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DOCTORAL SCHOOL 2020

UV inks and coatings

Presentation to: Doctoral School

Presented by: E. NOUZILLE

Company: SICPA SA

February 2022

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Enabling trust



Agenda

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Examples

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Ink formulation

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Introduction to the printing technologies

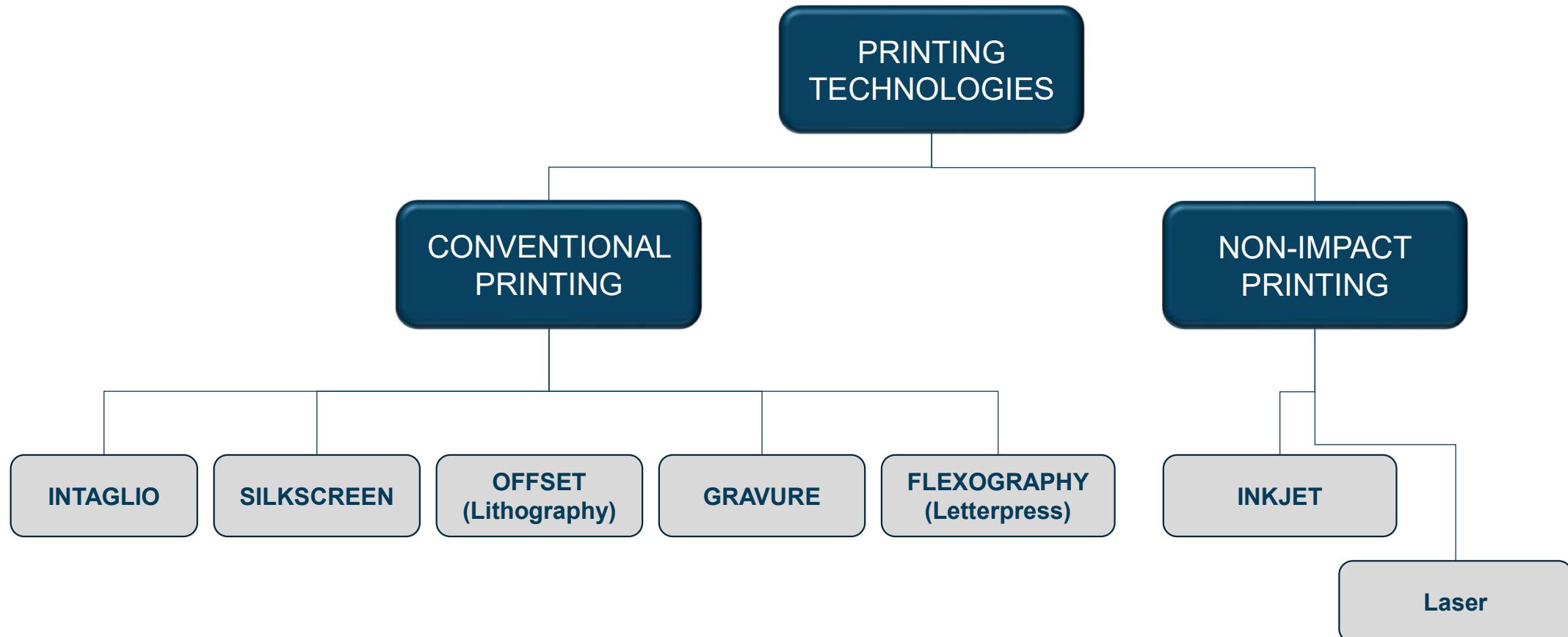


Definition

- Printing is a reproduction process in which a printing **ink** is applied to a **printing substrate** in order to transmit **information** (text, image...) in a repeatable form using an **image-carrying medium** (i.e. printing plate, cylinder...).

Source «*Handbook of Print Media*» Helmut Kipphan

Printing Technologies

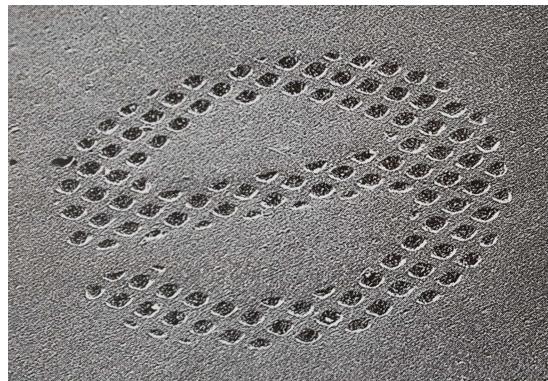


Conventional Printing Technologies

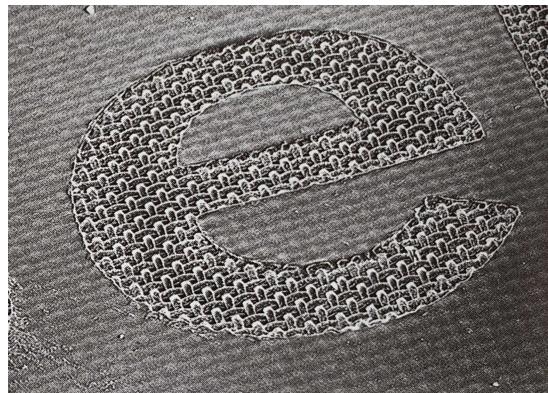
The information carried by the printing master can be:

- a surface relief
- a recessed surface
- a plane surface
- an opening surface

Gravure



Silkscreen



Typography



Offset



INTAGLIO



The Origins of INTAGLIO - XVTH Century

- 1400: paper started to be widely produced in Europe and gave a new medium for the diffusion of knowledge and information
- Accompanied by a reproduction method: printing
- Intaglio then developed to reproduced images

