Inkjet Printhead Characteristics and Application Requirements

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Outline

- Inkjet Print Heads and Solution Components
- Print Head Contenders
- Existing and Emerging Applications
- Matching Head Characteristics to Application Requirements

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Inkjet Solution Elements

- Print heads
- Firmware, driver, RIP and image generation software
- Print controller electronics
- Print head monitoring and maintenance
- Print head and/or substrate movement
- Ink or fluid
- Ink delivery and maintenance
- Color control
- Pre-coating to make substrate print receptive
- Substrate handling
- Curing, fixing and drying
- Integration

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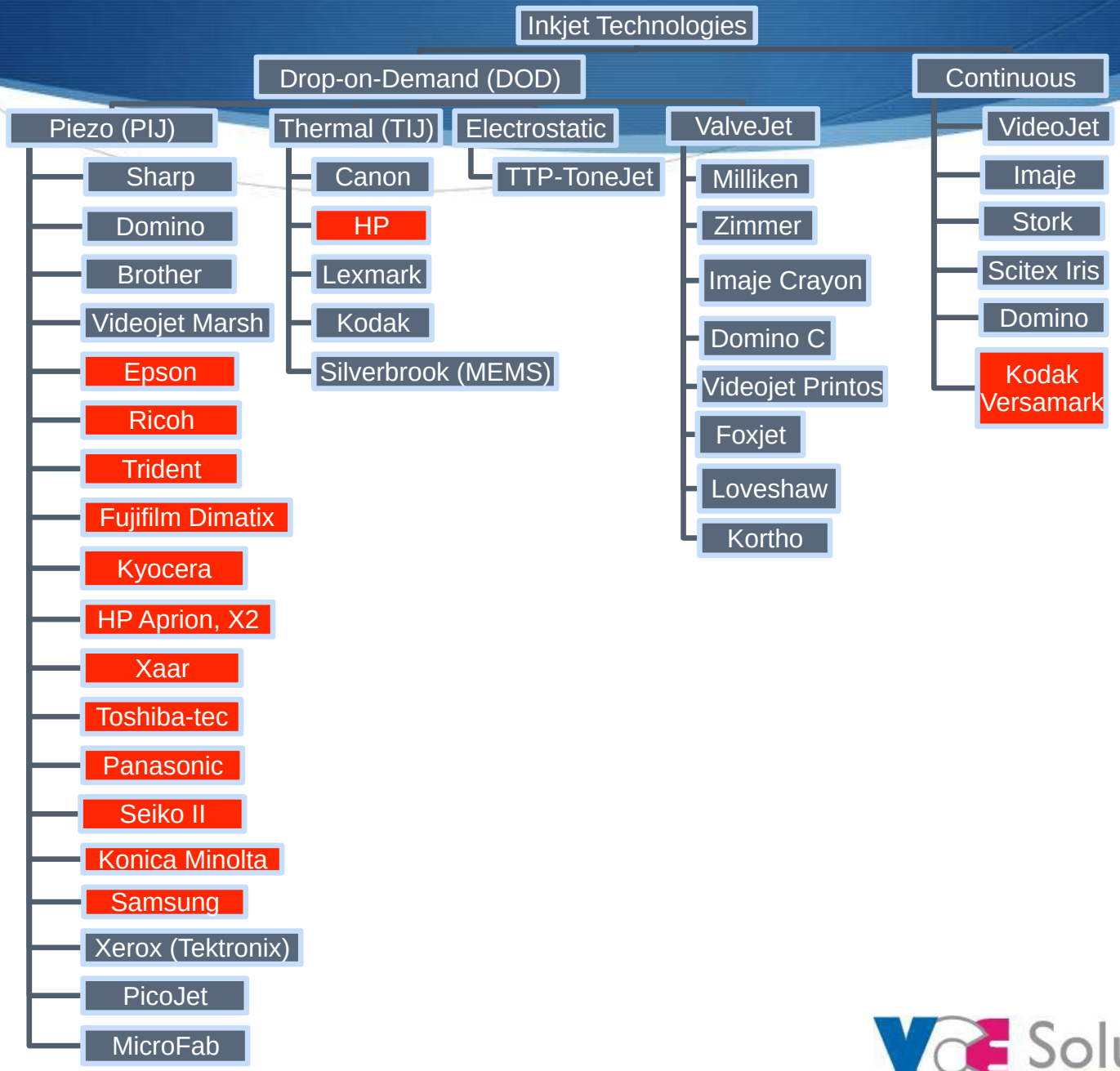

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PIJ Print Head Contenters

- Kyocera KJ4 A&B
- Panasonic
- Fujifilm Dimatix Samba & Q-class
- HP X2 and successor
- ToshibaTec
- Samsung
- Ricoh Gen4
- Epson
- Trident
- Xaar 1001
- Konica Minolta KM series

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Kyocera KJ4 Series

Head Characteristics

- Aqueous and UV ink models
- 2,656 nozzles
- 10.8 cm (4.25“) wide
- Binary: up to 60 kHz
- To $15x10^7$ drops/sec/head
- Grayscale: 40 kHz
- KJ4A drop vol: 6, 7, 11, 14 pL
- KJ4B drop vol: 5, 7, 12, 18 pL

Applications

- Commercial print (Aq)
- Textile and garment (Aq)
- Plastics (UV)

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Kyocera KJ4A&B

Resolution (dpi)	Grayscale	Print Speed KJ4A	Print Speed KJ4B
600x360	4 drop sizes	NA	330m/min (40kHz)
600x600	4 drop sizes	150m/min (30kHz)	200m/min (40kHz)
1200x1200	Binary	NA	150m/min (60kHz)

Kyocera KJ4

Global Inkjet Systems: KJ4 HPB

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Panasonic PIJ

Head Characteristics

- Resolution: 600 dpi
- 800 nozzles
- 75-150 m/min
- Max. Frequency: 30 kHz
- Binary: 11 pl
- Grayscale: 3, 11, 14 pl
- Aqueous-based ink

Applications

- Commercial: transactional
- Industrial: glass, ceramic, metal, wood, PE, PP, PET, paper, card
- Security: passports, licenses
- Packaging: flexible and rigid
- Label printing
- Kodak Versamark VL2000
- Impika iPress 600, 2400

Source: Impika

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Impika iPrint & iPress

Model	Resolution dpi	Throughput m/min
iPrint 75	600x600	76
	1200x600	40
iPrint 125	600x360	127
	600x600	76
iPrint 150	600x600	152
	1200x600	76
iPrint 250	600x360	254
	600x600	152
iPress 2400	1200x1200	76
	2400x1200	40

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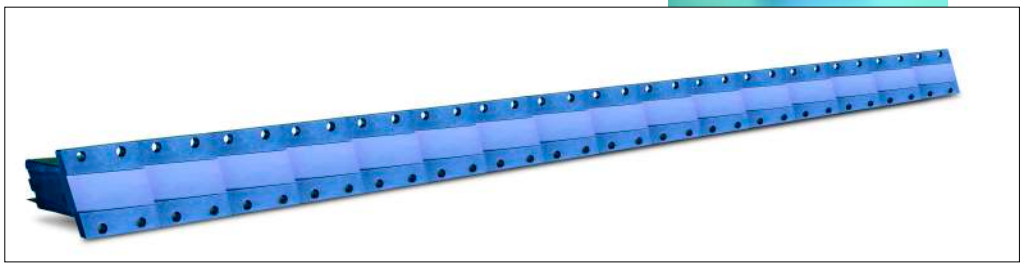
Fujifilm Dimatix Samba

Head Characteristics

- MEMS construction
- VersaDrop multi-pulsing
- Drop sizes: 0.1, 1.0, 2.0 pl
- Meniscus replenishment
- Ink recirculation
- Frequency: 45 to 100kHz
- 2048 nozzles per module
- 1200 dpi native
- Designed for large arrays

Applications

- Commercial and variable data printing
- Photographic reproduction
- Graphics displays



