rapid Development of High Performance

- Multiple die mounted on a single carrier enable high performance, scaleable systems



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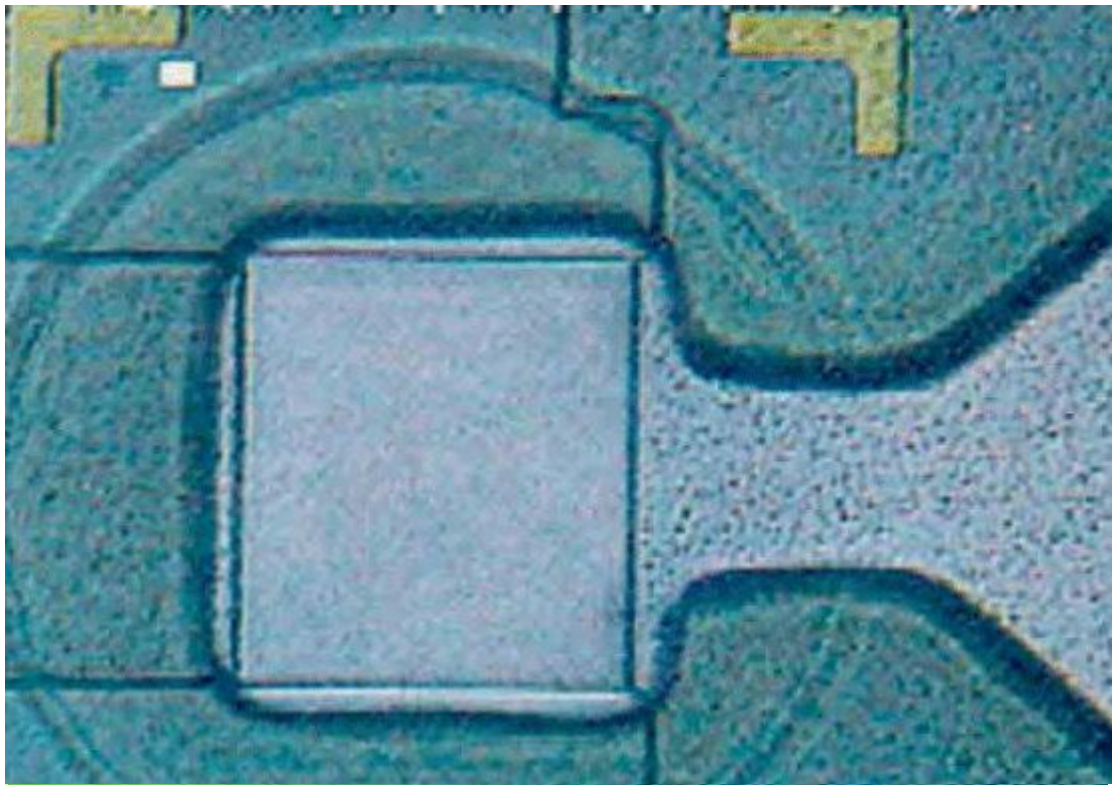
Drop on Demand Printheads : Thermal and Piezo Inkjet Technology



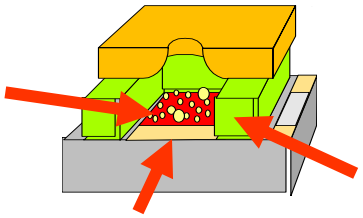


Thermal Inkjet technology



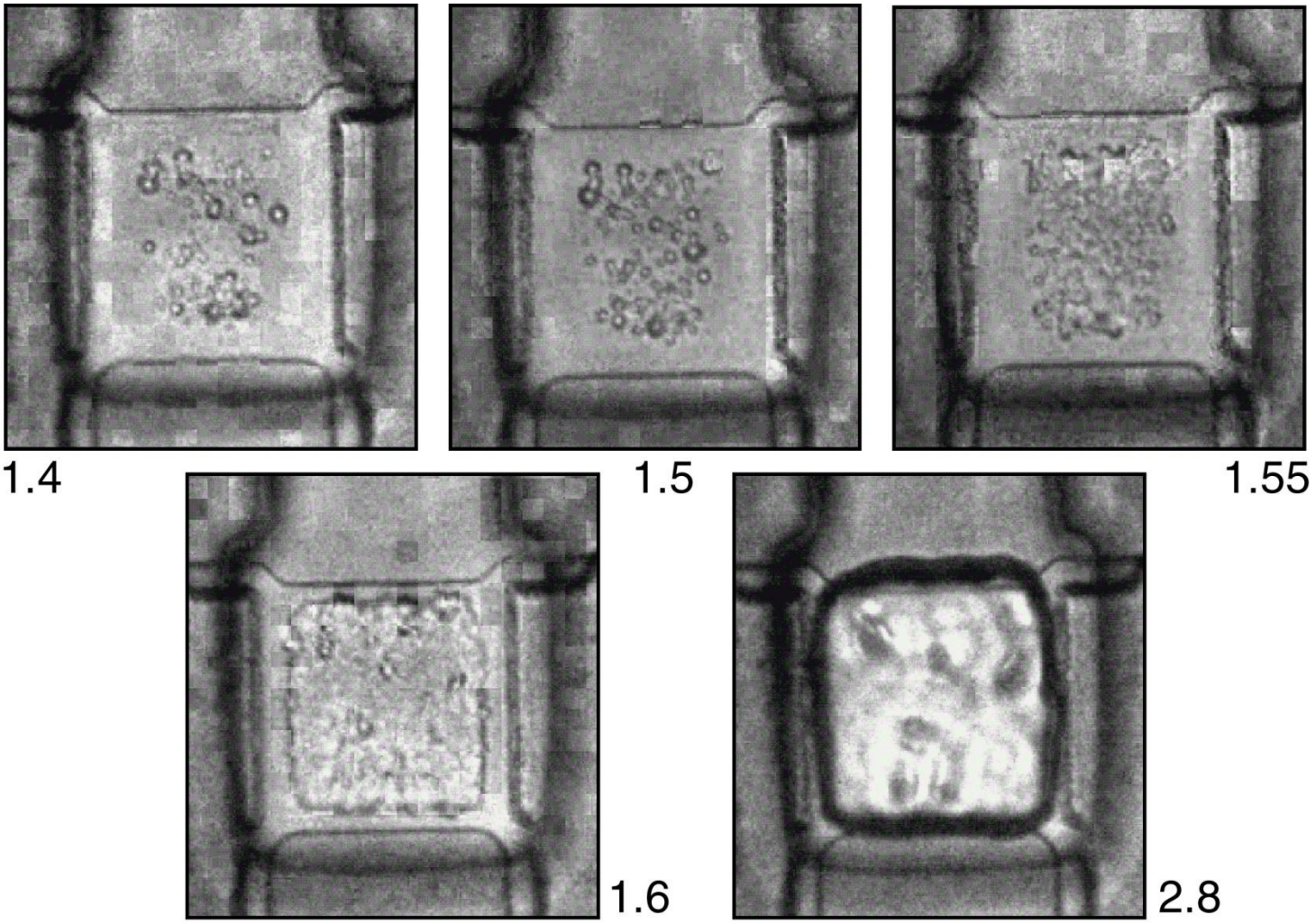
Microscopic view under stroboscopic illumination