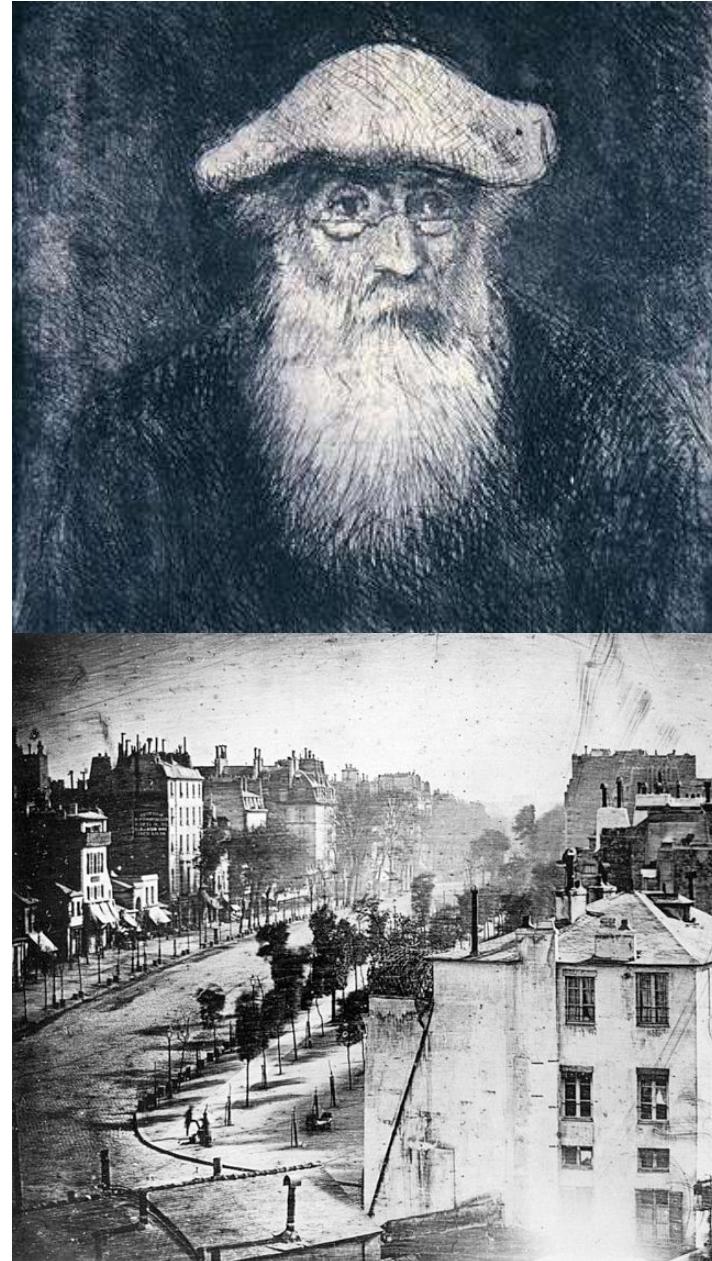
... and soon became an artistic expression on its own

- **ALBRECHT DÜRER**, born in Nuremberg in 1471, raised intaglio to the status of a recognized art form

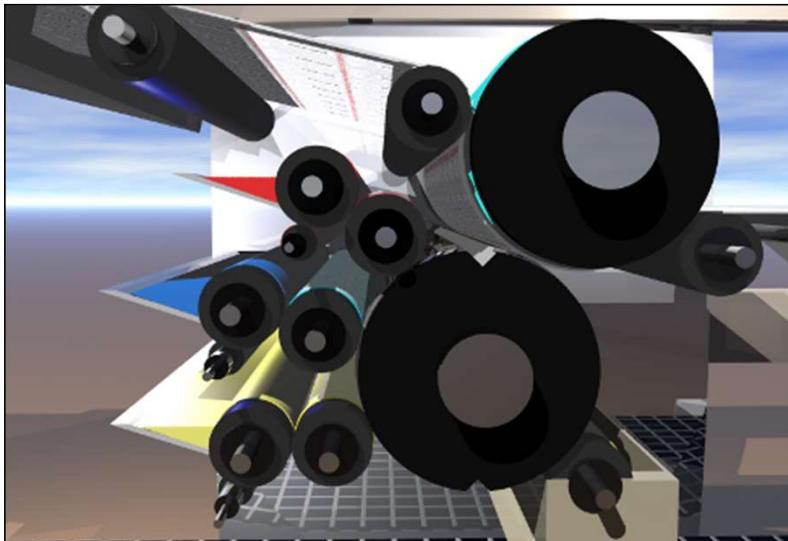


From Art to Security - XIXTH Century

- Photography revolutionized the reproduction of images
- In comparison, intaglio printing was considered too demanding in terms of skill and time
- Difficulty of using a burin and the unparalleled precision of intaglio gave the process a new purpose: security printing