Images' source: Fujifilm Dimatix

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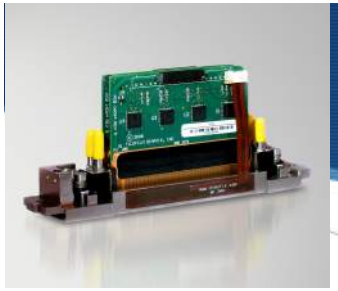
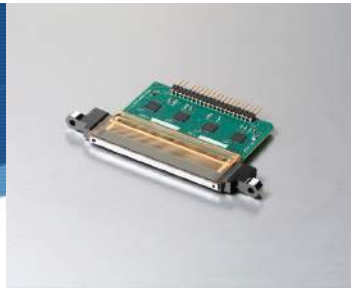


Fujifilm Dimatix Q-class



Heads

- VersaDrop binary and gray; drop ranges: 10-200pl
- Sapphire 256 nozzles QS-256/10, /30, /80
- Emerald 256 nozzles QE-256/10, /30, /80
- Polaris 512 nozzles PQ-256/15, /35, /85

System

- 9 Base heads, 9 nozzle plates
- 70 Q-class configurations
- Tailored to application
  - Native Drop Size
  - Nozzle Plate Technology
  - Gray Scale/Binary
  - Ink Connections
  - Frame Configurations

Applications

- Wide format graphics, labels, packaging

Source: Fujifilm Dimatix

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Fujifilm Dimatix New Printheads

Model	Nozzles	Frequency kHz	Drop Size pl (range)	Print Width mm	Native DPI	Fluid Viscosity cP
QS-256/10 QE-256/10	256	50 to 16.7	10-30	64.77	100	8-20 (10-14)
QS-256/30 QE-256/30	256	33 to 12.5	30-80	64.77	100	8-20 (10-14)
QS-256/80 QE-256/80	256	20 to 10	80-150	64.77	100	8-20 (10-14)
ScanPAQ 2.5	1024	50 to 16.7	15-30	64.77	100 to 400	8-20 (10-14)
PQ-512/15	512	40 to 25	15-50*	64.89	100 to 200	10-14
PQ-512/35	512	30 to 13	35-80*	64.89	100 to 200	10-14
PQ-512/85	512	20 to 8	85-200	64.89	100 to 200	10-14

Fujifilm Dimatix D-class

Head Characteristics

- 128 nozzles MEMS silicon
- D-128/1 DPN produces 1 pL drop volume binary
- D-128/10 DPN prints 10 pL drops binary
- For use with the FUJIFILM Dimatix DMP-3000 printer
- Feature definitions as small as 20 μm

Applications

- Digital deposition
- Photovoltaic silicon-based solar cells & other devices
- Small-size RFID antennae
- Organic thin-film transistors
- Printed circuits

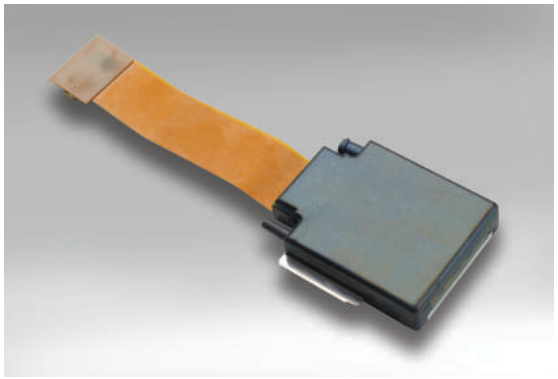

Image source: Fujifilm Dimatix

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HP X2 PIJ

Head Characteristics

- MEMS constructed
- 100 dpi native resolution
- Viscosity up to 15cP
- 42 to 50pl drops, binary
- 128 nozzles, 20 to 30kHz
- 32.5mm print swath
- 120m/min
- 8m/sec drop velocity
- Designed for wide arrays

Applications

- Large format graphics printing

Image source: HP Scitex

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Ricoh Gen 4 PIJ

Head Characteristics

- Push mode PIJ, dual port
- Aqueous, oil, solvent and UV-cure fluids
- 10-12cP at operating temp.
- Grayscale 3 drop: 7, 14, 21pl
- 384 nozzles (2 rows of 192 nozzles offset ½ pitch)
- 300dpi native, 480m/min
- 32.5mm Print swath
- 30kHz binary, 20 kHz grayscale
- Primarily stainless steel

Applications

- Textile and garment printing
- Wide format graphics
- 3-D Modeling
- Deposition for electronics
- Integrated heater & thermistor

Image source: Ricoh

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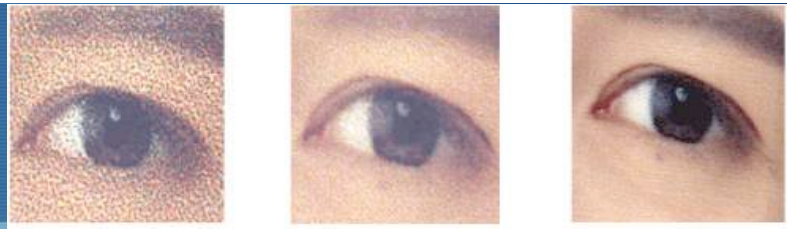
Epson



Head Characteristics

- Micro Piezo AMD & TFP heads
- Drops as small as 1.5pl (photo printers), 3.5pl AMD
- Viscosity 3 to 6cP
- Delicate ink channel walls
- Water tolerant
- Grayscale
- 2880 x 1440dpi DX4, DX5

Applications

- Coated photo paper & film
- Print receptive CD/DVDs
- Textiles and garments
- Graphics
- Color filters
- Circuit boards

Images' source: Epson

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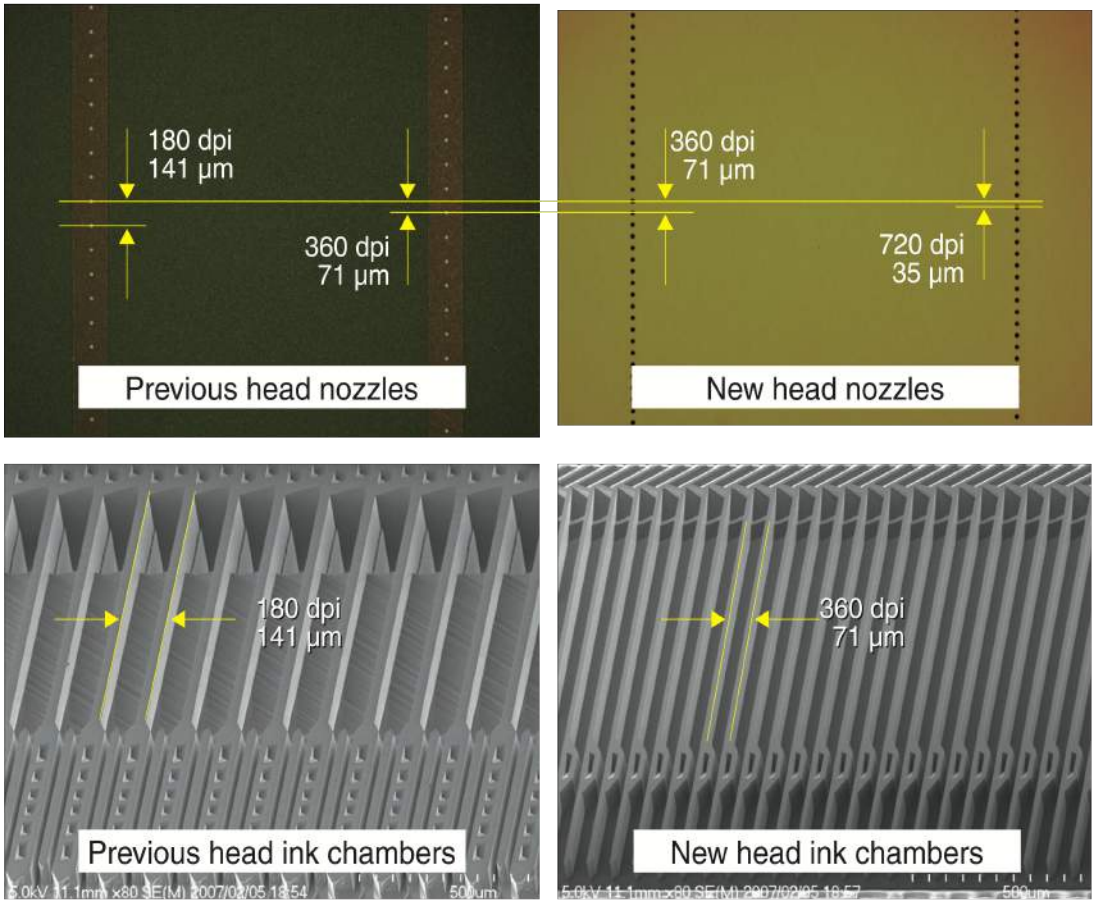
Epson Micro Piezo Refinement

