Distributed RFID Solutions

Sustainable RFID Antenna Production Processes for Direct Printing to Packaging Materials

Presenter:
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CTO, IIMAK

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Agenda

- Sustainable RFID Evolution
- Advances in antenna fabrication
- Metal foil cutting
- Inkjet printing
- Thermal Transfer Printing
- Hot and Cold stamping

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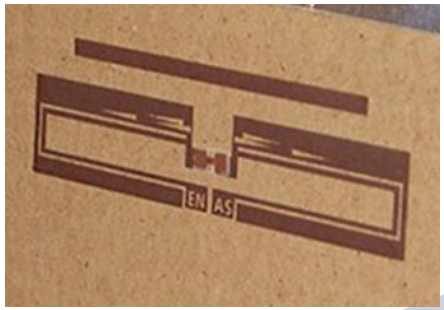
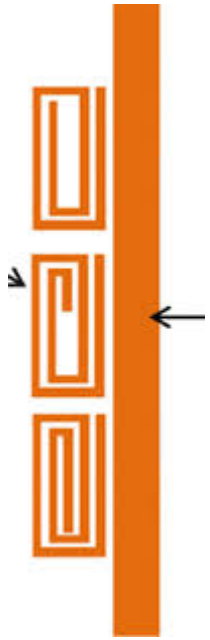
RFID Sustainability Evolution





Chipless RFID

Direct to substrate antenna

Paper Inlay/foil cut antenna

RFID Inlay/etched antenna

RF IC Printed Circuit

Analog RFID WW2

Sustainability and cost are driving the evolution of RFID

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RFID and Sustainability

- RAIN RFID has formed a working group to address the issue of sustainability and RFID in the field of packaging*
  - *"The largest end-use application for RAIN RFID is retail.*
  - *As consumers globally expect more and more sustainability, retailers have almost unanimously started to emphasize environmental friendliness.*
  - *Sustainability includes the environmental influences of the product throughout its life cycle.*
  - *RFID tag materials will evolve from polyester towards fiber-based, non-fossil substrates and from epoxies to less harmful adhesives.*
  - ***Antenna processing methods will likely shift from chemical etching towards dry and additive methods such as printing or cutting.***
  - *Microchips will get smaller, which means their environmental impact will reduce.*
  - ***Tags may become more integrated with the package, eventually leading into a process where the only additional materials applied onto the package are the antenna conductor and the IC."***

* https://rainrfid.org/wp-content/uploads/2019/05/Intelligent-Packaging-with-RAIN-RFID-V.1.0.pdf
* https://rainrfid.org/about-rain/workgroups/

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Drivers of Packaging/RFID Sustainability

- Reducing the packaging carbon footprint
  - Plastic RFID inlays add substrates and adhesives which could be eliminated with direct printing of antennae on the packaging substrate
- Recycling and composting of packaging materials and the circular economy;
  - Plastic RFID inlays do not breakdown in composting and need to be removed for paper recycling
- Elimination of hazardous waste
  - The antennae used on most RFID inlays are produced by the chemical etching of metals deposited on plastic films. Such processes produce hazardous waste and are not compatible with porous substrates such as paper.

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RFID and Sustainability

- Retail RFID tag providers have recognized that Sustainability must be designed into RFID for the technology to evolve into item level tagging to become a reality
- Cut foils are replacing etched antennae
- Paper inlays are replacing PET
- But is the industry going far enough?
- What about additive antenna printing directly on the packaging substrate?

