Printing Processes and their Potential for RFID Printing

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Outline

- General considerations
  - Why using printing processes ?
- The main printing processes
  - Offset
  - Flexography
  - Gravure
  - Screen printing
  - Digital printing
    - **Ink jet**
    - **Electrophotography**
- Conclusion

→
- ✓ Main characteristics
- ✓ Technical description
- ✓ Specific performances, regarding RFID production

General considerations

- The origin of the development of printing processes
  - The growing need for information in large volumes and at low price

    (around 1450, J. Gutenberg, letterpress, mobile movable types, and the associate printing ink)
- Growing interest to use the graphic arts printing platform :
  - Low cost
  - Efficient way of reproducing text and images, and more generally identical patterns, on various substrates, with different colours…
  - Capability of superimposition of very small patterns
  - Possibility of producing electronic elements in-line ("smart packaging", RFID…)

General considerations

- The choice of a printing process depends on :
  - The number of runs
  - The nature of the surface : paper, board, polymer, metal …
  - The nature of the liquid (or paste) to be deposited :
    - Choice of specific **functional inks**
  - The cost
  - The different steps in the production process
- Requirements for printing electronic components
  - Accuracy of position
  - Amount of material deposited, e.g. thickness and content of active materials
  - Resolution

General considerations

- Types of functional inks
  - Conductive inks
    - Inks containing dispersions of conductive particles (Ag, C,…)
    - Inks based on conductive polymers
  - Other functional inks

↳ Similarities with "conventional" printing inks :

⇒ Colloidal suspensions of pigments in liquids of various viscosities

⇒ Must form a continuous dry film, immediately after printing

⇒ Must resist to wear, solvent, light…

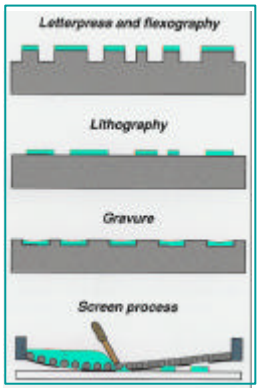
General considerations

- Application areas in electronics :
  - Printing circuits boards
  - Production of displays (OLED)
  - **RFID**
  - ....

Printing processes

"Conventional processes"
(with a printing form)

Digital printing processes
(no printing form)



« From the computer

to

the substrate »

Printing processes

"Conventional processes"
(with a printing form)

- ***"flat" processes***
  Offset
  Screen printing
- ***engraved processes***
  Gravure
  Intaglio
- ***"in relief" processes***
  Flexography
  Letterpress

Digital printing processes
(no printing form)

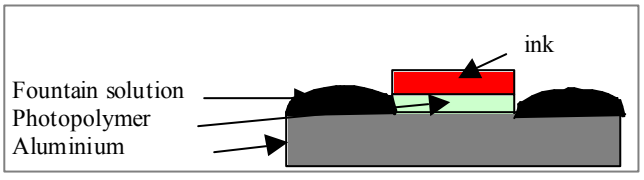
- **Ink jet**
  DOD or CIJ
- **Electrophotography**

Offset

- The most widespread printing process for publication
  - 80 % of publication printing
- Wide variety of materials :
  - Papers, board, metals, polymers…
- Middle to long runs :
  - from 500 to 50.000 copies on sheet-fed presses
  - from 10.000 to 1 million copies on web-fed presses

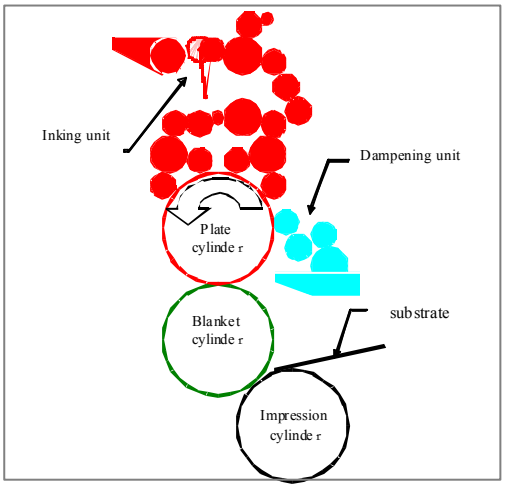
Offset

- « Flat » process
  - Aluminium plate (thickness ≈ 0.3mm) + photopolymer layer (thickness ≈1µm)



- Very viscous inks (η ≈ 10 Pa.s), with a low polarity
- Based on the antagonism of ink and water
- Double transfer

Offset



1 . Wetting of the plate with the dampening solution

$\gamma_{image\ areas} \approx 35\ mJ/m^2$

$\gamma_{non\text{-}image\ areas} \approx 70\ mJ/m^2$

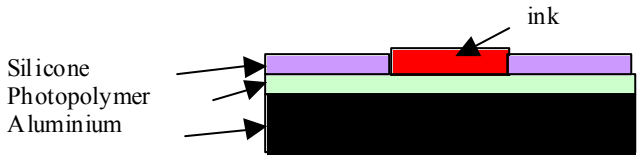
2. Inking of the printing areas

$\gamma_{ink} \approx 35\ mN/m$

$\gamma_{dampening\ sol.} \approx 25$ to $55\ mN/m$

Offset "Waterless"