Micro Piezo Head Nozzle Density Comparison



Images' source: Epson

Trident

Head Characteristics

- Performs in dusty environments
- Push mode PIJ
- End-user can disassemble and clean
- Stainless steel inert to acids to alkalines from 2 to 14 pH
- 5-30 cP

Applications

- Marking and coding
- Postal and addressing
- Document processing
- Textile marking and printing
- Etching
- Photovoltaics
- Material deposition and precision fluid dispensing

768 Jet™

Image source: Trident

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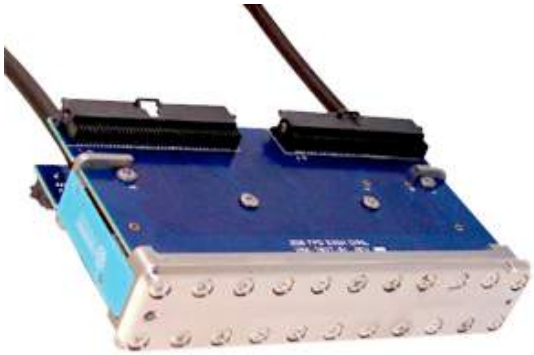
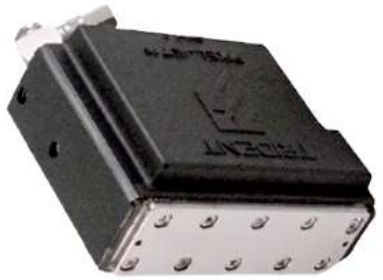
Trident ITW

Head Model	Channels	Nozzles	Swath (mm)	Frequency (kHz)	DPI	Drop Size (pl)
PixelJet 64	64	64	11.4	10-12	34	7,30,50,80
768Jet	256	768	101	10	64	50
384Jet	128	384	50	10	64	50
256Jet-D	256	256	101	10 (to 20)	64	7,30,50,80



256Jet™



PixelJet™ 64

Images' source: Trident ITW

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Xaar 1001

Head Characteristics

- 1000 nozzles, 360 dpi native
- 39kHz binary/6kHz grayscale
- 7 drop sizes from 6 to 42pl
- 7-50 cP viscosity range
- Not for aqueous ink
- Recirculation ABC head
- No dead end bubble trap
- Self recovery
- Designed for single pass

Applications

- Commercial printing
- Industrial printing
- Labels
- Ceramic printing
- Wide format graphics

Image source: XAAR

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Toshiba Tec

Head Characteristics

- Shared wall shear mode PIJ
- 2, 8 to 16 gray levels
- UV-cure and oil-based fluids
- CF1-with ink recirculation
- Photographic quality

Applications

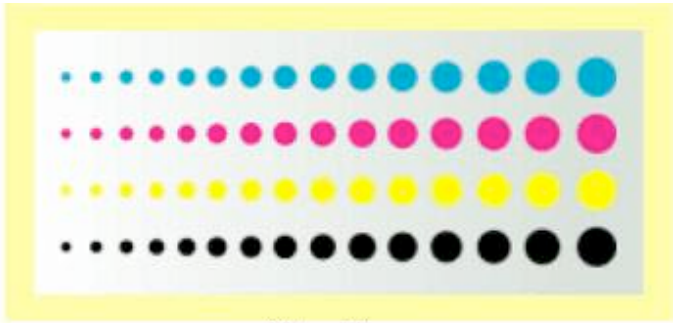
- Packaging
- Rigid substrates
- Metals, plastics
- Ceramic tile

CF1

CE2

CA4

CB1,CA3 model



CA4 model

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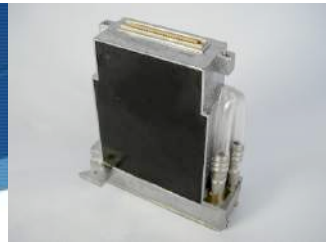
Toshiba Tec

	CB1	CA3	CA4	CA5	CE2	CF1
Swath	53.6mm	53.6mm	53.6mm	53.6mm	53.7mm	53.7mm
Channels	318	318	318	318	636	636
DPI	150	150	150	150	300	300
Grayscale	8 levels	8 levels	8-16 levels	2 levels	8-16 levels	8 levels
Drop Vol.	6-42pl	6-42pl	6-90pl	3pl	6-90pl	6-42pl
Max. kHz	4.8KHz (7drop)	4.8KHz (7drop)	28.0KHz (1drop) 6.2KHz (7drop) 2.8KHz (15drop)	17.9KHz (1drop)	28.0KHz（1drop） 6.2KHz（7drop） 2.8KHz（15drop）	5.7KHz (7drop)
Linear Speed	24m/min @7drop, 300dpi	24m/min @7drop, 300dpi	31m/min @7d,300dpi 35m/min @1drop, 1200dpi	23m/min @1drop, 1200dpi	31m/min @7d,300dpi 35m/min @1drop, 1200dpi	29m/min @7drop, 300dp

Konica Minolta



KM 1024

KM 512 X

Head Characteristics

- Shared wall & dry channel shear mode PIJ
- Large choice of mix and match grayscale print heads with drop volumes from 4 to 42 pl
- Cationic and free radical UV
- Models for aqueous, solvent, oil and UV-cure fluids
- KM 1024: 3 bit, 7 drop grayscale

Applications

- Wide format graphics
- Single pass 3-d decoration
- Textile printing
- Material deposition: LCD color filters and printed circuits
- Labels

KM 512 Y

Image sources: Konica Minolta and Industrial Inkjet Ltd.

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Konica Minolta Printheads

	KM512L	KM512M	KM512S	KM1024 SHB	KM1024 MHB	KM512 AQ
DPI	360	360	360	360	360	180
Nozzles	512	512	512	1024	1024	512
Grayscale	2	4	8	8	8	4
Drop Size	42 pl	14 pl	4 pl	6pl	14 pl	14 pl
Max kHz Frequency	7.6	12.8	23.0	26-32	12.8	12.8/13.2
Swath	36.1mm	36.1mm	36.1mm	72mm	72mm	72mm
Fluids	Oil, UV, solvent	Oil, UV, solvent	Oil, UV, solvent	UV, oil, solvent, +	UV, oil, solvent	Aqueous

KM 512AQ

Image source: Konica Minolta

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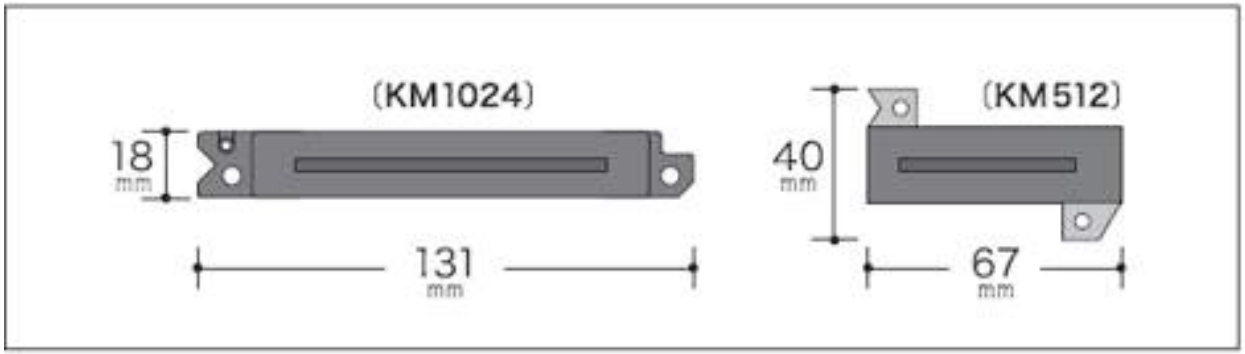
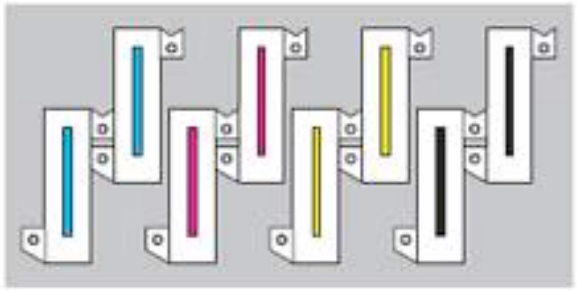
Konica Minolta 512 Vs 1024