Intaglio Printing Process



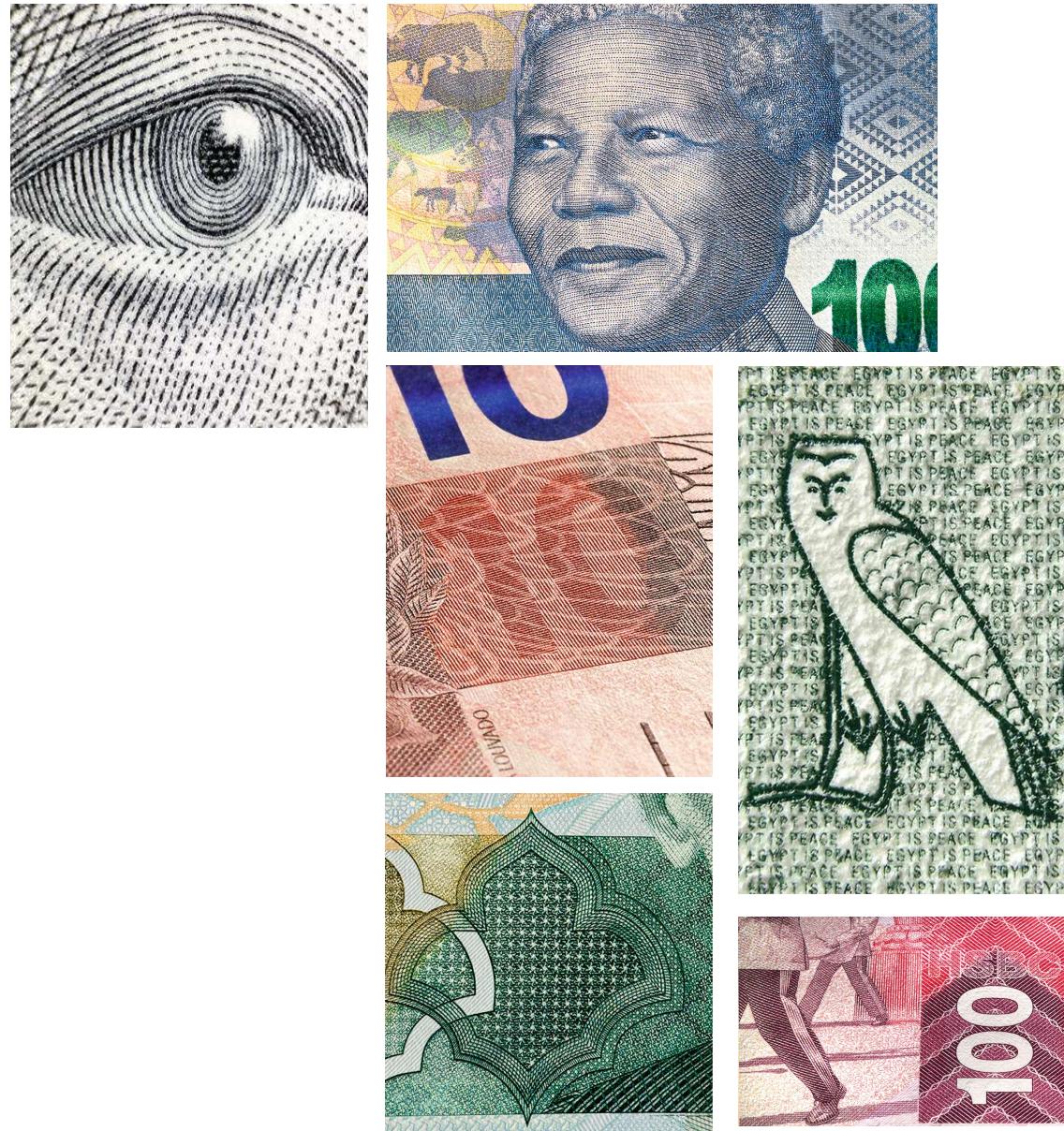
Variable film thickness: 2 to 40µm

Stamps, banknotes, passport



Intaglio is Security

- Portraits and design elements
- Intaglio tactile elements
- Latent images
- Microtexts
- Multi-tonal intaglio





OFFSET

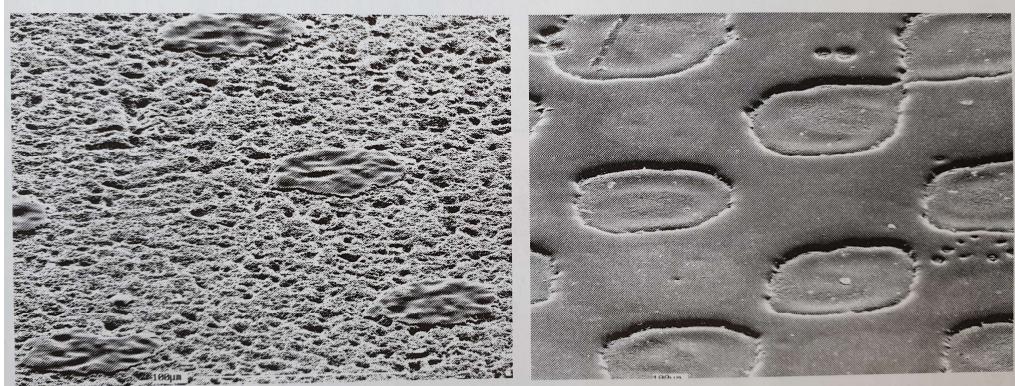


Offset Printing Process: Definition

Lithography was invented by Alois Senefelder in 1796 (Stone litho press).

Since

In Offset lithography, the printing and non-printing area are at the same level. By physical and interfacial surface phenomena, the ink is accepted in the printing area and not accepted in the non-printing area.