- Up to 36 000 vapor bubble cycles per second



- barrier defines the walls of the chamber where the vapor bubble forms
- refill channel lets fresh ink flow into chamber
- heater generates the vapor bubble in the ink
- nozzle is positioned over resistor to form a drop of ink

Nucleation and Bubble Growth

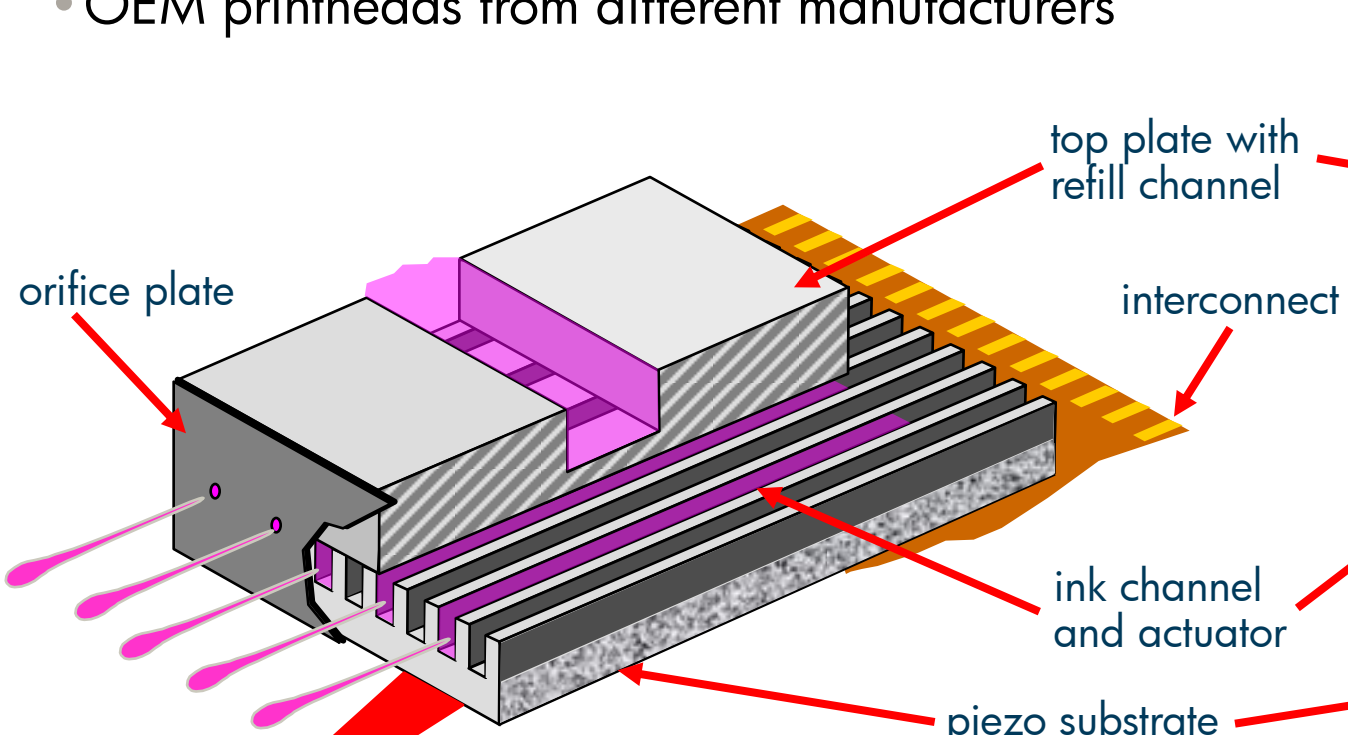


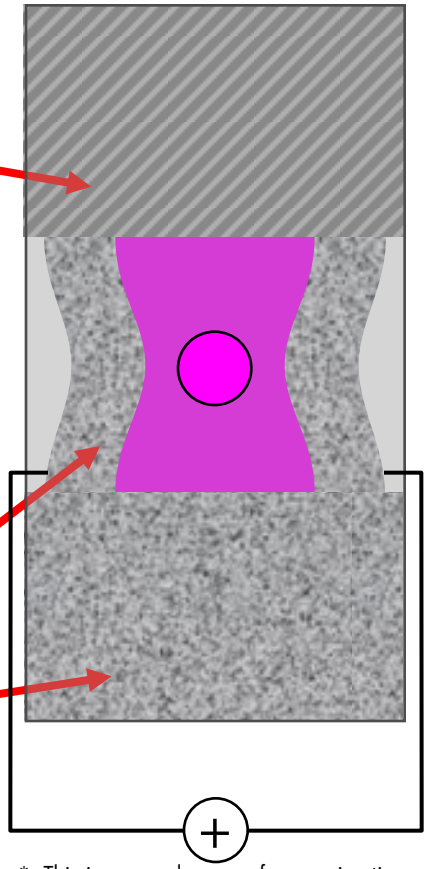
Images of bubble nucleation and expansion, numbers are microseconds