- KM 1024 compared with KM 512

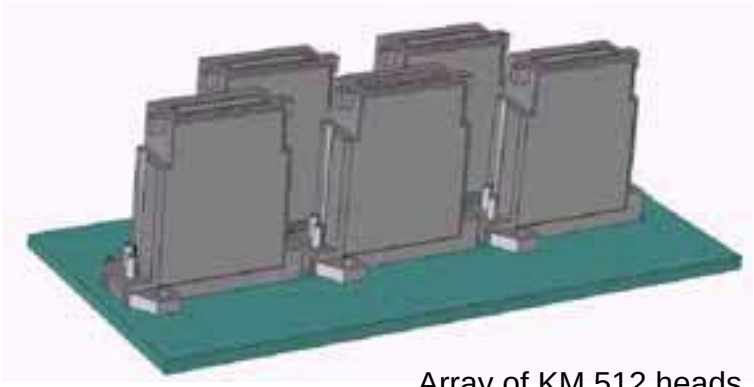


(KM1024)

(KM512)



80mm



Array of KM 512 heads

Image source: Konica Minolta

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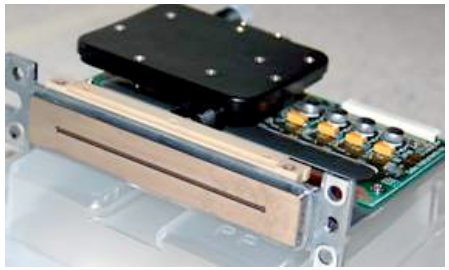
Seiko II

	JetT 508GS	JetT510
DPI	180	180
Nozzles	508	510
Grayscale	8	2
Drop Size	12, 24, 36, 48, 60, 72, 84 pl	35 pl
Max kHz Frequency	6-40	6-8
Print Swath	71.8mm	71.8mm
Fluids	Oil, aqueous, solvent, UV	Oil, solvent, UV
Linear Print Speed	29.4 m/min @360dpi, 7Khz	29.4 m/min

JetT508GS



JetT510

Images source: Triteck

Applications:
Wide format graphics
Marking and coding

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Samsung SemJet

Printhead Chacteristics

- 256 nozzles MEMS
- Models for 1, 5, 30, 80 pL
- Optional integrated heaters for in head and ink reservoir (max. temp. 100°C) and level sensor for fluid monitoring
- UV-cure, aqueous, solvent-based fluids
- Metallics: Cu, Ag, Au

Applications

- Printed circuit boards
- LCD, PDP, OLED
- Photovoltaic solar cell
- Micro lens, E-paper, RFID
- Biological applications
- Textile
- Graphics

Source: Samsung

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Other IJ Print Head

- HP TIJ 4 “Edgeline” architecture
- Kodak TIJ and Stream Technology
- ToneJet
- “d_shape” like systems
- Aerosol
- AIST SIJ

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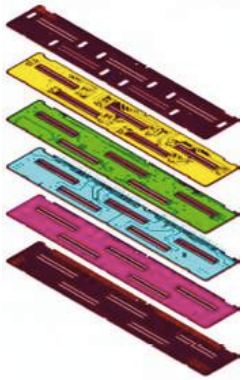
HP SPT Edgeline/TIJ4

Head Characteristics

- 108mm (4.25”) print swath
- Native 1,200 dpi
- 10,560 nozzles per head
- 2 colors per head
- 5,380 nozzles/head/color
- 5 print head chips/head with 2,112 nozzles/chip
- Aqueous and Latex inks

Applications

- Web Press
- Commercial printing
- Latex decal, sign and banner



Images source: HP

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Kodak ESP (Easyshare) TIJ

Head Characteristics

- 300 m/min capable
- 24kHz firing frequency
- 3,840 nozzles
- 2 nozzle sizes producing 2.7 and 6.5 pl drops
- MEMS fabricated
- One piece nozzle-head
- Long lasting head due to bubble collapse venting

Applications

- Desktop and photo printing
- High speed variable data

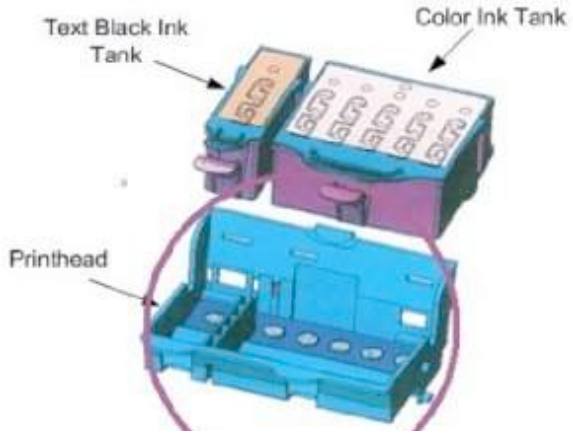

Image source: Kodak

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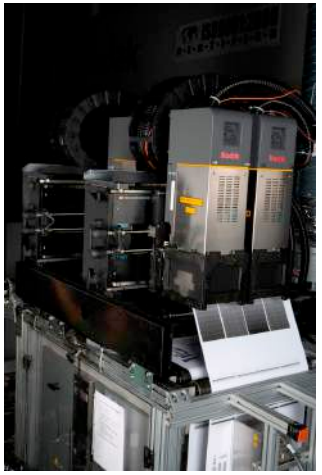
Kodak Stream Technology

Head Characteristics

- Continuous inkjet hybrid with heated nozzle drop formation
- Mounted inline with offset presses
- 600 dpi
- Single pass 305m/min
- Print width: 10.57cm (4.16”)
- Black ink

Applications

- Commercial variable information printing
- Postal self mailer
- Direct mail personalization
- Commercial gaming
- Coupons
- Inserts



Source: Kodak

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D_Shape, Monolite

Head Characteristics

- Resolution: 4 to 25 dpi
- Nozzles: 300 at 20mm interaxis
- 6m x 6m format
- Sand, stone dust, inorganic magnesium-based binder

Applications

- Sculpture
- Large 3D stone-like objects
- Buildings
- Bus stops; park benches/seats; kiosks; colored marble effect pavements; fountains.
- staircases; flower boxes; home stone furnishing: basins, kitchens, sofas, tables.

Images' source: Monolite UK Ltd.

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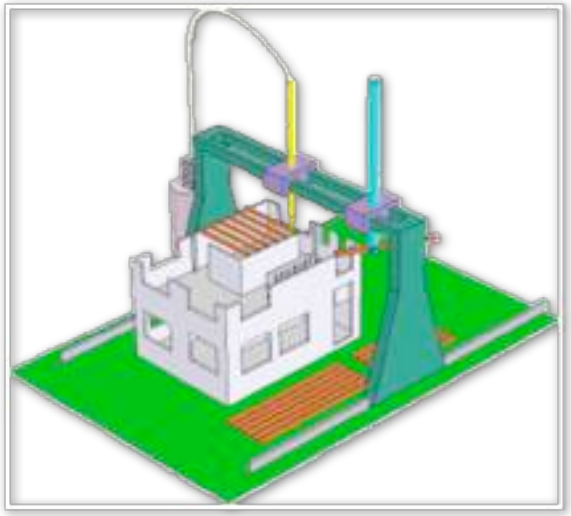
Contour Crafting

Development

- Dr. Behrokh Khoshnevis
- University of Southern California
- National Science Foundation
- Caterpillar Inc
- USG
- Printing buildings



Images Sources: nextbigfuture.com & contourcrafting.org

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Optomec Aerosol Jet

Head Characteristics

- 0.7 to 1,000 cP viscosity at ambient temperature
- > 1,000 cP with heat
- Atomized 1 to 2 microns
- Fine feature sizes < 10microns

Applications

- Biological materials
- Photovoltaic solar cell front side metallization
- 3D Interconnects for multi-chip packages
- Bridge/jumper circuits for touch screen displays
- LCD Line open repair