- Offset without dampening solution
  - Dampening solution replaced by silicone (PDMS)



- Better stability of the process
  - (provided the temperature is constant)
- Possibility of reproducing smaller dots and finer lines

Offset

From « the Print Production Manual », 8th ed. PIRA, ed. by Michael Barnard, 1998

- Lateral resolution : 15µm
  - ↳ up to 200lines/cm, in waterless offset
- Ink film thickness : 0.5 to 3 µm
- Ink viscosity : 1 to 50 Pa.s

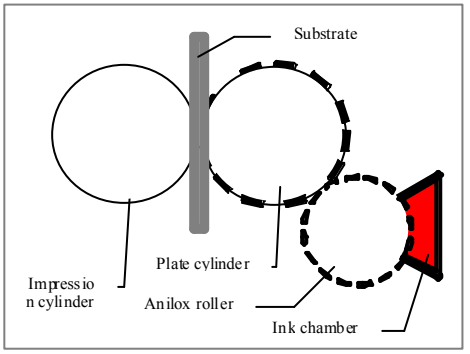
Flexography

- Printing process initially developed for packaging applications
- Various run length, from several 1000s
- Many substrates
  - Papers, board (including corrugated), polymer films…

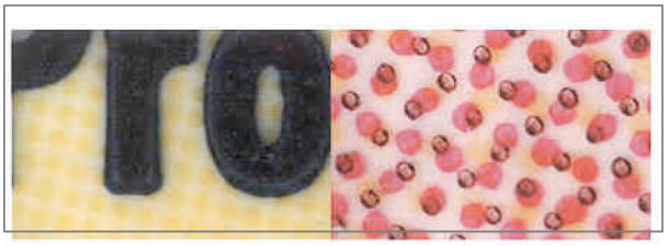
Flexography

- Direct process, using a relief flexible plate : flexible photopolymer (thickness ≈ 1 to 5 mm)

- Liquid inks (η ≈ 10 to 100 mPa.s)
  - Water-based
  - Solvent-based
  - UV-curing



Flexography



From « the Print Production Manual », 8th ed. PIRA, ed. by Michael Barnard, 1998

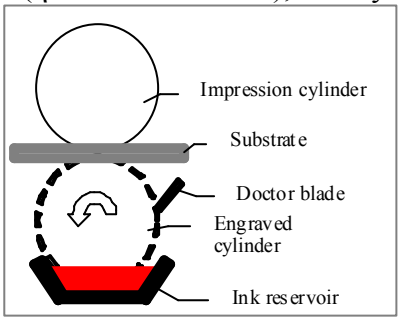
- Lateral resolution : 40 µm
  ↳ up to 60 lines/cm,
- Ink film thickness : 6 to 8 µm
- Ink viscosity : 0.01 to 0.1 Pa.s

Gravure

- Significant process in publishing and packaging
  - 18 % of publication
- Adapted to very long runs
  - Over 500 000 impressions
- Various substrates
  - Thin light coated papers, polymer films, board…

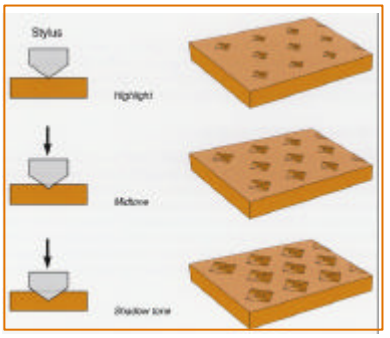
Gravure

- Intaglio process
  - Steel-based cylinder, covered with a thin nickel layer, then electrochemically covered with a thick copper layer. This layer is electromechanically engraved, and covered with a thin chrome layer (2-3 μm), which improves resistance to wear and hardness
- Liquid inks ($\eta \approx 10$ to 50 mPa.s), mainly solvent-based

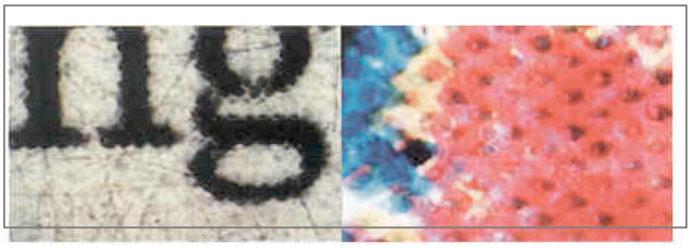


Gravure

Resulting cells' depth ≈ up to 40µm



Gravure



From « the Print Production Manual », 8th ed. PIRA, ed. by Michael Barnard, 1998

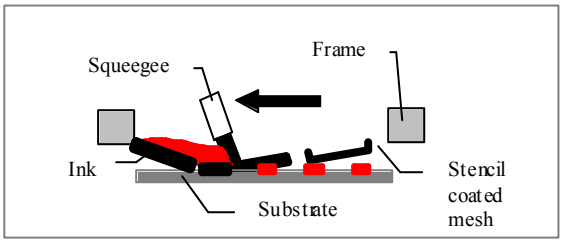
- Lateral resolution : 15 µm
  - ↳ up to 1000 lines/cm, with laser engraved cylinder
- Ink film thickness : 8 to 12 µm
- Ink viscosity : 0.01 to 0.05 Pa.s