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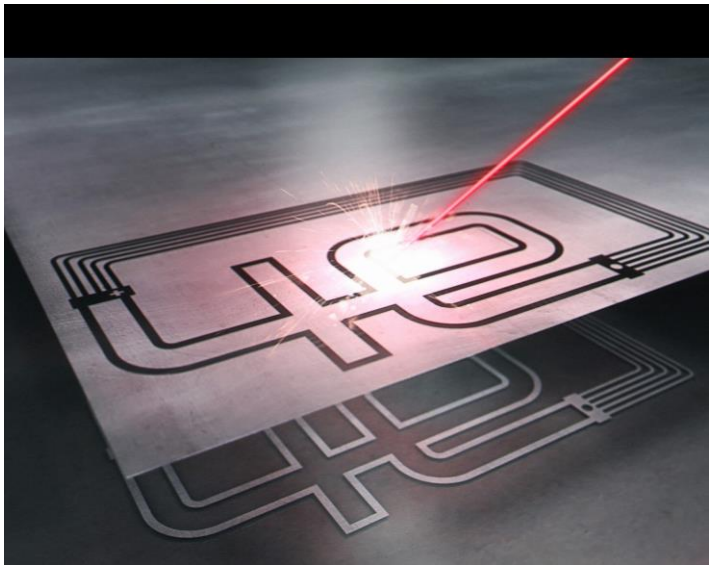
RFID Tags: Printing Direct to Packaging

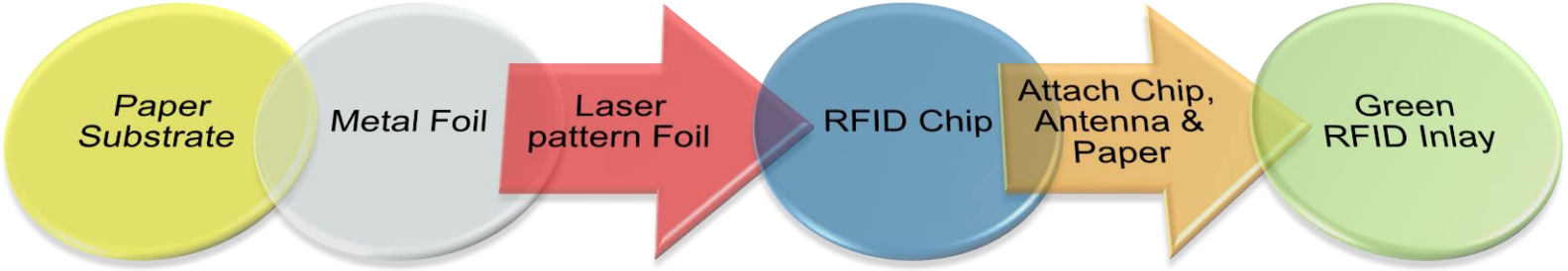
- Several processes are capable of additive RFID antennae production directly on sustainable substrates
  - Foil cutting/patterning
  - Ink jet printing
  - Thermal transfer printing
  - Hot and cold stamping
- Embed Chips in foil or ribbon
  - Form the antennae around the chip
  - Foil and transfer printing enabled such capabilities

Metal foil RFID Antenna Laser Patterning

- Processes to Laser pattern antennae are well know
  - Avery, Smartrac, Walki, etc.
- Metal foils are cut with dies and lasers rather than etched
  - Foil is still thicker than necessary
- Patterned foil antennae are bonded to substrates and chips attached
- Laser ablation may be used to create fine attachment points for chips
- Digital capability of the process is a ?



Walki-4E laser foil cutting technology



Foil Pattering of RFID Tag

Conductive Inkjet RFID Antenna Printing

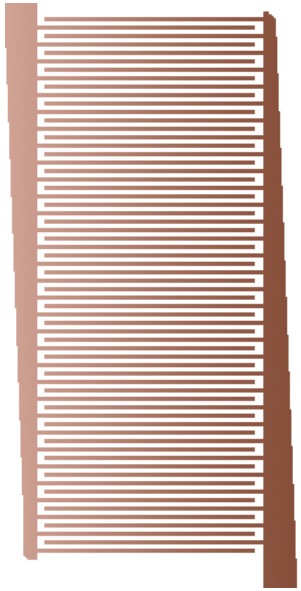
Conductive Ink printing is an established method for printed electronics

- Analog conductive ink printing is widely used,
  - digital inkjet conductive printing has not been nearly as successful
- Conductive IJ printing has been successfully used to print RFID antennae
  - Research at U. Glasgow and Tampere University of Technology showed good read distance but…
    - Silver based IJ requires drying and sintering,
    - Conductive inks, printers and sintering devices are very expensive