Image source: Optpmec

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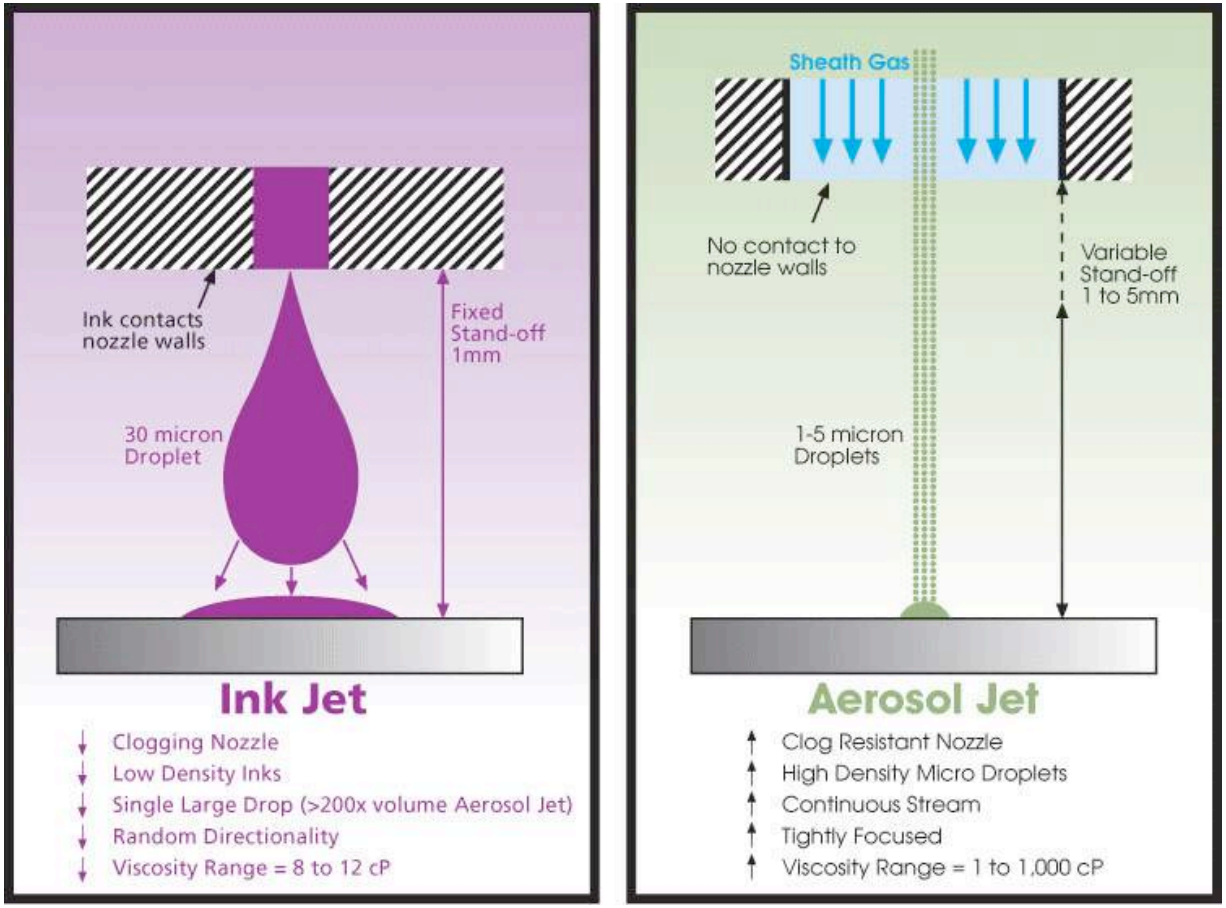
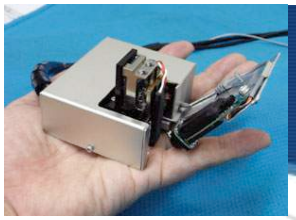
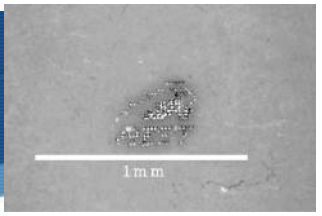
Inkjet Vs. Aerosol Jet



Source: optomec.com



AIST Super-fine Ink-jet SIJ

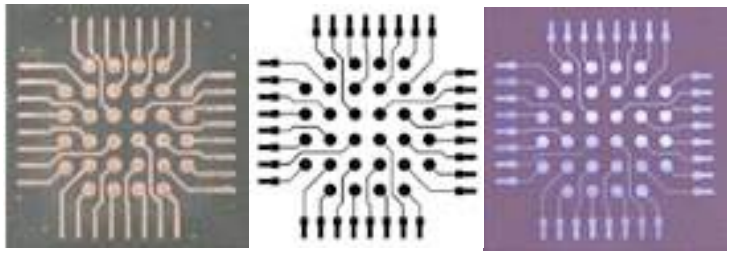


Head Characteristics

- SIJ Technology Japan
- DC 5 volt power source
- Jet particles < 20nm
- Super-fine metal particles melt at much lower temp.

Applications

- Micrometer scale printing
- Maskless precision patterns
- Electro-conductive polymers
- Functional ceramics
- Carbon nanotube
- Super fine wire patterning



Conventional IJ Cad Drawing Super-fine IJ

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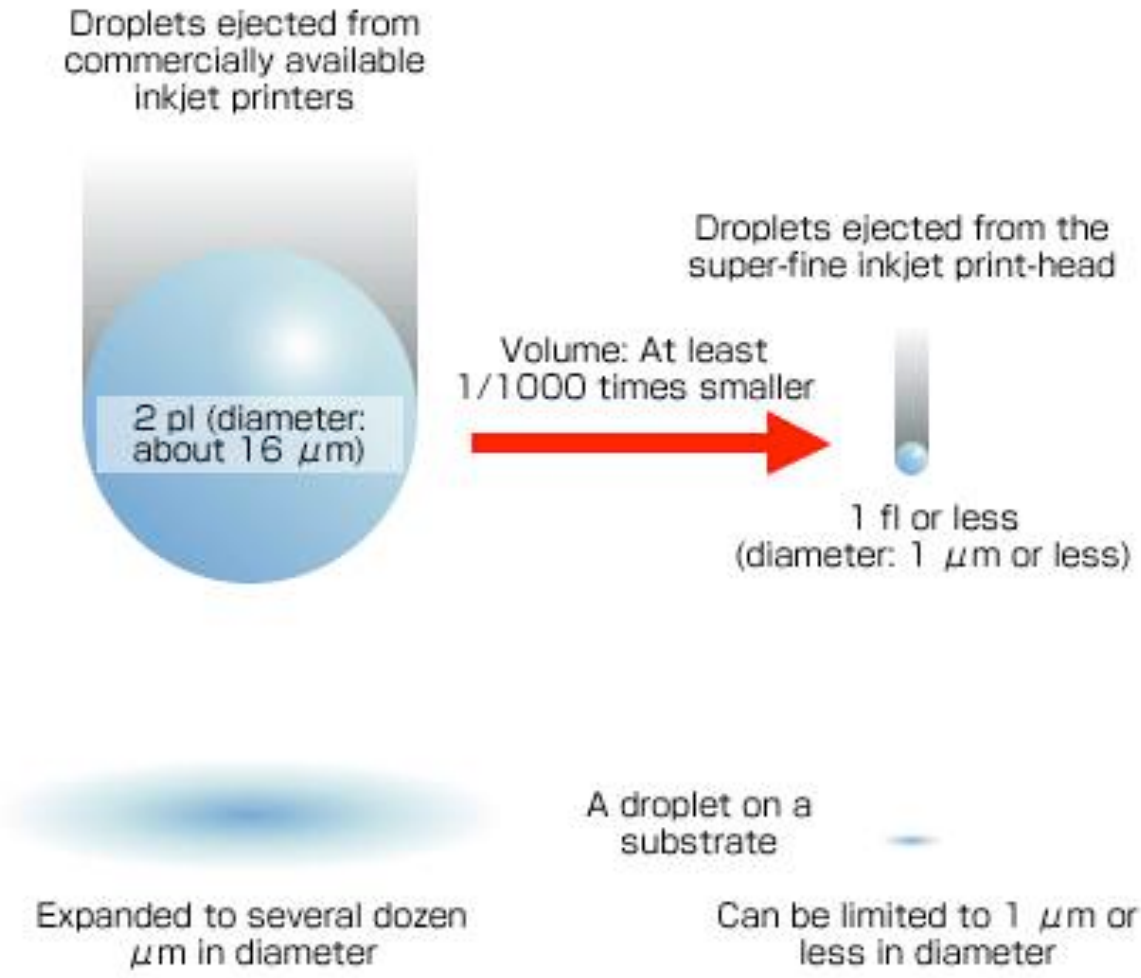
AIST SIJ Super-fine Drops