Screen printing

- Printing process already efficient for printed circuits
- Short runs, slow process
- Allows to print thin to very thick ink films (up to 100µm)
- Many substrates
  - Papers, board (including corrugated), polymer films, metal surfaces, textile…

Screen printing

- Stencil process
  - The ink is transfered through a stencil covering a fine fabric mesh of threads
  - The ink is poured on the stencil and a squegee forces the ink through the stencil
- Ink viscosity ≈ 0.1 to 10 Pa.s



Screen printing

From « the Print Production Manual », 8th ed. PIRA, ed. by Michael Barnard, 1998

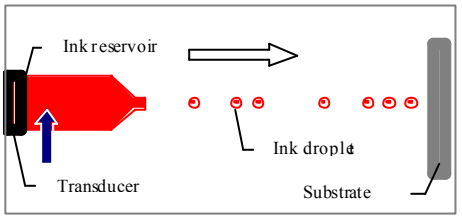
- Lateral resolution : 100 µm
  ↳ under 50 lines/cm,
- Ink film thickness : 1 to 100 µm
- Ink viscosity : 0.1 to 10 Pa.s

Ink jet

- The most developing printing process in the last 10 years
- Digital, non impact printing process
  - Print directly from the computer data to virtually any substrate
- Any substrate, of any size
- Very versatile process, very short runs (from unit) to 1000s
- Already used in microtechnologies

Ink jet

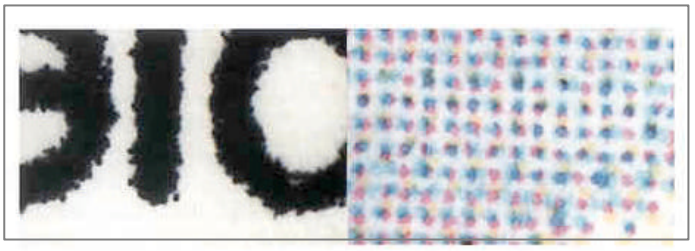
- Two main techniques :
  - Drop-on-Demand
  - Continuous Ink Jet



- Size of the droplets ejected by the nozzle : a few pL
  - Drop diameter ≈ 20 - 30 µm

- Very fluid inks : η ≈10 mPa.s
  - Water-based
  - Solvent-based
  - UV-curing
  - Hot-melt (solid at room temperature, liquid when jetted)

Ink jet



From « the Print Production Manual », 8th ed. PIRA, ed. by Michael Barnard, 1998

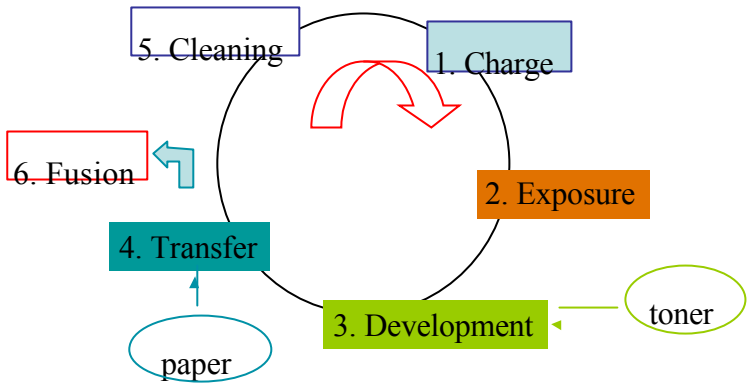
- Lateral resolution : 50 µm
  ↳ limited to 60 lines/cm,
- Ink film thickness : depends on ink properties
- Ink viscosity : ≈ 10 mPa.s

Electrophotography

- Process in evolution and extension
- No printing form
- Limited to short runs
- Liquid or solid toners
- Papers (coated or not), polymer films…

- Applications in RFID printing ???

Electrophotography



Conclusion

- Any printing method could be used for printing antenna
- Common methods for RFID printing : screen and ink-jet printing, but:
  - Cannot be used for very high volume
  - Difficulties of resolving fine lines in screen printing
  - Satellites drops may occur in ink jet printing
- Still to be studied :
  - The nature of the inks, and their properties (rheological, physico-chemical, and functional properties)
  - The effect of the substrate properties : roughness, porosity, electrical properties…
  - The interactions between conductive inks and substrates
  - The conditions of printing : pressures, drying mechanisms

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Thank you for attention

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