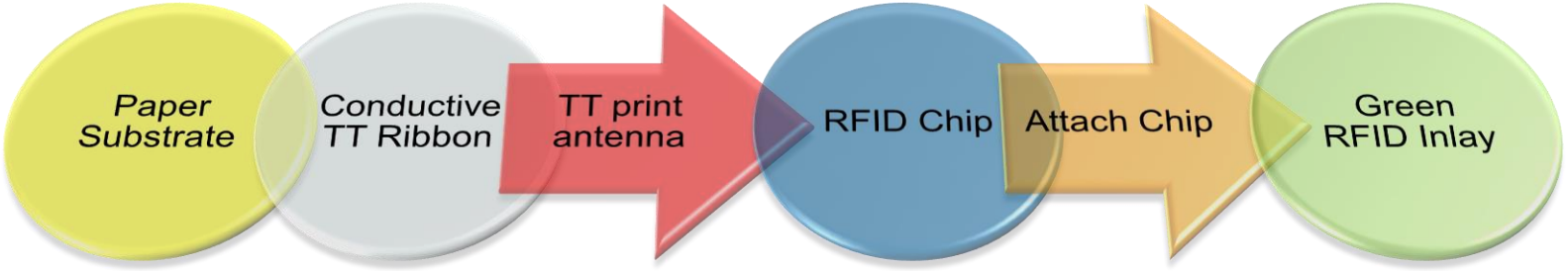
Inkjet Printing of RFID Tag

Thermal Transfer Printing of RFID Antennae

Conductive Thermal Transfer Printing is a well-established method for printed electronics



- Conductive TT printing has been successfully used to print RFID antennae
  - Prints directly to paper and film substrates
  - Capable of printing ~100µ gaps for chip mounting
  - Metal thickness of 0.25µ creates prints very fine patterns with no trimming or ablation required
  - Thermal transfer printers and ribbons are inexpensive



Thermal Transfer Printing of RFID Tag

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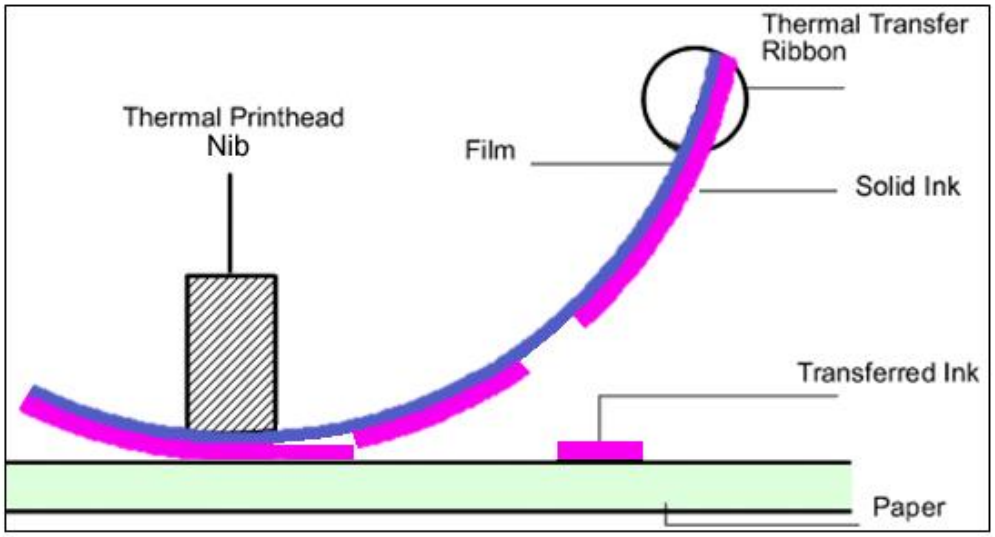
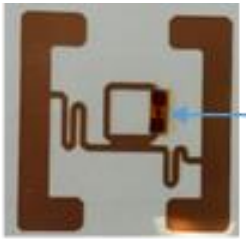
Thermal Transfer Technology

- **Raster-based (pixel not vector)**
- **Ribbon construction**
  - **Backcoat, Carrier, Top Coat(s)**
- **Receiver**
  - **Paper, film, fabric, etc.**
- **Thermal Printhead**
  - **Linear array of individually addressable heating elements**
- **Mechanism**
  - **Topcoat softens / melts**
  - **Sticks to receiver**
  - **Metal layer releases from PET Substrate**