Source: http://www.sijtechnology.com/en/technology/index.html

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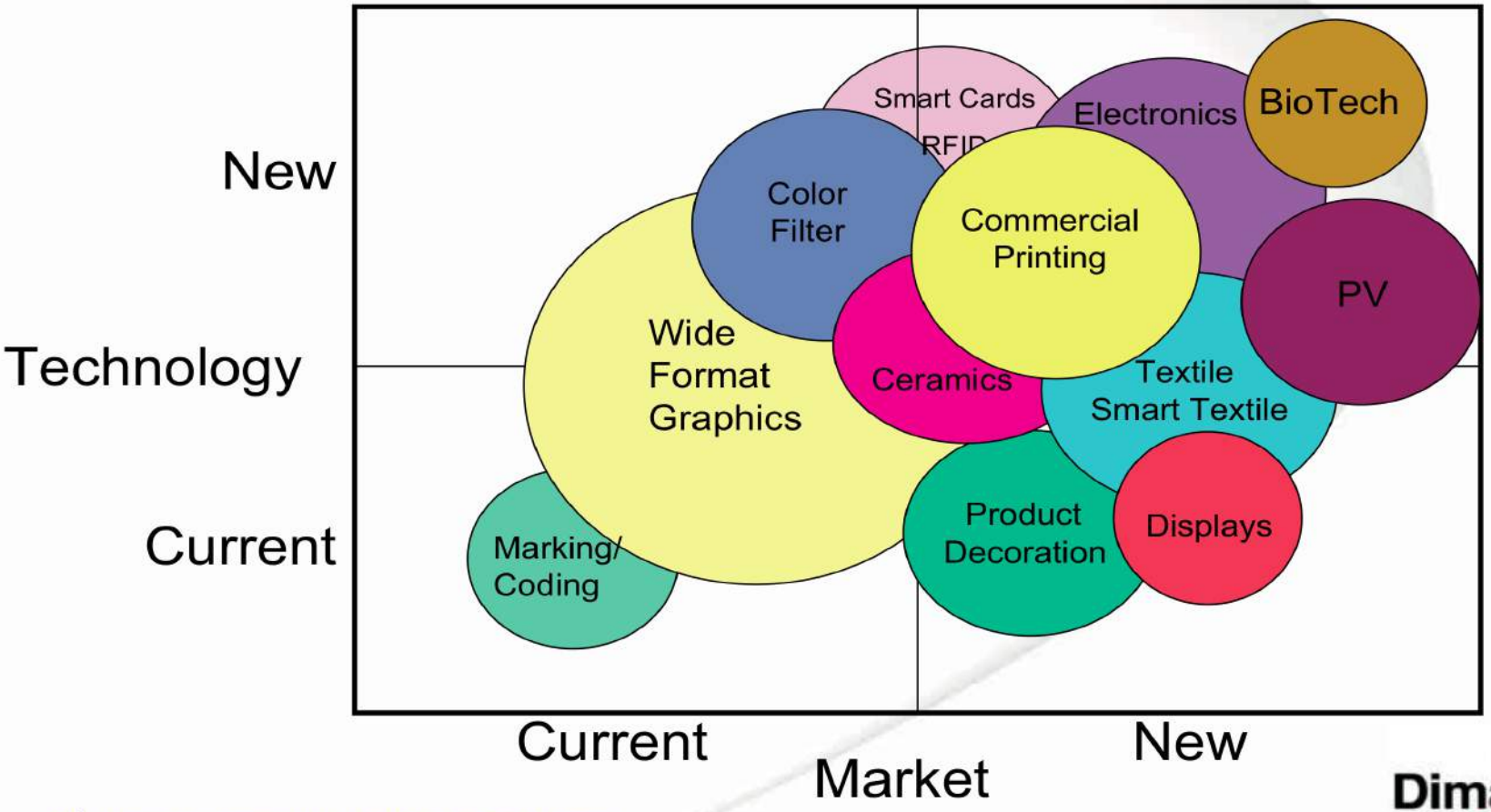
Current and Evolving Applications



Source: FujiFilm Dimatix

Applications for PIJ Inkjet

- Marking & coding
- SOHO printing
- Photo printing
- Wide format graphics
- Textile & garments print
- Color filters
- Labels
- Ceramics
- Product decoration
- Commercial printing
- RFID smart cards & packaging
- Photovoltaics
- Printed electronics
- Batteries
- Smart textiles
- Rapid prototyping and 3D manufacturing
- Biotech

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Matching Heads to Applications

- Single-pass throughput
- Firing frequency
- Fluid firing viscosity range
- Fluids tolerated
- Drop velocity
- Native dpi
- Crosstalk
- Print line length
- Fluid to substrate, treatments
- Nozzle diameter
- Nozzle pitch
- Drop size(s) range
- Drop firing straightness
- Grayscale capability
- Drop throw distance
- Heater
- Maximum operating temperature

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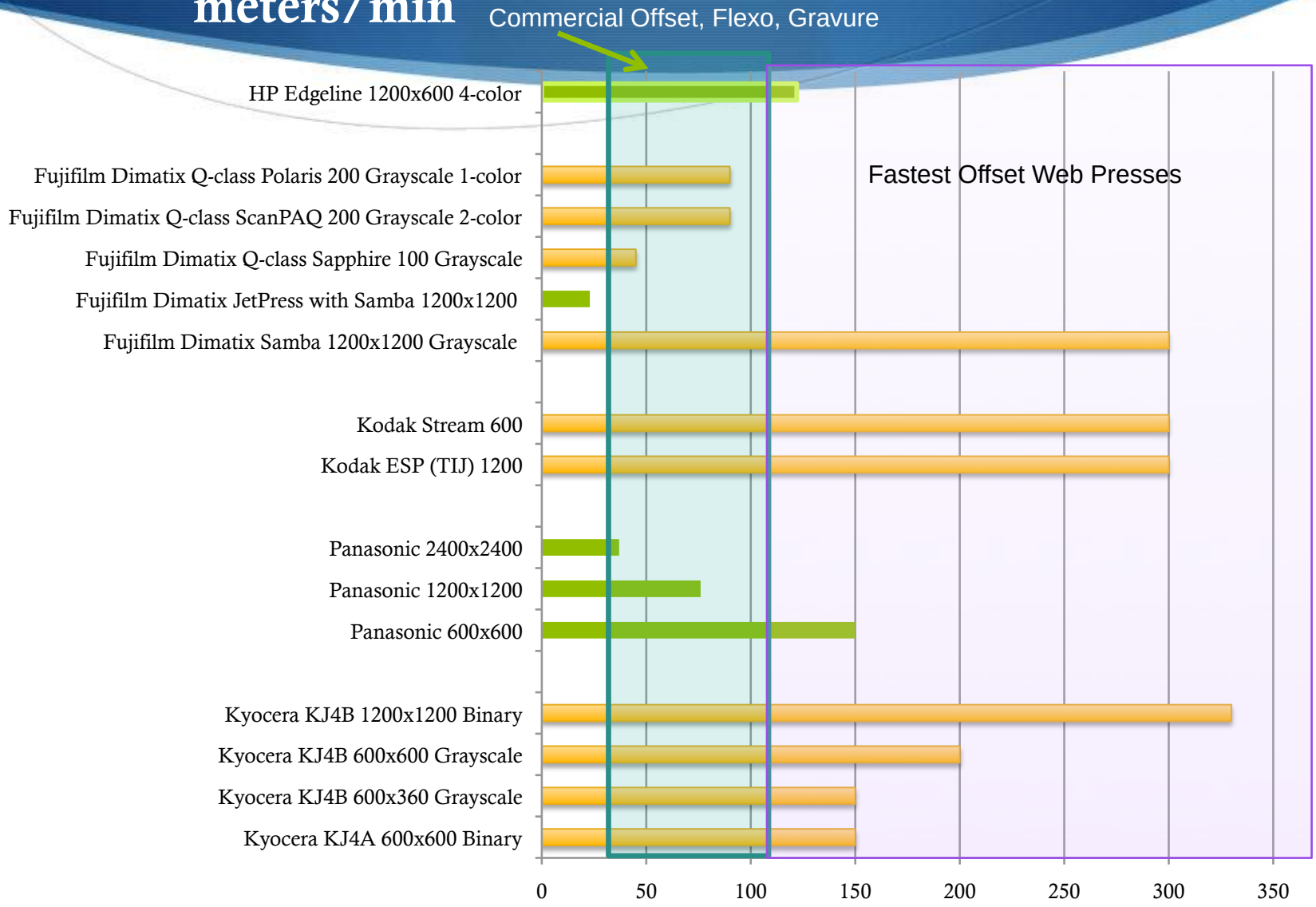
Analog Throughput