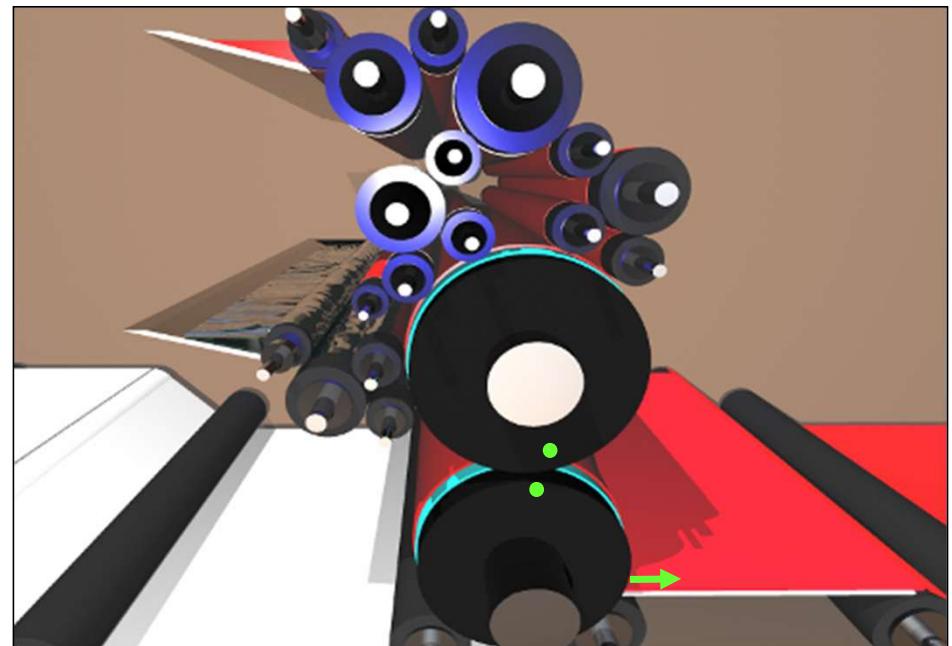


Conventional Offset

Wet Offset

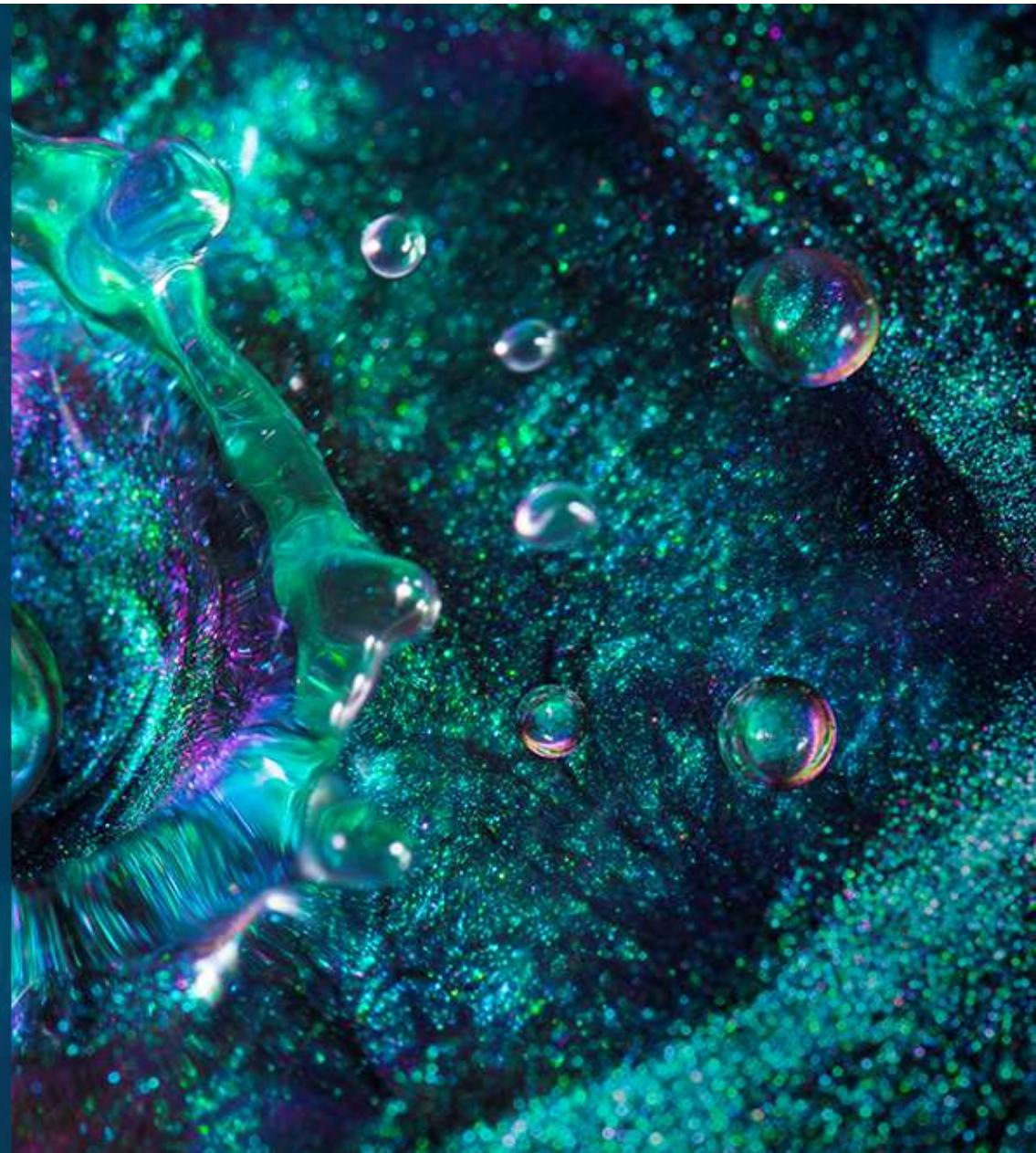
OFFSET printing

UV inks: 1 to 2 μ m





LETTERPRESS



Letterpress: History

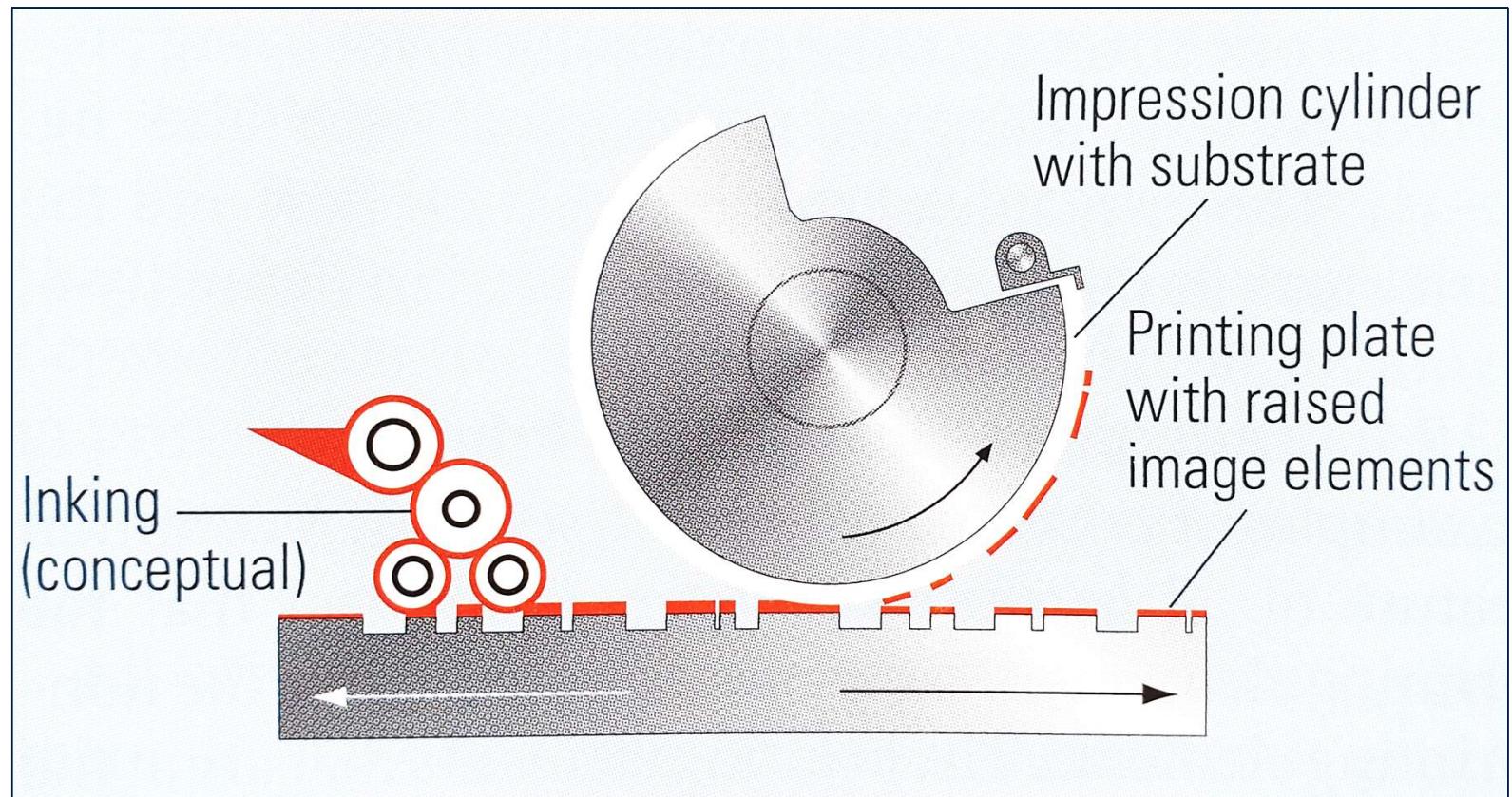
The invention of the Letterpress (by Johannes Guttenberg around 1440) revolutionised the slow reproduction of texts by hand.

For five centuries, letterpress was the primary technique used to print books and newspapers. In the 20th Century, letterpress began to be replaced by offset.

It is nowadays mainly used to print numbering on banknotes.