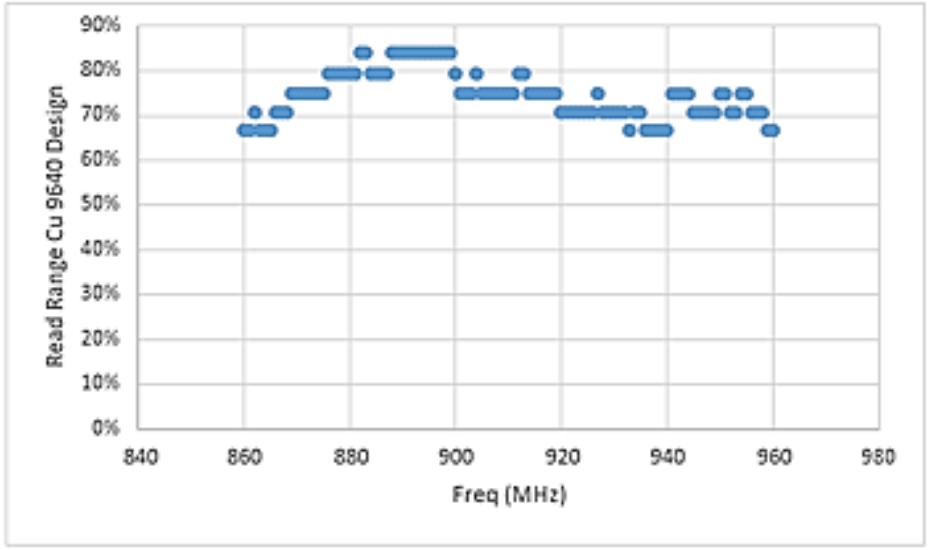


Metallograph® Performs well in RFID Applications

- Performance Comparison of Al & Cu Metallograph® with Etched Antenna*
  - Alien Technology® 9640 antenna - ~70% of read distance
  - Alien Technology® 9634 antenna - ~80% of read distance



Chip mounted on a polyimide strap with etched Cu pads for attachment to the antenna



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*** Test comparison Conducted at Vizinex**

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Environmental Impact– Inlay vs Metallograph

Antenna Area = 1 in² – 3.23 cm²

RFID Antenna Inlay

- Inlay (50 µm PET)
  - 22.0 mg
- Aluminum (12 µm)
  - 10.5 mg
- Adhesive (12 µm)
  - 3.9 mg
- Hazardous Waste
  - Yes

Metallograph® Antenna*

* Printed onto Packaging Substrate

- Ribbon (6 µm PET)
  - 2.7 mg
- Aluminum (0.024 µm)
  - 0.02 mg
- Adhesive (1 µm)
  - 0.3mg
- Hazardous Waste
  - No

10x less material than an equivalent Inlay and no hazardous waste

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Conductive TTR on paper and board

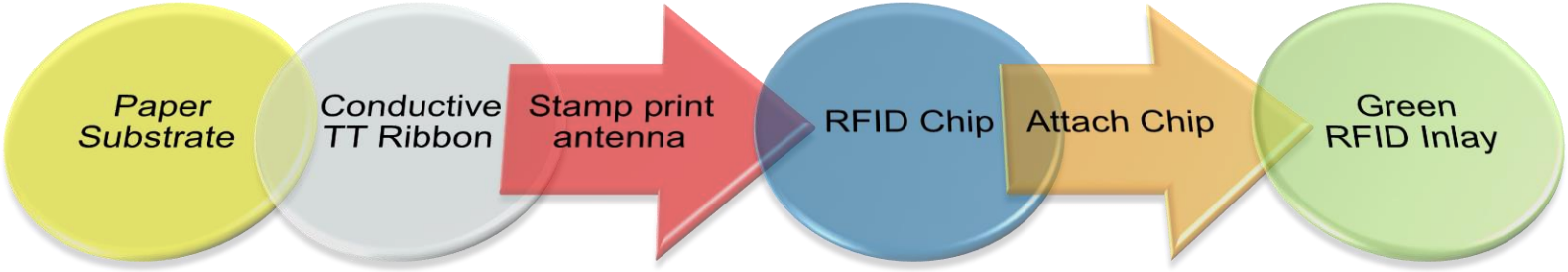
- **Pulp & Paper Research Institute (VUPC) Slovakia program to increase paper utilization and recycling, and bring low environmental footprint manufacturing to Slovakia.**
- RFID Example:
  - VUPC active program demonstrating printing of RAIN RFID by thermal transfer with Metallograph®.
  - Careful about fundamentals
    - Preferred paper properties
    - Actually measure antenna impedance to select matching IC
  - Determined that read range of aluminum antenna tags by Metallograph® or etched are the same with the preferred chip.*(Gigac et al)*
  - Next program stage is to develop process for high volume production by hot stamping Metallograph® on paper and paperboard.

