



A Virtual Conference presented by AIM & RAIN
9 - 10 December 2020





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Metallograph® Printed Electronics

Distributed RFID Production and other applications using Conductive Thermal Transfer Printing

Presenter:

Dan Harrison, PhD
CTO, IIMAK



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Agenda

- Digital Transformation of Auto-Identification
- What is Metallograph®
- Printer Technology
- Distributed RFID Production
 - Direct to label or package
- Interesting Applications for Metallograph®



Auto Identification Evolution

Digital processes have enabled analog Auto ID technologies to migrate into distributed applications – marking or coding at the point of production

Analog Origins



1974 1st Commercial UPC Barcode – Analog Printed

Digital Printing

Present Embodiments

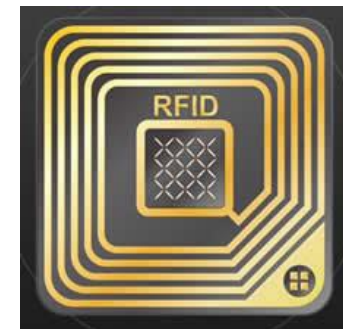


Digitally Printed UID



1940's RFID in WWII

Integrated Circuit



DOD IUID RFID Inlay

Digital Enables Variable Information Printing

- Analog barcode printing still widely used for UPC and other applications
 - Analog printed on packing materials



Thermal printhead is a linear array of resistors 150 to 600 per inch

Development of the thermal printhead enabled distributed barcode printing

- Digital barcodes thermally printed on the manufacturing, packing or shipping line
 - Variable information such as lot codes, date codes, ingredients, addresses, etc.



Metallograph® Digital Conductive Printing

Provides a means of innovation

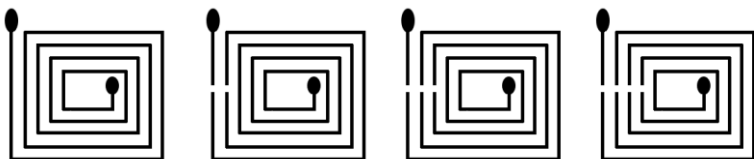
Digital Conductive Printing Opens New Doors

Parallel thermal printheads provide extremely reproducible dimensions

Not Only Barcodes



**But Also Chip-less RFID –
300, 600 and 1200 dpi!**

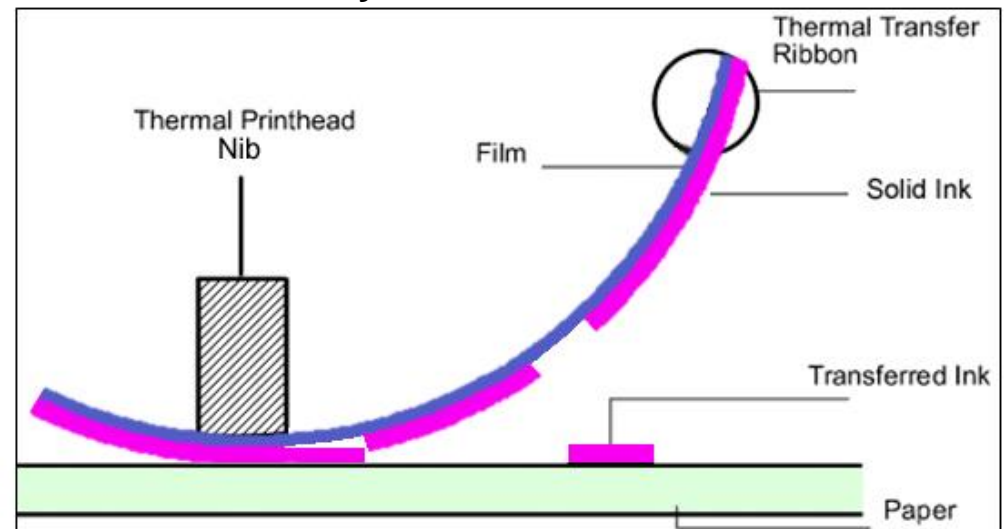


**250 μ m Lines and Spaces
can be robustly printed**

Digital: 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® Ribbon Structure

1. Back coat

- Processing aid

2. Carrier Film

- Dimensional stability

3. Top coats (ink equivalent)

- Release layer
- Conductive metal layer by vacuum deposition or
- Dielectric layer
- Thermoplastic tie layer (Optional)
 - Adhesive for thermal and hot stamp
 - Not needed for hot foiling with printed adhesive

Heat Resistant Coating

PET Carrier Film

Release Layer (not-conductive)