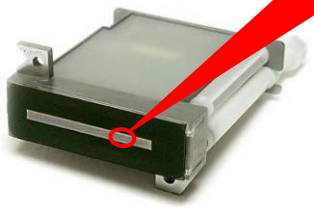
Piezo Inkjet Printheads

optimized for aqueous, solvent, and UV-curable inks

- proven industrial inkjet technology
- OEM printheads from different manufacturers







- How it works:
  - voltage pulse* deforms walls of ink channel
  - ink drop is squeezed out

* This is a complex waveform, animation shows the squeeze phase for simplicity

Inkjet Ink

Ink Technologies

- Aqueous Inks
- Latex Inks
- Solvent Inks
- UV-curable Inks

Aqueous Inks
for absorbent and coated media

(figure does not represent exact proportions)

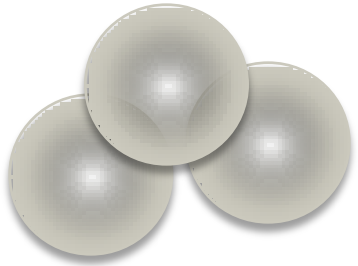
- Pigment or Dye
- Surfactant
- Polymer/Binder
- Humectant
- Anti-curl additive
- Anti-kogation additive
- Preservative
- Chelation Agent
- Buffer
- Co-solvent
- Water

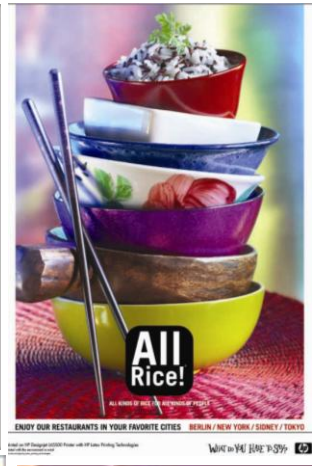
ink "vehicle"

With water, many additives are needed to obtain the required vehicle properties

Latex Printing Technologies
overview

- "Latex" is a descriptive term for aqueous-dispersed polymers
  - polymer particles are dispersed (suspended) in the ink
  - the polymer in Latex Inks is synthetic and chemically different from natural rubber latex
  - Latex Inks are non-allergenic
- Latex Inks are water-based
  - compatible with most low-cost media for low-solvent inks
  - compatible with a variety of uncoated media
- Performance is comparable to low-solvent inks*
  - indoor, in-window/outdoor display permanence
  - scratch-, smudge-, and water-resistance
  - color gamut



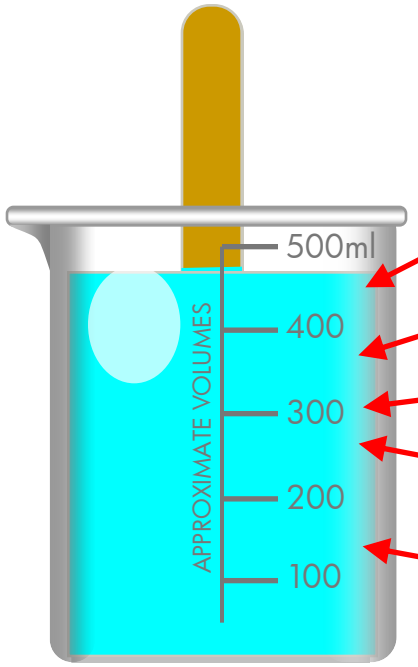


* Low-solvent inks include HP 780 and HP 790 Supplies for HP Designjet 8000sr, 9000s, and 10000s printers. HP image permanence and scratch, smudge, and water resistance estimates by HP Image Permanence Lab. Display permanence tested according to SAE J2527 using HP Latex and low-solvent inks on a range of media, including HP media; in a vertical display orientation in simulated nominal outdoor display conditions for select high and low climates, including exposure to direct sunlight and water; performance may vary as environmental conditions change. Scratch, smudge, and water resistance tested using HP Latex and low-solvent inks on a wide range of HP media; water resistance is comparable when printed on water-resistant substrates. Laminated display permanence using Neschen Solvoprint Performance Clear 80 laminate. Results may vary based on specific media performance. For more information, see www.hp.com/go/supplies/printpermanence.

Latex Inks (water based)

liquid and solid components

Latex Inks deliver performance comparable to low-solvent inks using a water-based ink vehicle, co-solvent concentration similar to aqueous inks, and Latex (dispersed) polymer.



solids

Colorant
- pigments

Latex (dispersed polymer)

liquids

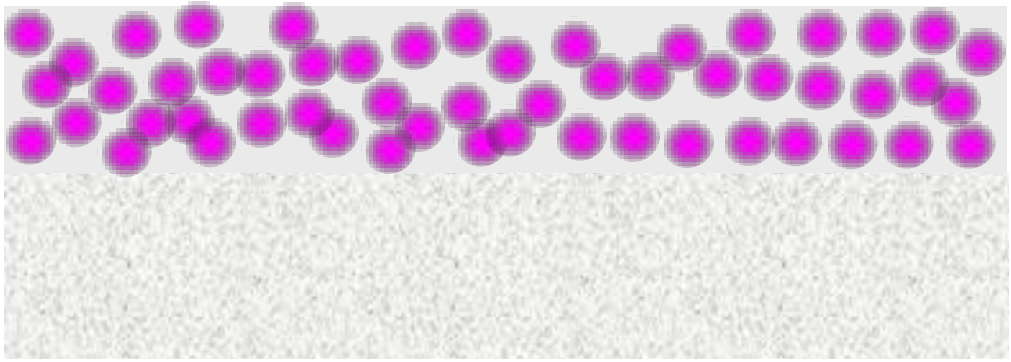
Additives
- surfactants
- humectants

Co-solvents for aqueous inks

Water

(figure does not represent exact proportions)