Ref: Juraj Gigac, Mária Fišerová, Maroš Kováč, and Svetozár Hegyi; Passive UHF RFID Tags with Thermal Transfer Printed Antennas; MATERIALI IN TEHNOLOGIJE *(accepted for publication)* www.vupc.sk

Hot and Cold Stamp Printing of Antennae

Analog hot and cold foil transfer is widely used to print metallic images on films and paper

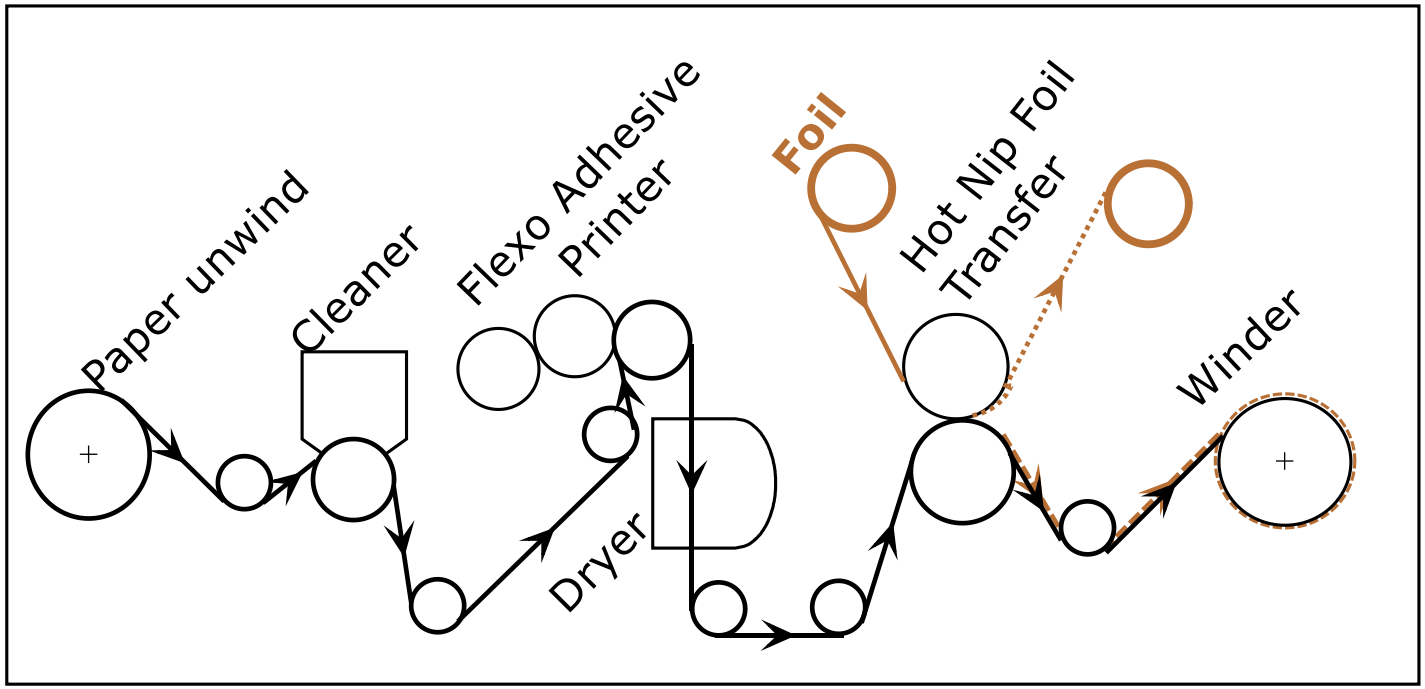
- Adhesive foil transfer and hot stamping have successfully printed RFID antennae
  - Prints directly to paper and film substrates
  - Metal thickness of 0.25µ creates prints very fine patterns with no trimming or ablation required
  - Inkjet or Flexo adhesive patterns for cold Metallograph® transfer disclosed by RRD
  - Hot stamp Metallograph® transfer of antenna by VUPC and others