Vacuum Metalized (Continuous) Layer

Thermoplastic Tie layer



Thermally Printed AI Properties

- **Volume Resistivity..... 3.00 $\mu\Omega\cdot\text{cm}$**
- **Power Capacity..... 2.50W**
- **Maximum Current Density..... 410 A/mm²**
- **Bend Test (ASTM F2750-09) **
 - Percent increase in resistivity**
 - **after 100 Bends – Compression..... 0.65%**
 - **after 100 Bends – Extension..... 0.50%**
- **Cross – Hatch Adhesion Test**
(ASTM F1842-09)..... 5
- **Environmental Aging Test (ASTM F1996-06)**
38°C, 95%RH, 10 Days..... Pass
- **Drying Time..... Immediate**
- **Sintering..... Not Required**
- **Thickness..... Al: 0.26 μm , Cu: 0.35 μm**



Bench Top Industrial Label Printers



Zebra ZT610

- **Research,**
- **Development,**
- **Prototype,**
- **Production**

**No Scale Up Needed!!!
(In-line for large volume)**

Industrial quality thermal transfer roll-to-roll printers

- Zebra, Avery Dennison, DataMatrix, QuickLabel, CAB, Honeywell, Sato, Logopak, Toshiba Tec and others
- 200, 300 and 600 dpi
- 4, 5, 6 and 8 inch wide
- 1 to 14 ips – 300 dpi proven for RFID antenna at 5 ips (18,000 inch/hr)
- Internal rewinder (8 inch max) normal configuration
 - Can use 18 inch external supply and take up or install engine in-line
- 300 dpi least difficult to use.
- Pricing: 300 dpi devices: 4" ~ \$2500 to \$3000; 8" ~ \$7000

Multilayer Single Pass



QuickLabel QLS 4100

To 140 mm - QuickLabel is a
Metallograph Tech partner & distributor



mprint LP 2000

to 240 mm



Precision Industrial Printer



Full Color Graphic Arts – Gerber Edge

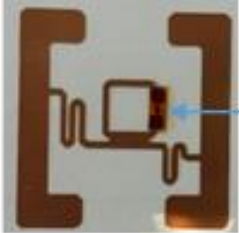
- **300 mm wide,**
- **300 to 1200 dpi,**
- **Precision 10 μ m**
- **Up to 10 layers**