HP Latex Inks
image formation process



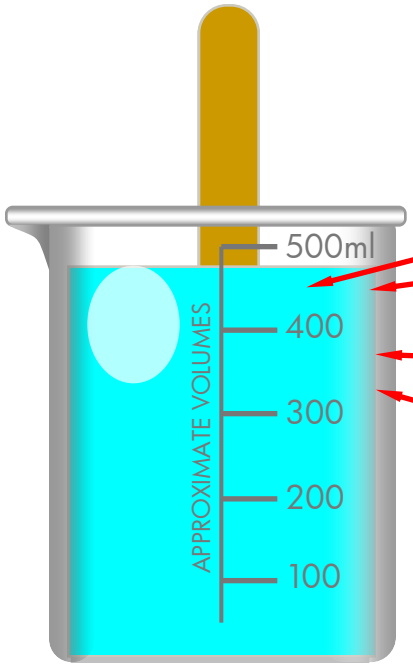
(schematic drawing is not to scale)

- Ink drop makes a colored dot on the media surface
- Ink vehicle softens vinyl for good film adhesion
- Print Zone Heater evaporates water from the ink vehicle
  - ink forms a thin liquid film on the media surface
  - pigment particles are dispersed throughout the film
  - dot is "fixed" to prevent color bleed and dot coalescence
- Curing Zone Heater causes latex particles to form a continuous film on the media
  - co-solvents evaporate
  - latex particles coalesce
  - pigments are encapsulated
  - print is now dry and durable

Solvent Inks
primarily for uncoated and nonabsorbent media

The formulation of solvent inks is somewhat simpler than aqueous inks.

The solvent is specifically selected for certain requirements, and its properties require less modification by additives.



(figure does not represent exact proportions)

Colorant (pigments)

Dispersing Agent
- ensures stable pigment suspension

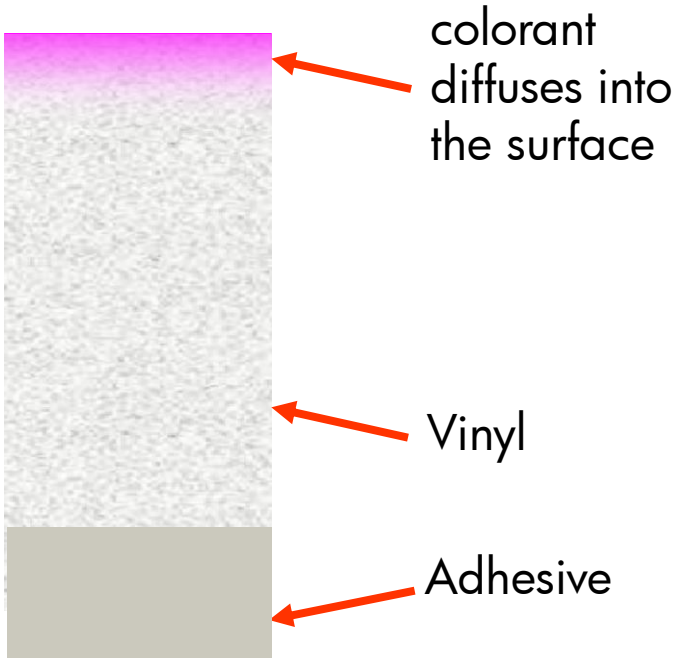
Polymer/Binder
- forms surface film

Solvent
- drop-formation
- can soften and dissolve vinyl

ink "vehicle"

Solvent Ink Technology

Colorant is encapsulated into the dissolved region to form a permanent bond.



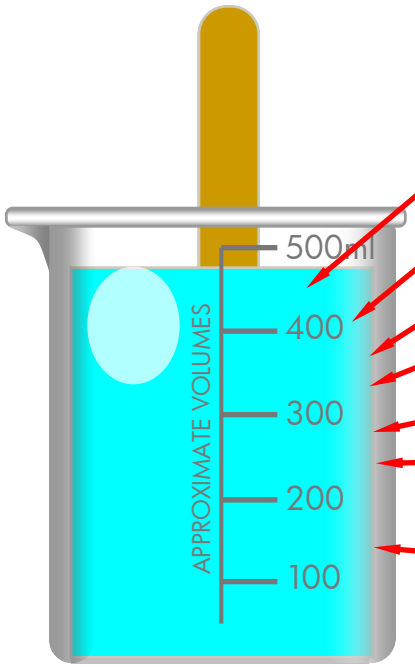
cross-section of uncoated vinyl
(not to scale)

- Solvents in ink vehicle dissolve or soften nonabsorbent materials (such as vinyl)
- Pigments are encapsulated in surface layer
- Solvents evaporate to leave a durable colorant film

Solvent Inks
features and benefits

- Prints on low-cost, nonabsorbent materials, such as vinyl
- Flexible colorant film for substrates that will be folded, bent, or stretched in applications
- Long-term outdoor durability (up to 2 years unlaminated)
- High durability
  - excellent scratch and smear resistance
  - excellent water-resistance
- Good color gamut
- Low cost/m^2 suitable for
  - building wraps
  - billboards

UV-curable Inks
free radical cure, 100% solids



(figure does not represent exact proportions)

Colorant (pigments)

Dispersing Agent
- ensures stable pigment suspension

Oxygen Inhibitors
- inhibits polymerization during storage

Surfactants
- improve wetting of print medium

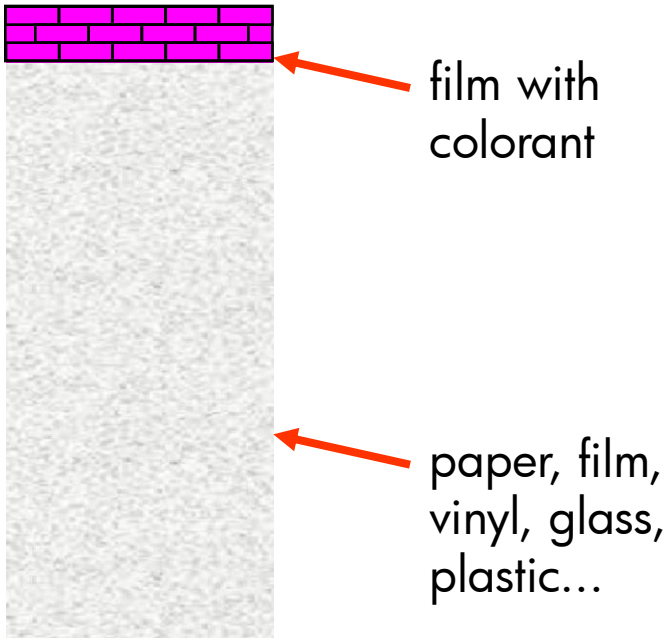
Oligomers
- provide film durability/flexibility