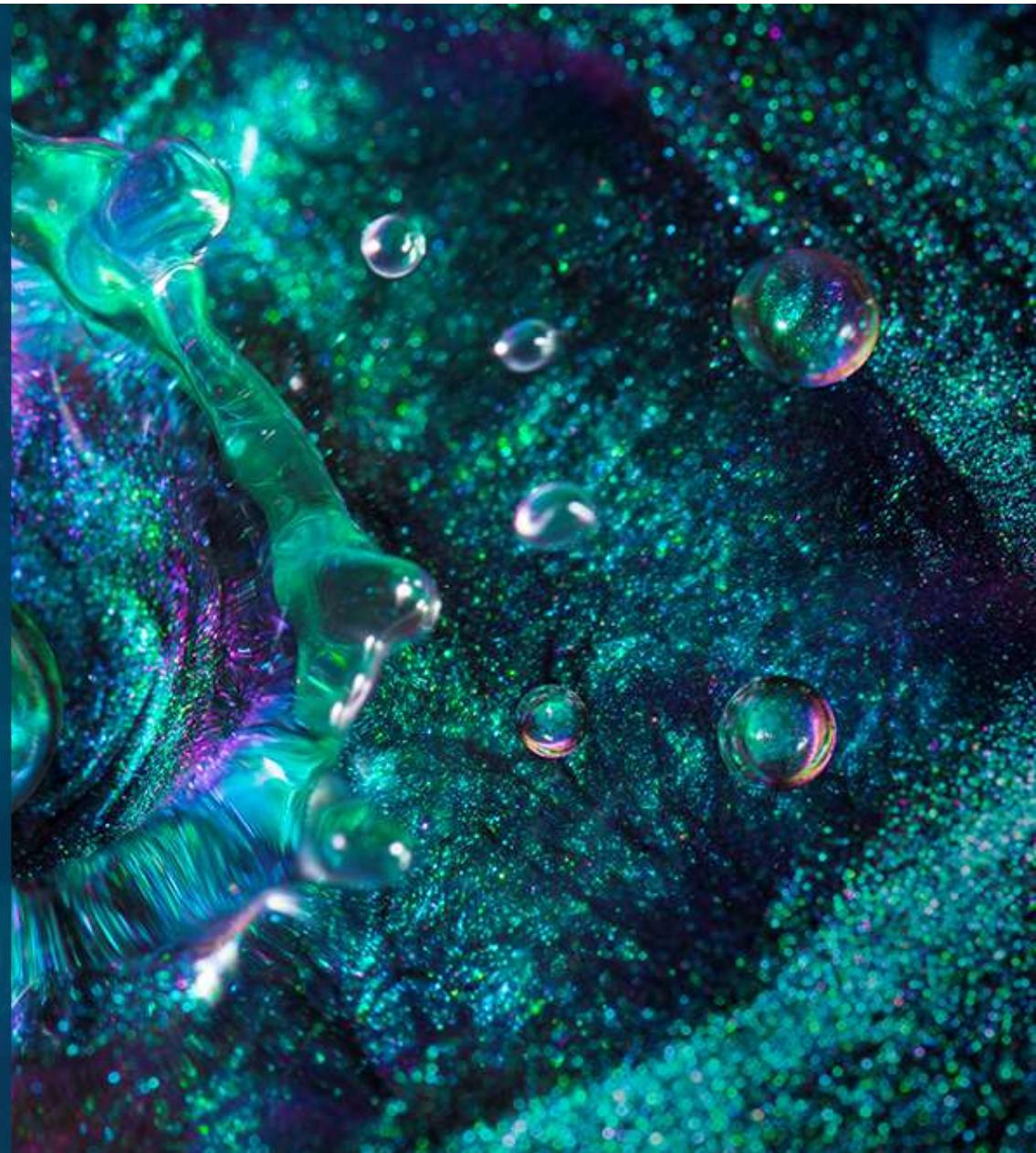


Letterpress Printing Process





SILKSCREEN

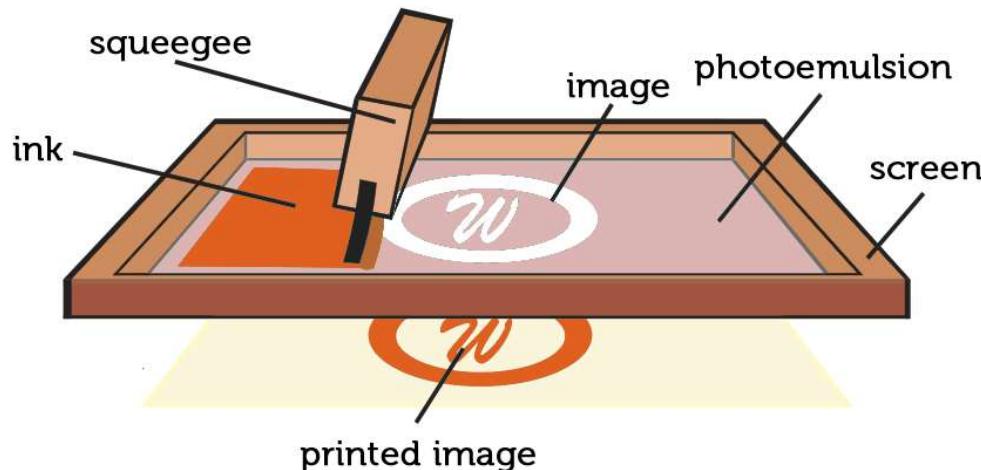


Silkscreen printing: Definition

Screen printing is a push-through process which means that the ink pass through the screen and onto the substrate.

There are 3 kinds of screen printing:

- **Flatbed printing:** the printing plate and the printing substrate are both flat. The ink is transferred through the mesh apertures and onto the printing substrate by a movement of the squeegee.