Print Technology	Format Size	Throughput m/min	Applications
Litho Offset Duplicator	30.5x45.7cm (12”x18”)	Up to 100	Business forms, labels, postcards, letterhead
Litho Offset Web Press	43cm or 86cm (17” or 34”rolls)	Up to 900	Newspapers, magazines, books
Rotogravure	60cm to 120cm typically	120	packaging, magazines, catalogs, pressure sensitive labels, gift wrapping, wallpaper, plastic laminates, printed upholstery, imitation wood grain finishes, vinyl flooring
Flexography	60cm typical to 200cm	Up to 100	Plastic packaging, gift wrap, wallcovering, magazines, newspaper inserts, paperback books, telephone directories, business forms

meters/min



Print head speed associated with print device

Print head speed independent

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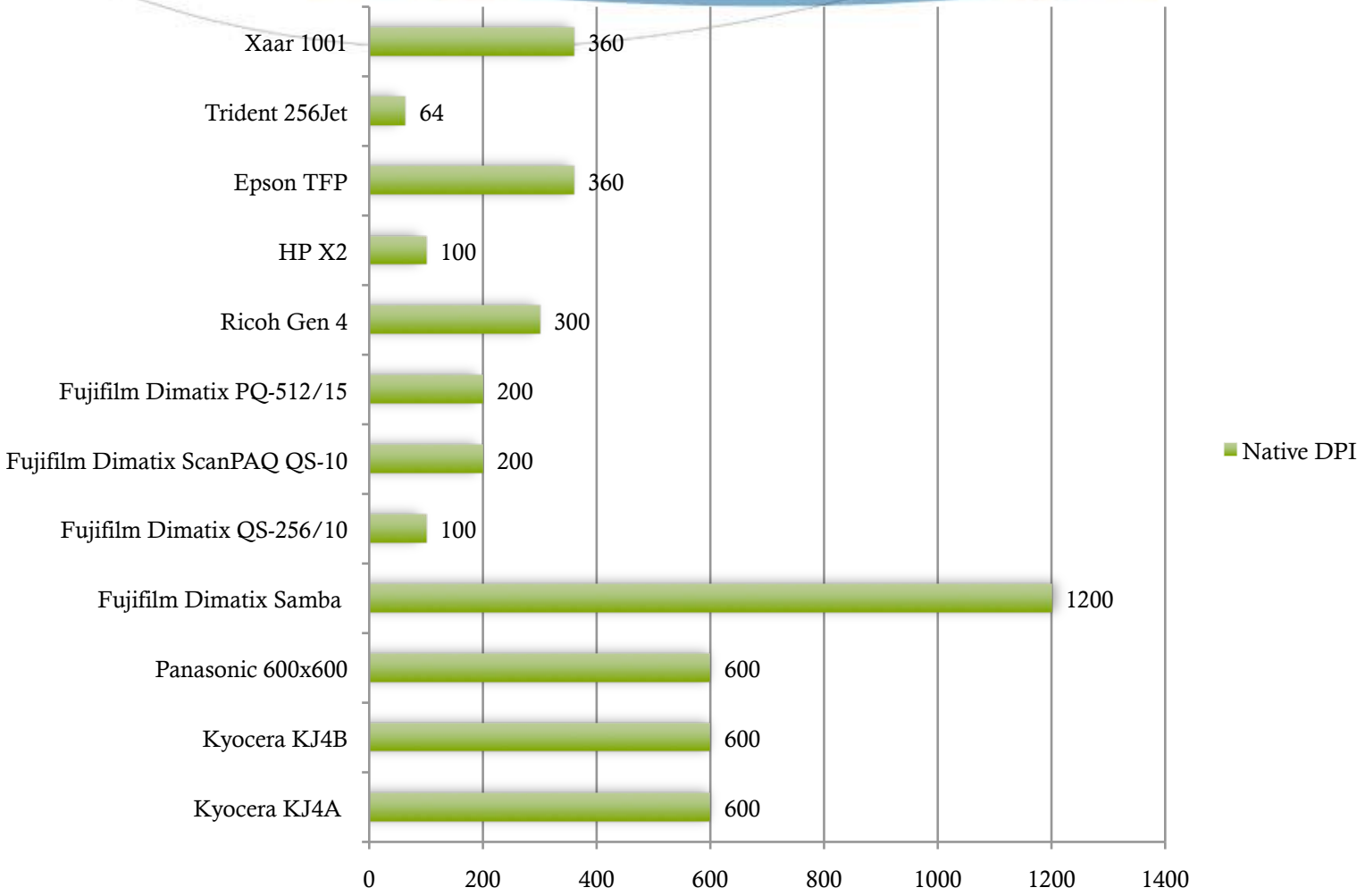
PIJ Heads Fluid Tolerance

Print Head Model	Oil	Water	Solvent	UV-cure	Max cP Viscosity
Kyocera KJ4A	x	x	0	0	8
Kyocera KJ4B	x	x	0	x	6
Panasonic 600x600	x	x	0	x	10
Fujifilm Dimatix Samba	x	x	0	x	8
Fujifilm Dimatix QS-256/10	x	x	x	x	20
Fujifilm Dimatix ScanPAQ QS-10	x	x	x	x	20
Fujifilm Dimatix PQ-512/15	x	0	x	x	14
Ricoh Gen 4	x	x	x	x	12
HP X2	x	0	0	x	15
Epson TFP	x	x	x/0	0	6
Trident 256Jet	x	x	x	x	20-30
Xaar 1001	x	0	x	x	50