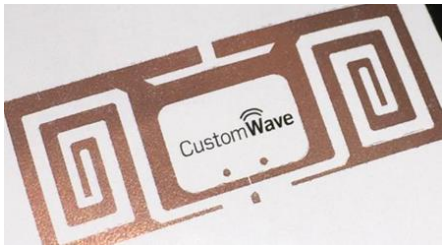


Inkjet Printing of RFID Tag

Analog: Hot Foiling with Printed Adhesive

Print thin thermo-plastic adhesive. Cure and dry.
Nip to glue-less Metallograph® ribbon. Separate. Wind. 100 fpm design permitting





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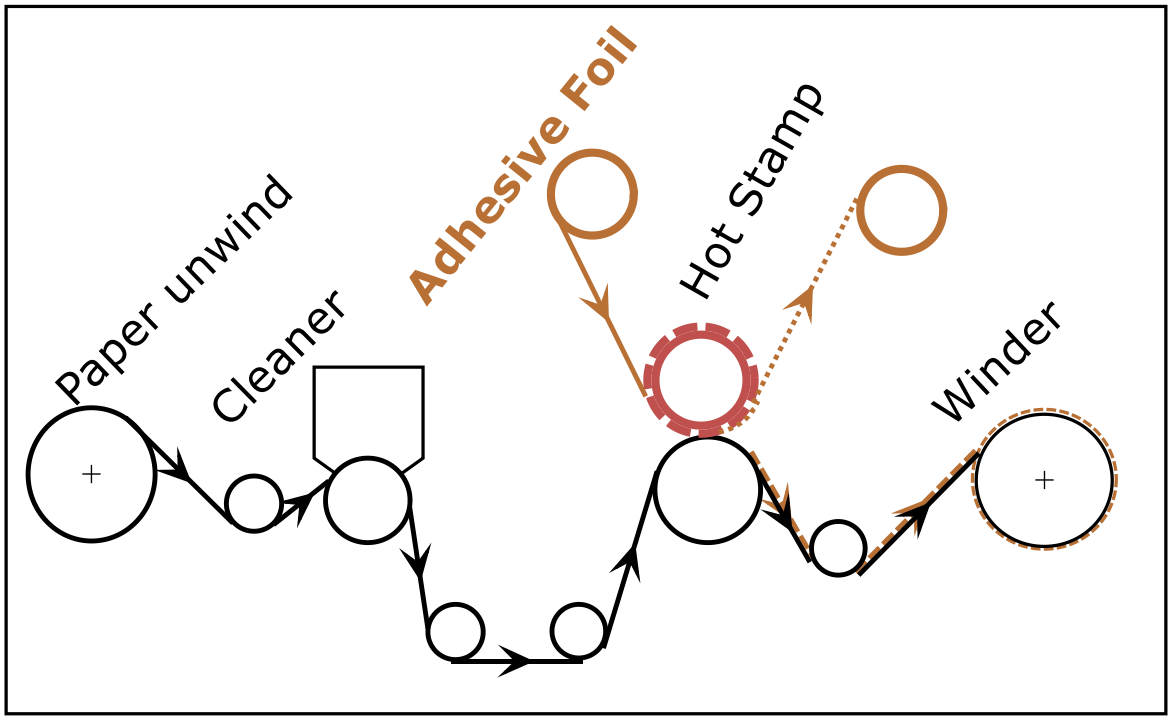
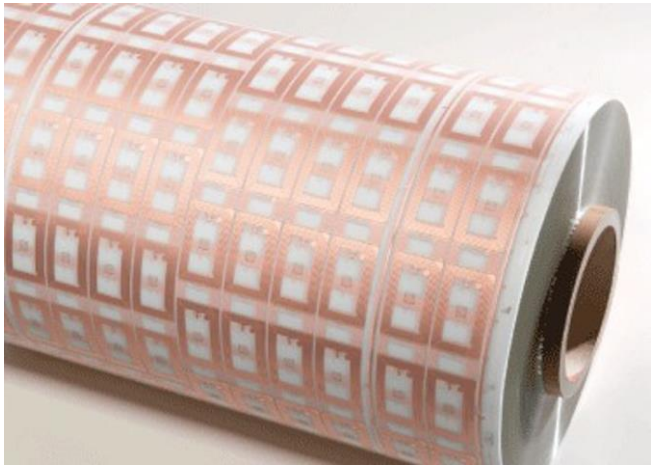
Analog: Rotary Hot Stamp