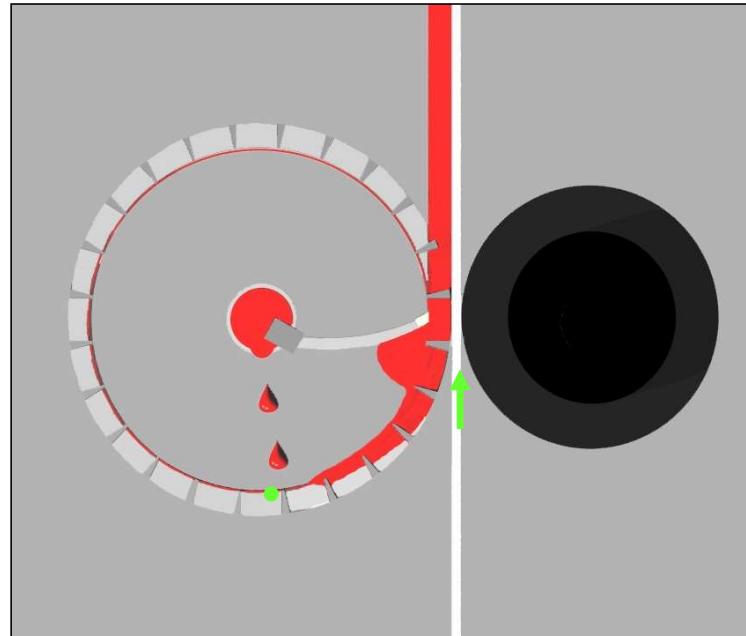
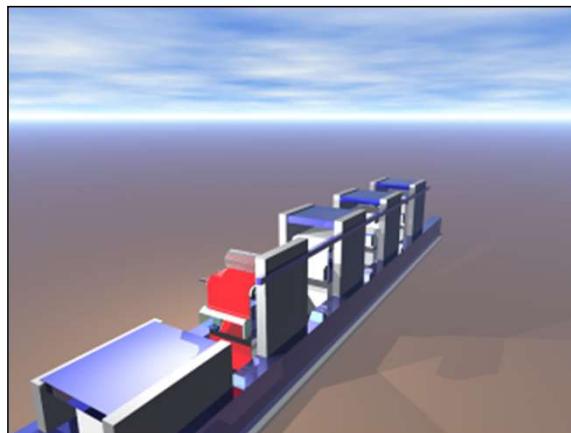
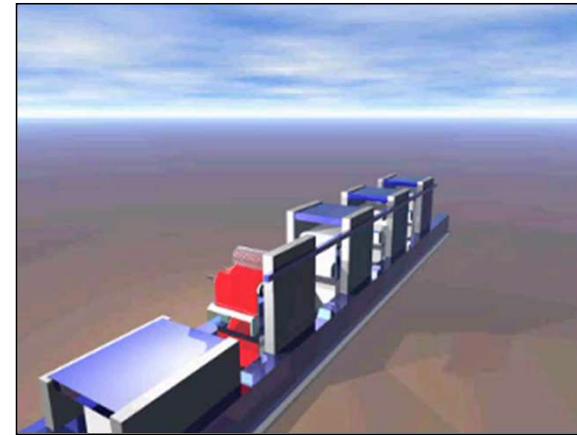
Rotary Screen Printing Process

Estimation of dry ink coating weight:

UV inks: up to 25 μm

SB inks: 10 μm

WB inks: 10 μm



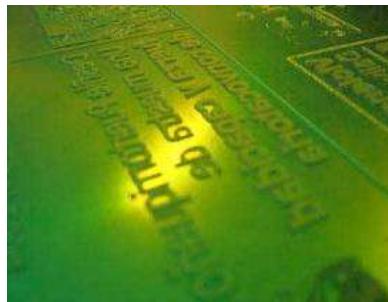


FLEXOGRAPHY



Flexography: Printing Process

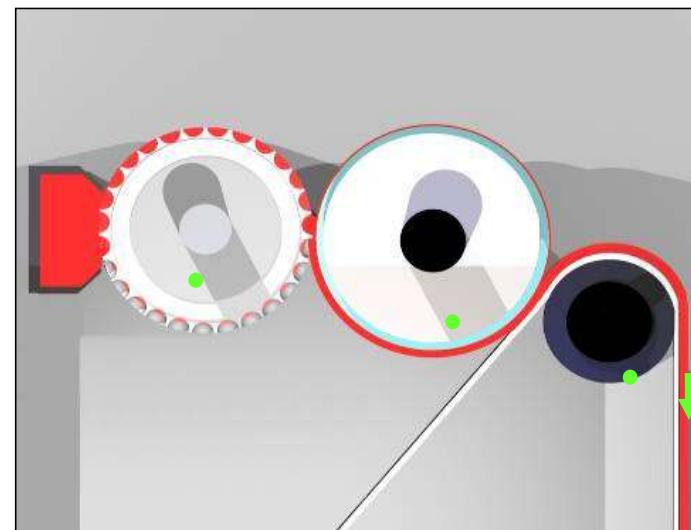
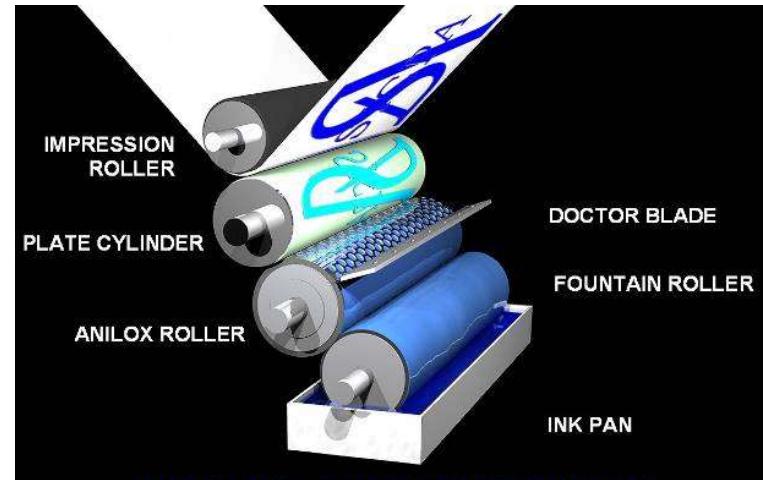
Plate Cylinder



Chambered
Doctor Blade



Impression
Roller (Anilox)