- **\$18,000**

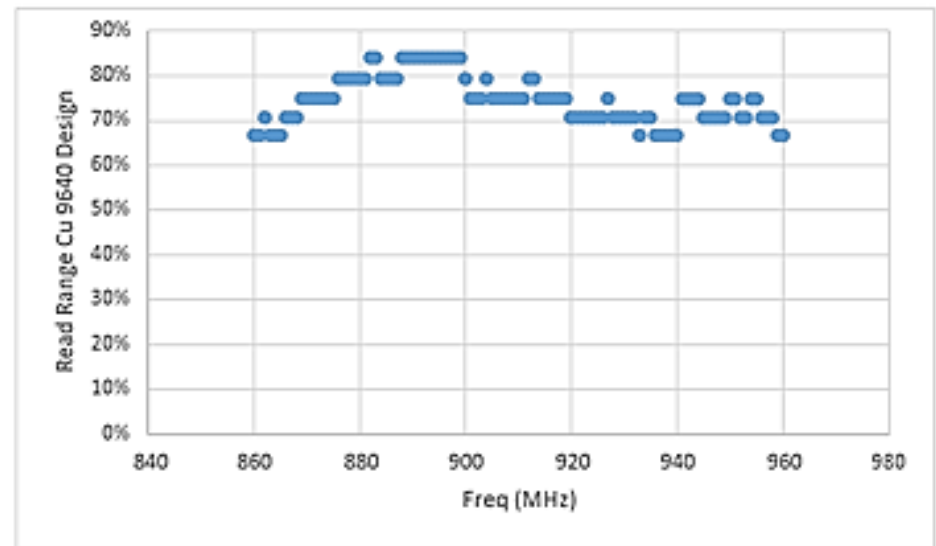
- **Matching cutter**

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

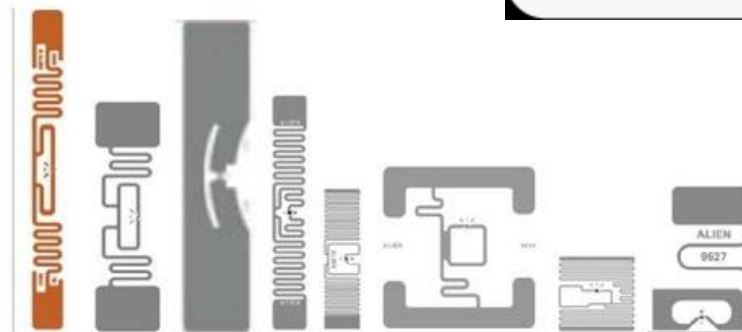
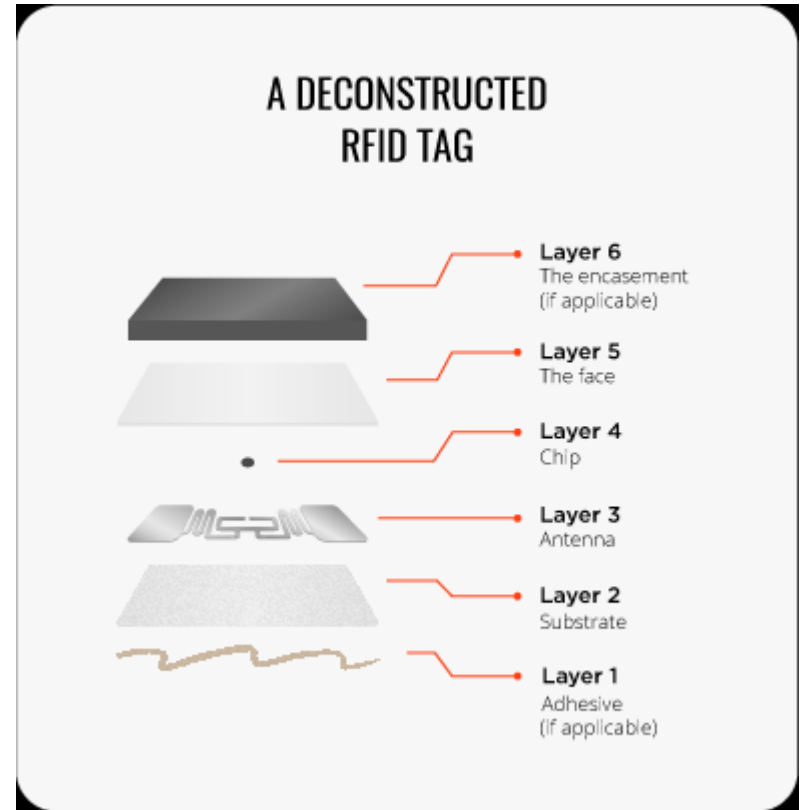


Inkjet vs Thermal Transfer

- Research at U. Glasgow and Tampere University of Technology
 - Compared Digital Antenna printing
 - Conductive IJ and Thermal Transfer achieved equivalent read distance.
 - Silver based IJ requires drying and sintering, inks and printers are much more expensive
 - Metallograph® is ready to use after printing, does not require ink receptive substrates, even works on paper

Centralized RFID Tag Production

- RFID Inlays have enabled the rapid deployment of wireless auto-identification of parts, products, supplies, equipment, etc.



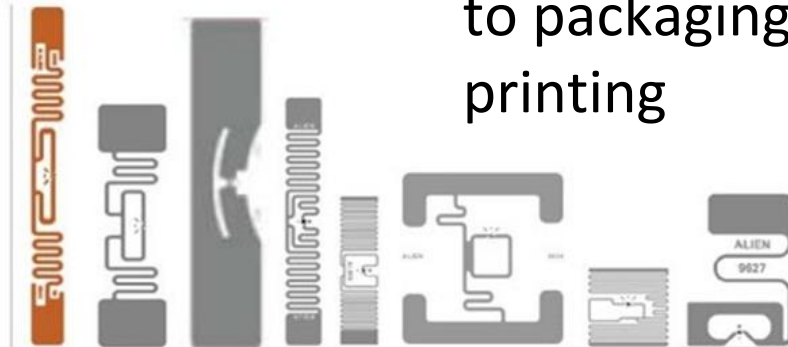
Centralized RFID Tag Production

Pros

- Large selection of chips, antenna's and form factors
- Regional Producers add value by combining existing components to create customized solutions
- Programmable at the point of inlay attachment

Cons

- Many items required customized antenna design
 - MOQ for customized antenna is very high
- Inlay cost is too high for many inexpensive product categories
- Inlays to not enable direct to packaging material printing



Distributed RFID Production

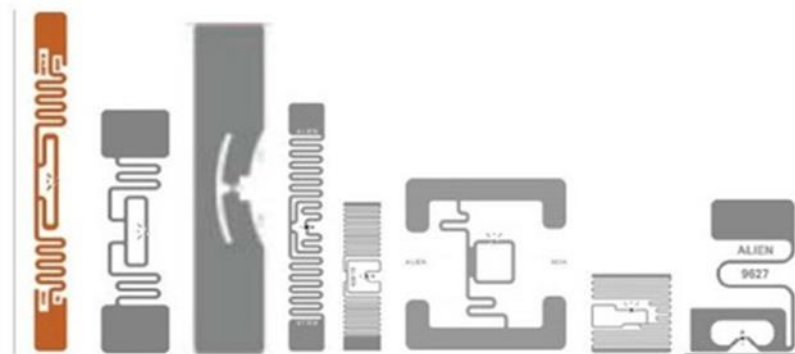
Enabled by Metallograph

Pros

- Antenna design optimized for item
- Direct to packaging materials
 - Paper or film
- Low MOQ/low cost
- Value added resellers
 - Capital sale
 - Design services
 - Consumable annuity