Thermal transfer style ribbon – coated with thermo-plastic adhesive.
Rotary hot stamp - 60 fpm design permitting





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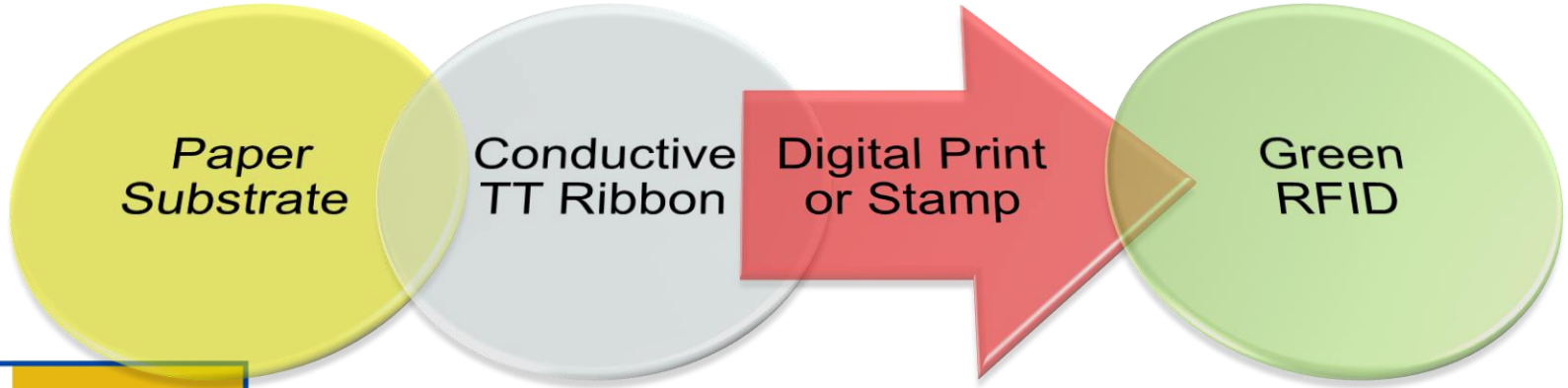
Chipless RFID - the final Frontier

By eliminating the chip, RFID has the potential to become as well utilized as barcoding

- Inexpensive metallic resonators printed directly to paper and film packaging materials
- Non-line of sight reading
- Reliable reader technology needs development



Chipless RFID

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Distributed RFID Production
Value Proposition

- Direct antenna printing onto product or package is enabled with Metallograph® Conductive Thermal Transfer
  - Green process – prints direct to packaging materials
  - 100 micron resolution for antenna printing
  - No inlay expense & waste
  - Customized antenna design with low MOQ
  - Low equipment cost and supply costs
  - Digital or analog printing options
  - Capable of printing Chipless RFID

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Metallograph®

Transfer Ribbons for Printed Electronics

- Developed and Manufactured by iimak, Amherst, NY
- Distributed Globally by SPF-Inc, New Hope, PA
  - Distributors:
    - FLEXcon Films for Electronics
    - Graphic Marking Systems – No. 1 Gerber Dealer
    - AstroNova's QuickLabel

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www.metallograph.tech
www.spf.com/metallograph
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