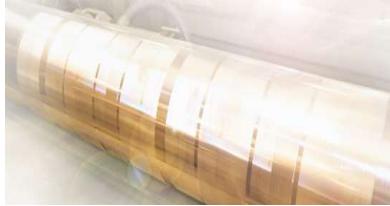




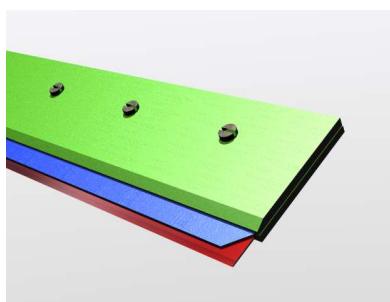
GRAVURE



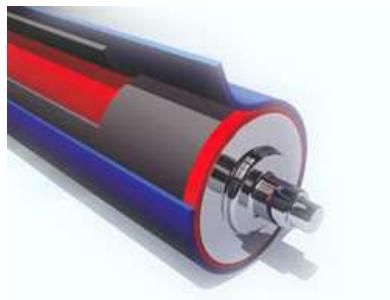
Rotogravure Printing Process



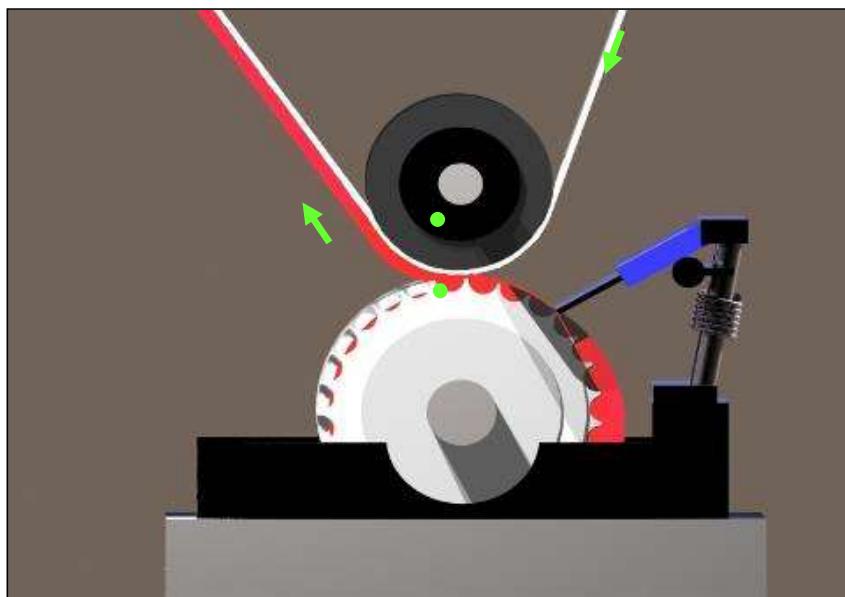
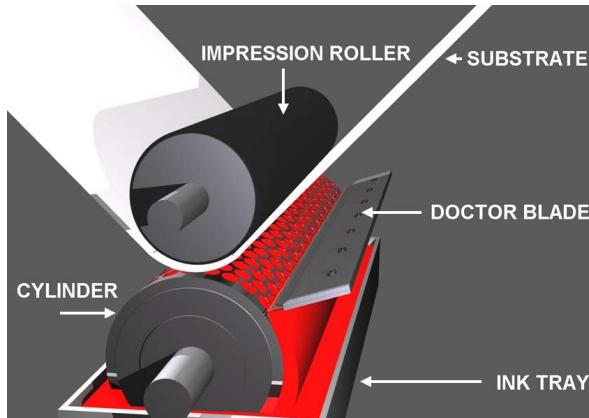
Cylinder



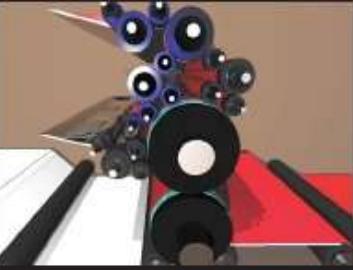
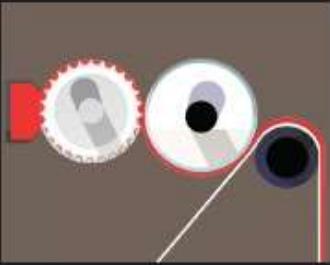
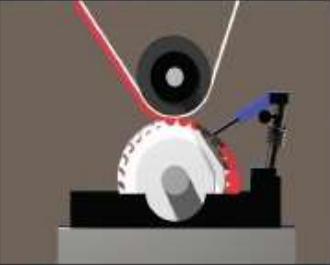
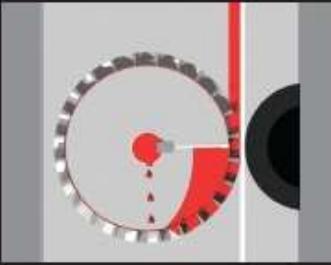
Doctor Blade



Impression Roller



Comparison of the Printing Process

OFFSET	FLEXOGRAPHY	GRAVURE	SILKSCREEN
			
<ul style="list-style-type: none">• Thin ink film: ~ 2 µm max• Low cost of prepress• Cheap plates & short pre-print manufacturing• Expensive presses• High production cost• High dot printing quality	<ul style="list-style-type: none">• Think ink film: ~ 12 µm max• High cost of prepress• Short life of the photopolymer plate re-usable• High production cost for long printing runs• Multi substrate printing• High printing speed	<ul style="list-style-type: none">• Think ink film: ~ 12 µm max• High cost of prepress• Long pre-press manufacturing• Long life of the cylinder• High production cost for short printing run• Multi substrate printing but not recommended for PE• Not dedicated for UV printing inks even if available• High printing speed	<ul style="list-style-type: none">• Think ink film: ~ 25 µm max• Average cost of prepress• Short life and fragility of the screen• Low cost of printing press• Simplicity of the printing process• Multi substrate printing• Low printing speed• Low resolution printing



INKJET



Inkjet: definition

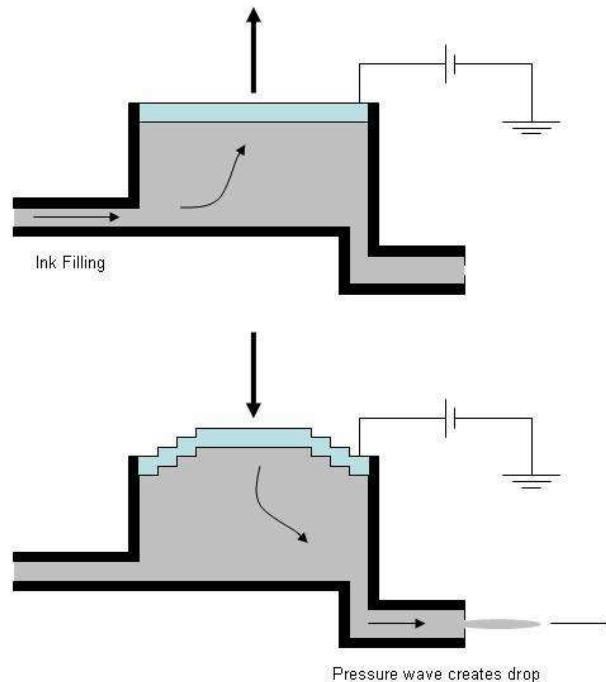
The process:

- a non-impact printing technology
- not requiring an intermediate carrier
- Ink directly transferred to the substrate
- Ink is liquid