Photo Initiators
- initiate & sustain the UV curing process

Monomer
- provides low viscosity liquid carrier
- crosslinks to form solid film on media
- provides substrate adhesion

UV-curable Inks
media interaction

Colorant is contained in a layer that durably binds to the surface of the print medium



cross-section of print medium
(not to scale)

- ink vehicle:
  - does not "dry" by evaporation
  - all the ink remains on the substrate
- ink hardens "instantly"
  - ink is polymerized by intense UV light
  - photoinitiators produce "free-radicals" that convert liquid monomers to a solid
- colorant is a thick film
  - ink is formulated to prevent cracking on flexible substrates
  - well-suited to flat-bed printers and rigid substrate applications
- UV-curable inks can be formulated to print on virtually any substrate

UV-curable Inks
features and benefits

- Excellent durability
  - up to 2-year outdoor durability[1]
  - high substrate adhesion
  - resists abrasion
  - resists cracking on flexible substrates
  - resists smearing from common cleaners
- Prints on virtually any substrate
  - inks form a durable mechanical bond to surface
  - rapid cure (typically 0.1sec under UV exposure)
    - minimizes ink spread and feathering
    - minimizes penetration into absorbent media
    - can produce very sharp lines and edges and highly-saturated colors on a variety of media
- Delivers high production rates
  - "instant drying"
- Reduced environmental, health, and safety issues compared to organic solvent-based inks
  - extremely low VOCs
  - low risk of fire or explosion
  - high ink efficiency

[1] based on HP Scitex testing according to ASTM D2565-99

Ink Technologies
how to choose?

- There many aspects to consider when choosing a printing solution
- Each type of ink and printing technology (i.e., thermal inkjet and piezo inkjet) satisfies different requirements

- Product/Solution acquisition price
- Prints on economical uncoated media
- Cost per Copy
- Image Quality
- Durability and Fastness
- Environmental Health and Safety requirements
- Media Versatility

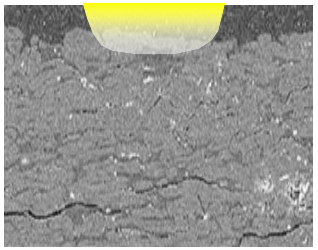
- Because there is no "universal" solutions.

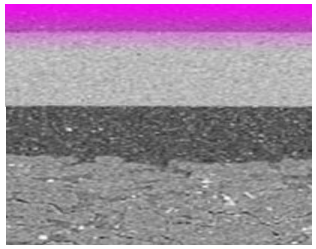
Aqueous	Latex	Mild/Low-solvent	Hard-solvent	UV-Curable

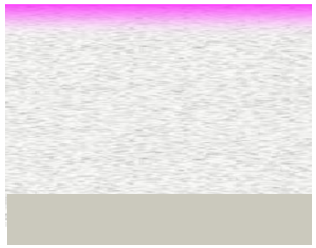
Inkjet Media

Inks and Media

many different ways to make a colored dot





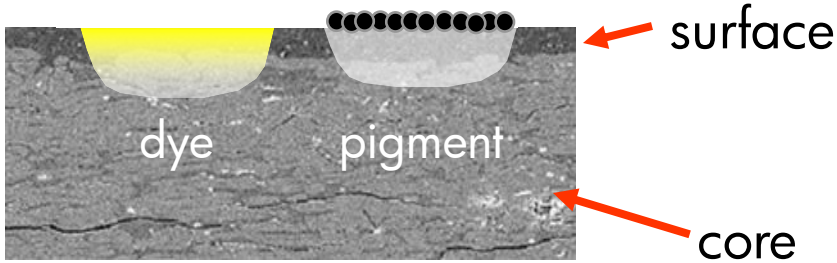


- Absorbent, Uncoated Media
  - ❑ papers, cloth
    - ❖ aqueous and solvent inks
- Coated Media
  - ❑ swellable and porous coatings
    - ❖ aqueous and solvent inks
- Nonabsorbent, Uncoated Media
  - ❑ typically adhesive-backed vinyl
    - ❖ hard-solvent inks
    - ❖ low-solvent inks
    - ❖ UV-Curable inks

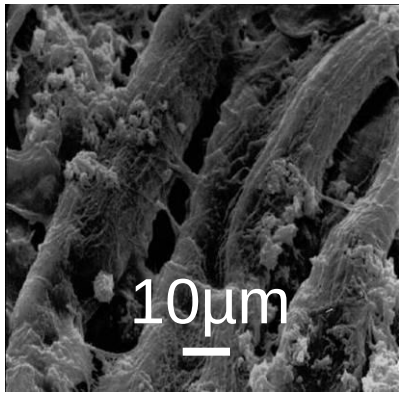
Absorbent, Uncoated Media
materials such as paper and cloth

Ink vehicle and colorant penetrate a porous surface.

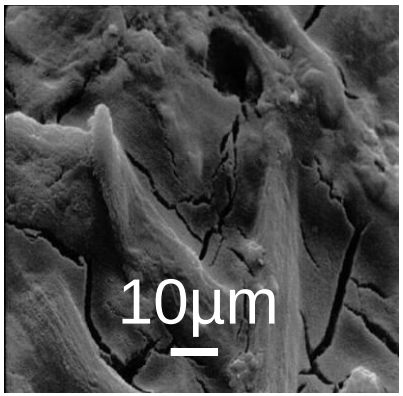
Bonding between colorant, binder, and cellulose provides durability.