PIJ Head Native DPI



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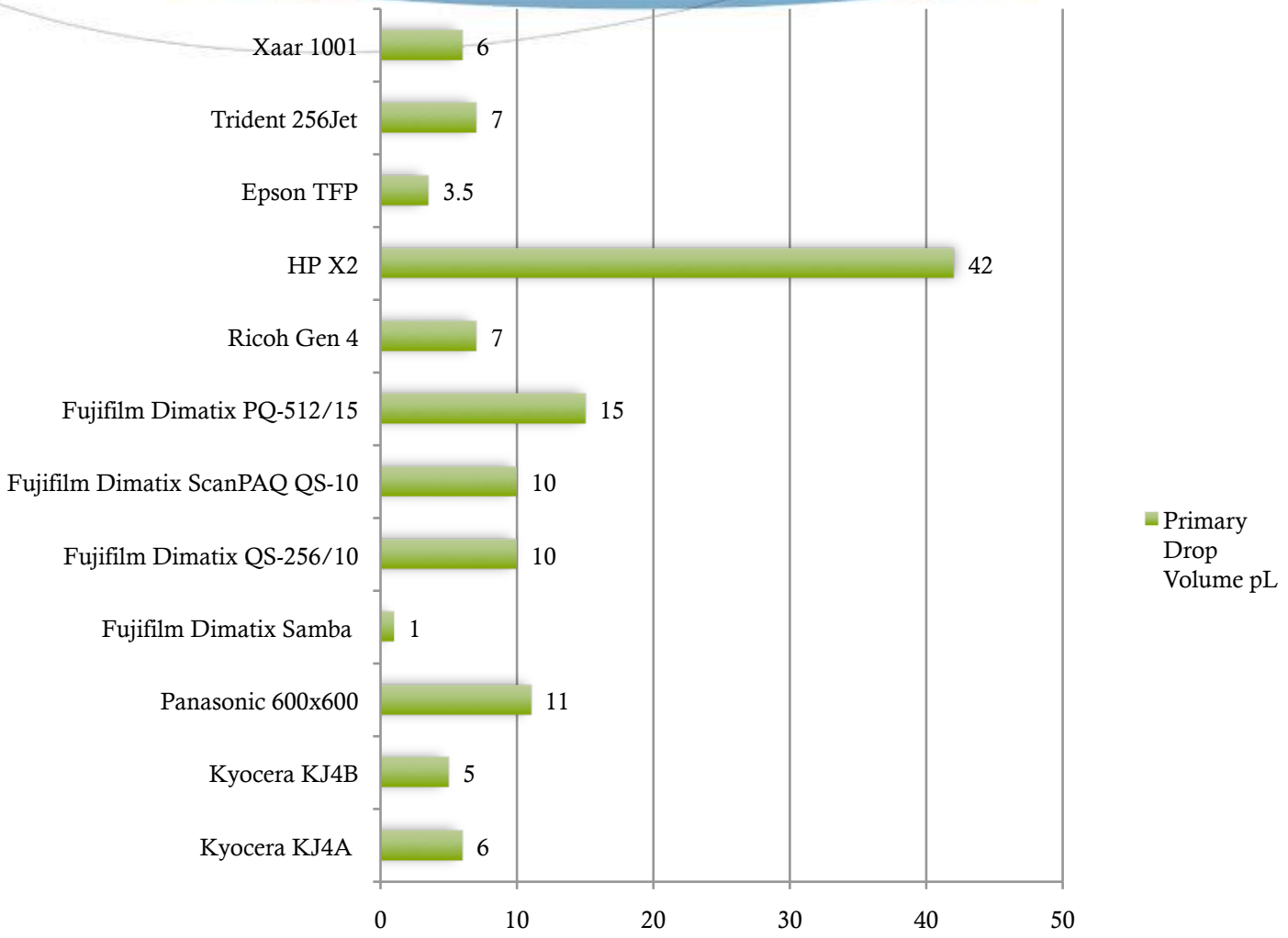
PIJ Primary Drop Volume pL



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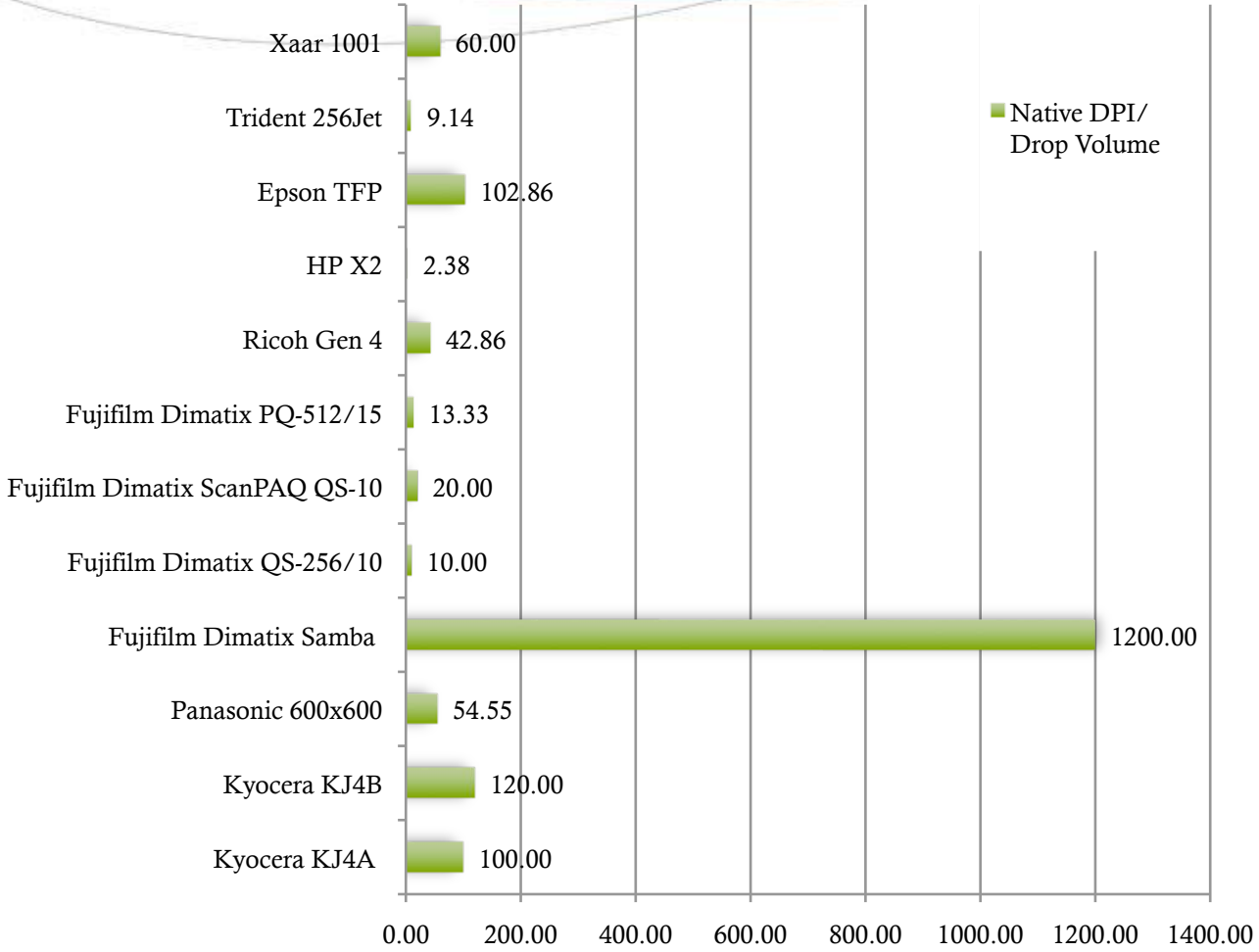
Native DPI/Drop Volume



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Solid Freeform Fabrication Technologies

- Electron beam melting Fully fused void-free solid metal parts from powder stock
- Electron beam freeform fabrication Fully fused void-free solid metal parts from wire feedstock
- Fused deposition modeling Fused deposition modeling extrudes hot plastic through a nozzle, building up a model.
- Laminated object manufacturing Sheets of paper or plastic film are attached to previous layers by either sprayed glue, heating, or embedded adhesive, and then the desired outline of the layer is cut by laser or knife. Finished product typically looks and acts like wood.
- Laser engineered net shaping A laser is used to melt metal powder and deposit it on the part directly. This has the advantage that the part is fully solid (unlike selective laser sintering) and the metal alloy composition can be dynamically changed over the volume of the part.
- Polyjet matrix PolyJet Matrix Technology (developed by Objet geometries) is the first technology that enables simultaneous jetting of multiple types of model materials
- Selective laser sintering Selective laser sintering uses a laser to fuse powdered nylon, elastomer, or metal. Additional processing is necessary to produce fully dense metal part.
- Shape deposition manufacturing Part and support material are deposited by a print head and then machined to near-final shape.
- Solid ground curing Shines a UV light on an electrostatic mask to cure a layer of photopolymers, uses solid wax for support.
- Stereolithography Stereolithography uses a laser to cure liquid photopolymers.
- Three-dimensional printing This label encompasses many technologies of modern 3D Printers, all of which use inkjet-like printheads to deposit material in layers. Commonly, this includes thermal phase change inkjets and photopolymer phase change inkjets.
- Robocasting Robocasting refers to depositing material from a robotically controlled syringe or extrusion head.

Items in red use inkjet or inkjet like deposition technology

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Key Questions

- How does inkjet technology and printhead action achieve application requirements?
- How do you choose the right printheads, electronics, maintenance systems, inks and surface treatments to achieve application performance requirements, such as abrasion resistance, adhesion and image sharpness and fastness?

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Conclusions

Printhead & System Trends

- Higher drop frequency
- MEMS construction
- Single-pass
- Aqueous tolerant
- Multiple head type systems
- LED-UV curing
- Monitoring for drop-outs
- Fluid recirculation

Application Requirements

- Sustainable, eco-friendly
- Hybrid with analog and digital
- Automatic maintenance
- Temperature & humidity control
- Print quality it depends on the substrates: e.g. Print smoothness and sharpness on non-porous surfaces requires matching the surface energy of the ink with the substrate.

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