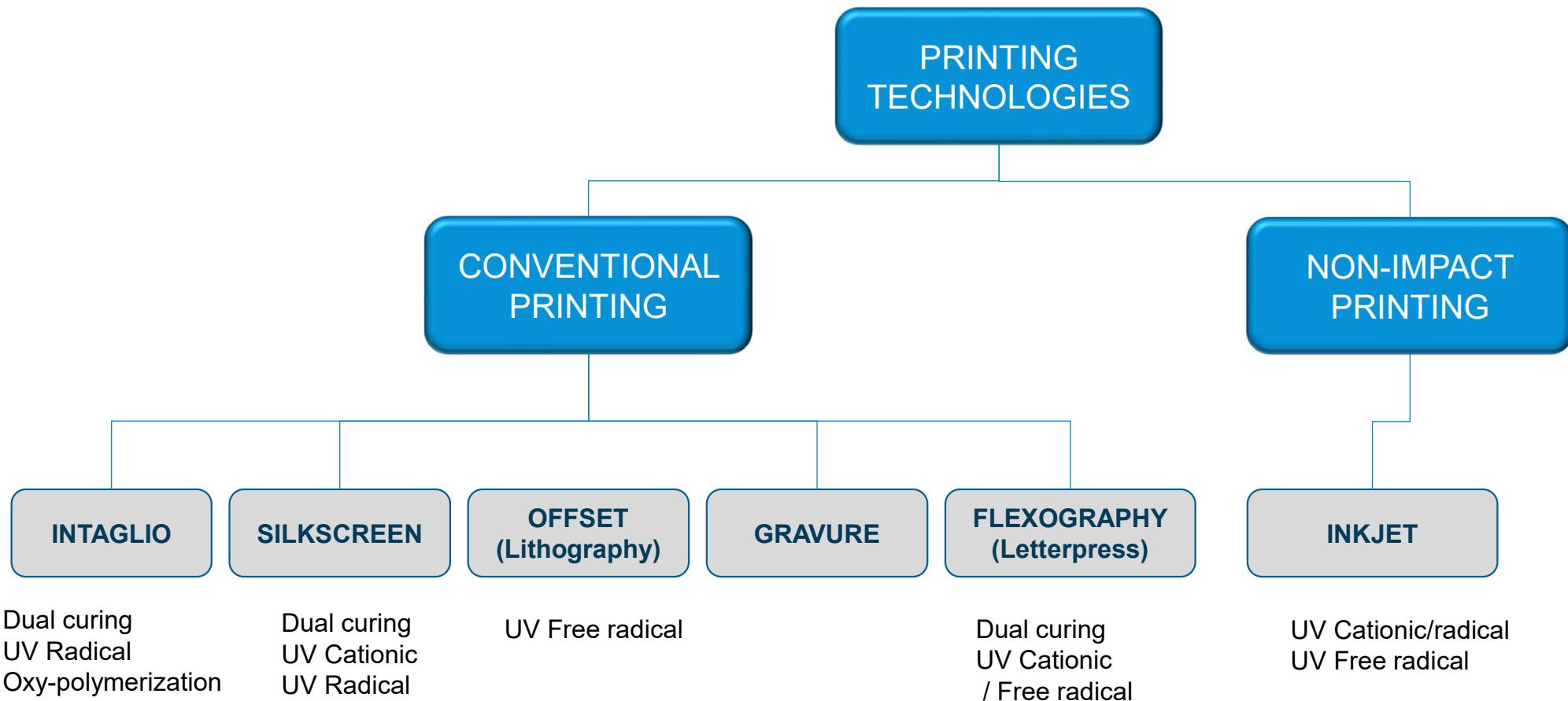
- 2 technologies:
- Continuous inkjet (CIJ)
- Drop on Demand (DOD)

Piezo Drop-On-Demand (DOD) technology

- Based on “shear mode” piezoelectric (PZT) components which are deformable under electrical voltage
- The PZT components act as small pumps by moving up and down, to eject a drop from the nozzle every time required



Printing Technologies





INK FORMULATION



Formulating inks is a challenging work

The development of an effective radiation curing ink relies on several factors which include curing equipment, physical properties of the cured ink, and economics of the process

Press side

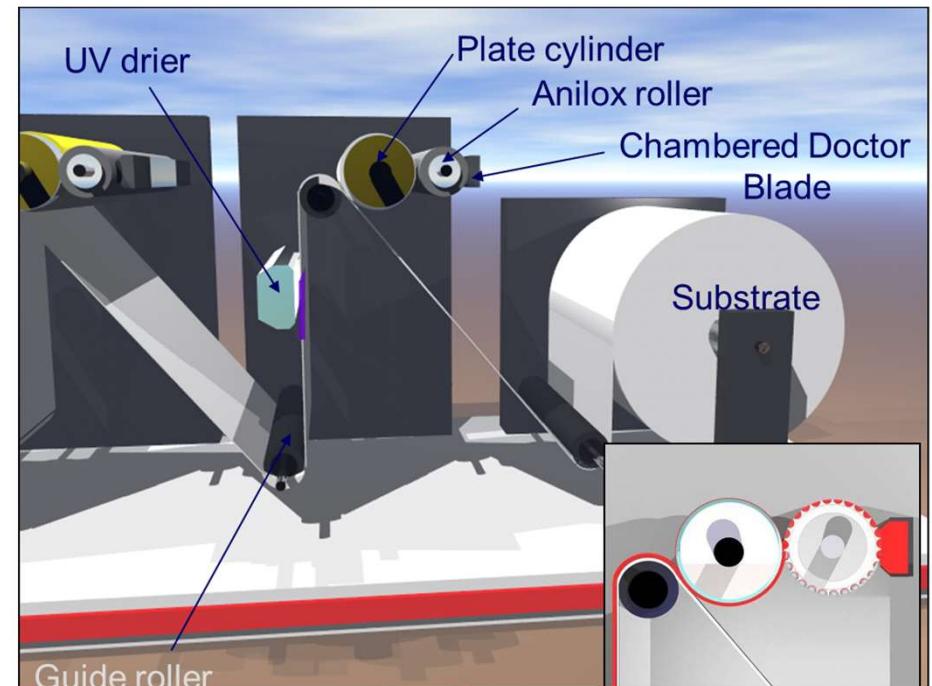
- Printing process
- Line speed
- UV lamps
- Inhibition from O₂
- Relative Humidity

Formulation side

- Raw Material Chemistry
- Pigmentation and fillers
- Rheology
- Compliance of Raw Material

Customer side

- Physical properties
- Safety and environmental concerns
- Application
- Cost



Optimizing a formulation consists of finding the best compromise between cure speed, printability, physical properties and end-use

Formulating inks is a challenging work

Ink Composition

Pigments provide the color. In UV curing they greatly influence the ability of UV rays to penetrate the ink film.

Monomers are used as reactive diluents. They influence rheology, cure speed, surface tension, chemical and mechanical resistances.

Oligomers (epoxy, ester, urethane...) combined with monomers form the binder (or the vehicle) of the ink. They contribute to the final properties of the cured film.

Photoinitiators activate the polymerization reaction; their efficiency will influence surface curing, through cure, total degree of polymerization

Additives give complementary properties, such as storage stability, scratch and rub resistance, etc.

UV ink chemistry

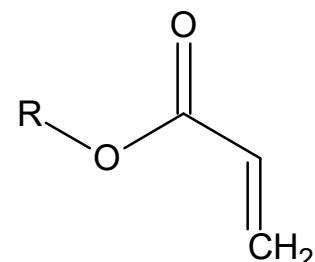
The polymerization reaction can proceed via a radical or a cationic mechanism ; the radical process is the most current

Free
Radical

Hybrid

Cationic

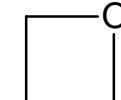
Acrylates
Di- to hexa-



Di-Epoxy



Oxetane



Di-vinyl ether