cross-section near the paper surface



dye



pigment

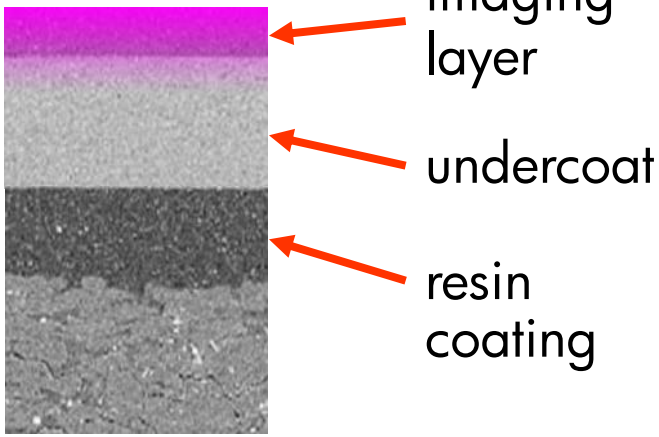
Electron microscope images
(Source: HP R&D)

- dyes carried by ink vehicle into the core material
  - this can reduce color saturation
- pigments coat the surface with a film ~1micron thick
  - this can improve color saturation
- ink dries by evaporation
- dyes: low fade-resistance and poor waterfastness (aqueous inks)
- pigments: generally excellent fade resistance and good waterfastness

Coated Media
encapsulating coatings

In an encapsulating (or "swellable") coating, ink vehicle and dyes are absorbed by the coating and dyes are encapsulated.

Encapsulation protects dyes from airborne chemicals but not from light and water.



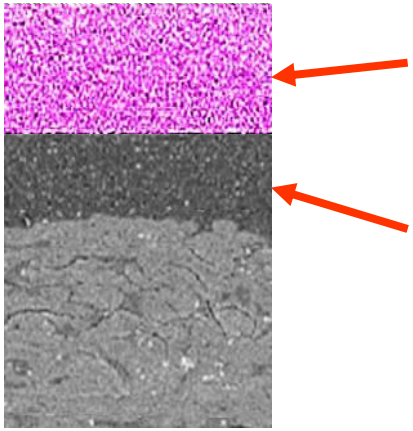
cross-section near the surface of photo paper with encapsulating coating

- ink-receptive coating: synthetic and natural polymers
- ink and dyes are absorbed into the coating
- coating swells then shrinks as ink vehicle evaporates
  - dries by evaporation: can be handled in ~5 minutes
  - generally poor water- and wet-smudge resistance
- offers excellent fade resistance when designed together with HP dye-based inks

Coated Media
porous coatings

In a porous coating, ink vehicle and dyes penetrate into the open spaces (pores) between particles in the coating.

Dyes are protected from water but airborne chemicals can diffuse into the pores to cause fade.



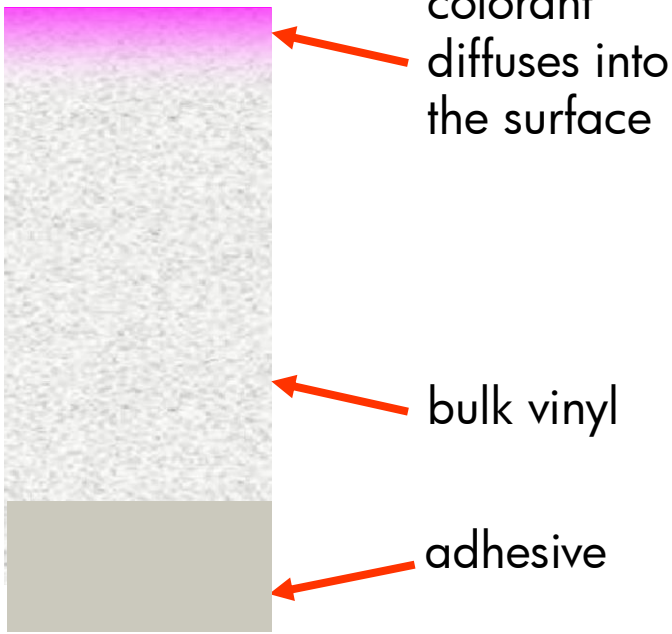
cross-section near the surface of photo paper with porous coating

- ink-receptive coating: open-matrix of pores formed from microscopic particles bound together
- "instantly" dries by absorption
- ink capacity limited to void volume
- very high, uniform gloss with dyes
- pigments are too large to penetrate into pores
  - gloss uniformity issues
- excellent water- and wet-smudge resistance
- lower permanence for dyes than with encapsulating coatings

Nonabsorbent, Uncoated Media
solvent inks dissolve or soften the substrate

Colorant is encapsulated into the dissolved region to form a permanent bond.

Hard (or "aggressive") solvent inks work this way on uncoated vinyl.



cross-section of uncoated vinyl
(not to scale)

- drop of solvent ink softens and dissolves the surface
- colorants are absorbed into the dissolved region
- solvent evaporates leaving colorant integrated into the print medium
- image is highly-durable because it is incorporated in the substrate
  - resists scratches and abrasion
  - resists smearing from cleaning solvents

The ColorLok® Paper Program – An Industry Effort

Benefiting the Industry and the End User

ColorLok® paper benefits	Inkjet	Laser
Bolder text, darker black	◉	
More vibrant images and sharper colors	◉	
Fast dry time	◉	
High reliability	◉	◉
Fewer electrical defects for better print quality		◉
Better paper for better printing	◉	◉

APRIL Fine Paper

COPAMEX®

Domtar

GP Georgia-Pacific

INTERNATIONAL PAPER

mondi

m-real

STORAENSO

SUZANO PULP AND PAPER

antalis

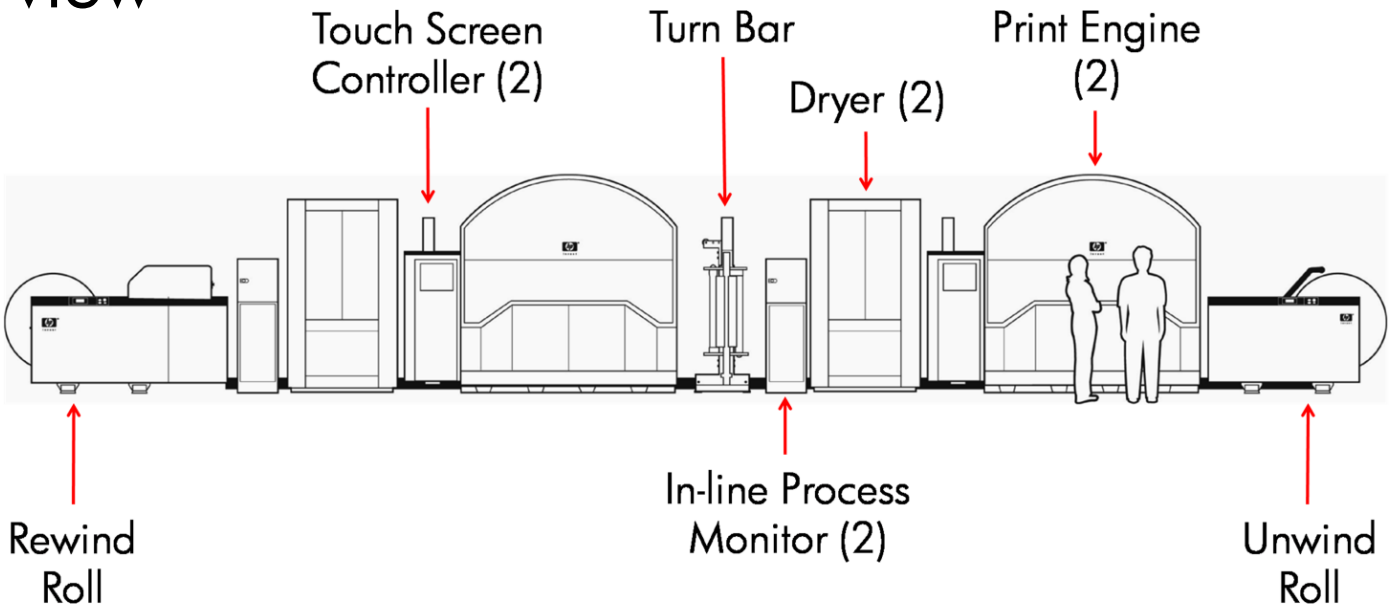
Office DEPOT

PAPYRUS

STAPLES that was easy.

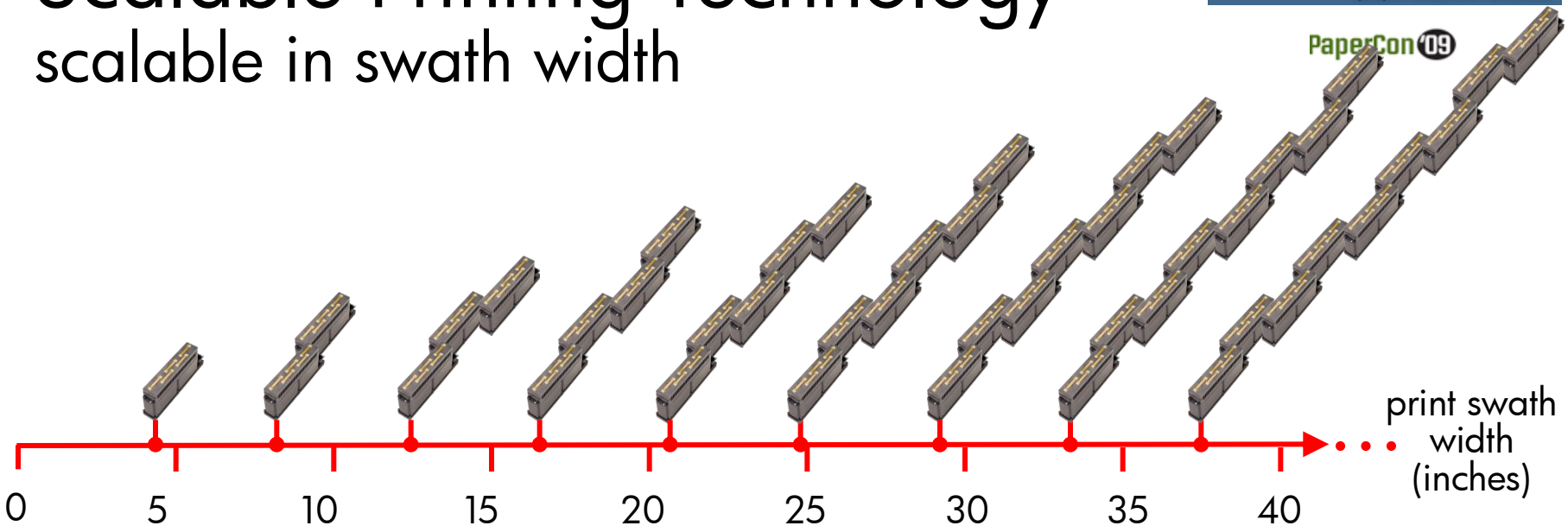
Inkjet Web Press

Inkjet Web Press
overview

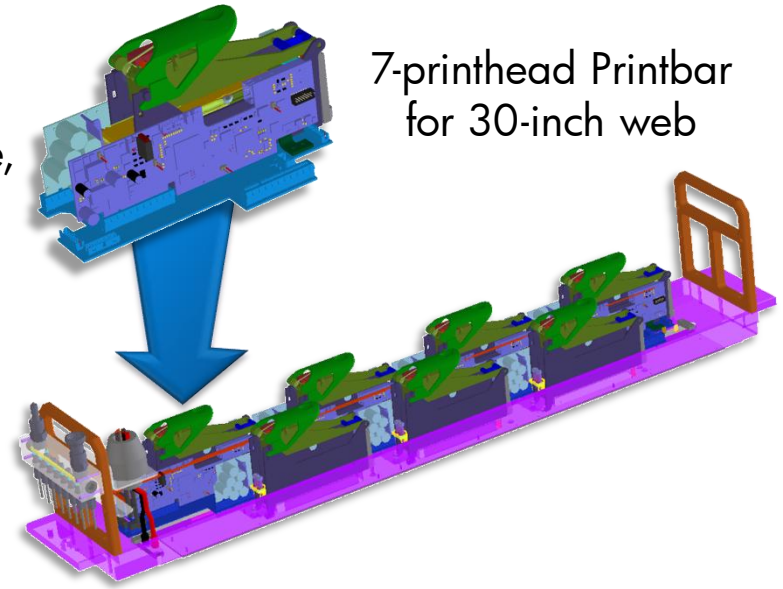


- Prints a 30-inch web at speeds up to 400 ft (122m) per minute
- 1200 X 600 dpi, duplex 4-color printing
  - Bonding Agent for uncoated stock
- 4.25-inch SPT-based printheads
- Fault-tolerant design
- In-line process monitoring
- Raster image processing and process control at full press speed

Scalable Printing Technology
scalable in swath width



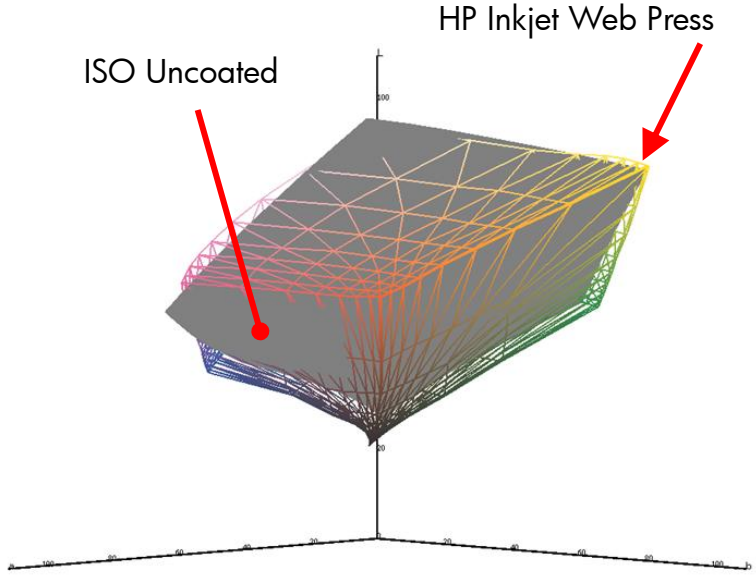
- Assembling printheads <u>across the web</u>
  - prints across web width without a gap
  - fully-modular printhead "pocket"
  - replace only printheads that require maintenance, not the entire printbar
    - in-line process monitoring identifies printheads to be replaced
    - printheads are user-replaceable
- Automatic printhead alignment across the web
  - using in-line process monitoring system



7-printhead Printbar for 30-inch web

Pigment Inks
uncoated paper performance

- Water-based formulation
  - very low VOC emissions*
  - no ozone, no hazardous air pollutants**
  - non-flammable and non-combustible
- Inks work with PET (paper enhancing technology) or Bonding Agent on uncoated papers.
- Compared to Euroscale Uncoated gamut:
  - better black optical density
  - larger color gamut
- Durability
  - smudge-resistant
  - water-resistant
  - highlighter-resistant
  - suitable for direct mail and book production



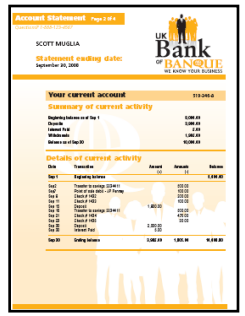
Gamuts on Uncoated Paper

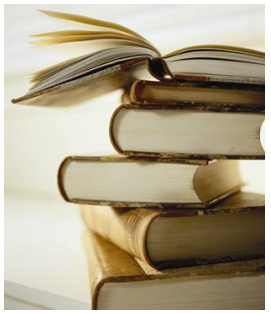
* Dryer and print zone exhaust systems, along with non-hazardous, very low VOC inks provide a safe printshop work environment. Typically, no air discharge permitting is required for the HP Inkjet Web Press. Customers should consult state and local requirements and regulations

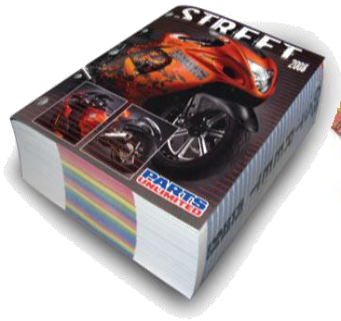
** No ozone products expected based on ink composition and printing technology; HAPs per US Environmental Protection Agency Method 311.

Inkjet Web Press
media solutions

- Coated media
  - HP has developed coated media works at 400fpm and delivers highest print quality available today on digital ink jet presses.
- Uncoated media options
  - Web press can supply bonding agent to increase media flexibility.
  - "For best performance", use Paper Enhancement Technology (PET), which is optimized to provide offset comparable quality on uncoated papers.
    - Overall IQ similar to offset
    - Color gamut larger than SWOP
    - Black Optical Density similar to offset
    - Delivers 90gsm quality on 75gsm paper
    - Available though HP licensing program (announcing details at Print '09)

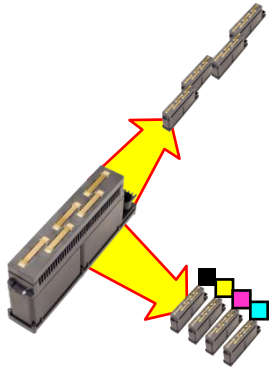






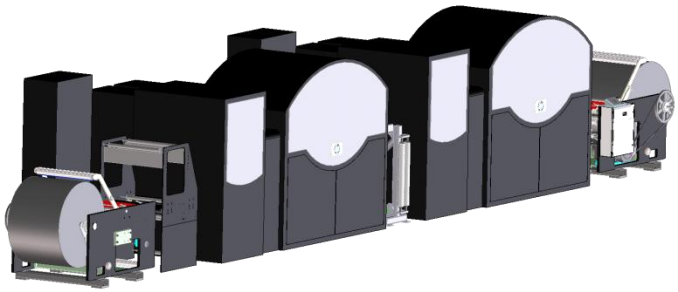
Take-away Messages

- Scalable Printing Technology extends core inkjet technologies into industrial printing solutions
  - industrial solutions benefit from HP's manufacturing expertise and economies of scale



- With SPT, Inkjet Web Press offers performance scalable in features, speed, and web width
- Pigment inks and bonding agent give good print quality on a variety of uncoated stock

- Pigment inks and PET are optimized to provide offset comparable quality on uncoated papers.
- In-line performance monitoring and control assure consistent performance and fault-tolerant web printing.




Thank you!