Cons

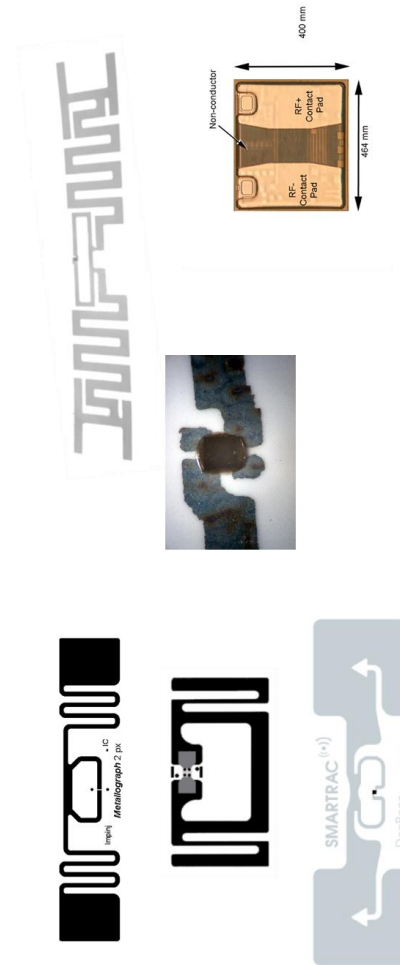
- Requires small capital investment by end user
- End user responsible for process
- High volume inlays may be less expensive



Distributed RFID Production

Enabled by Metallograph®

- Factors to consider
 - Optimize the antenna design to the article
 - Size, shape, contents and case packing density
 - Antenna - chip impedance matching
 - Printing on packaging materials
 - Paper and film
 - Mounting of the chip
 - Strap attachment
 - Modest volume pick & place machines in development
 - Attaching the chip
 - Conductive or non-conductive adhesives



RAIN Tags 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:
 - Plastic downgrades paper meant for recycle. Growing demand for tags without plastic for packaging and retail.
 - 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



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*

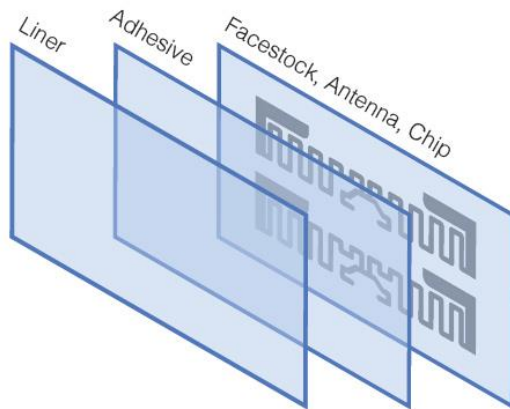
* Printed onto Packaging Substrate

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

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

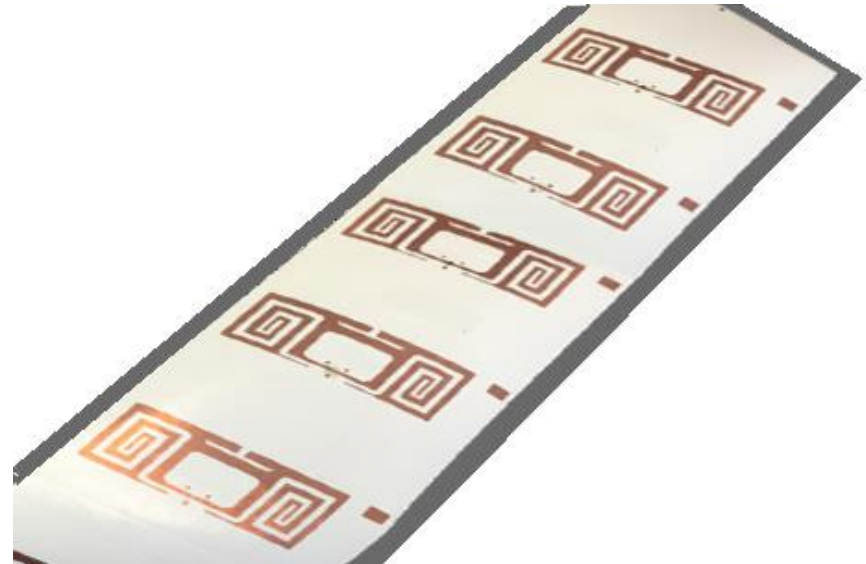


High Volume Analog RFID Production



CustomWave Inlay-less Smart Label Construction

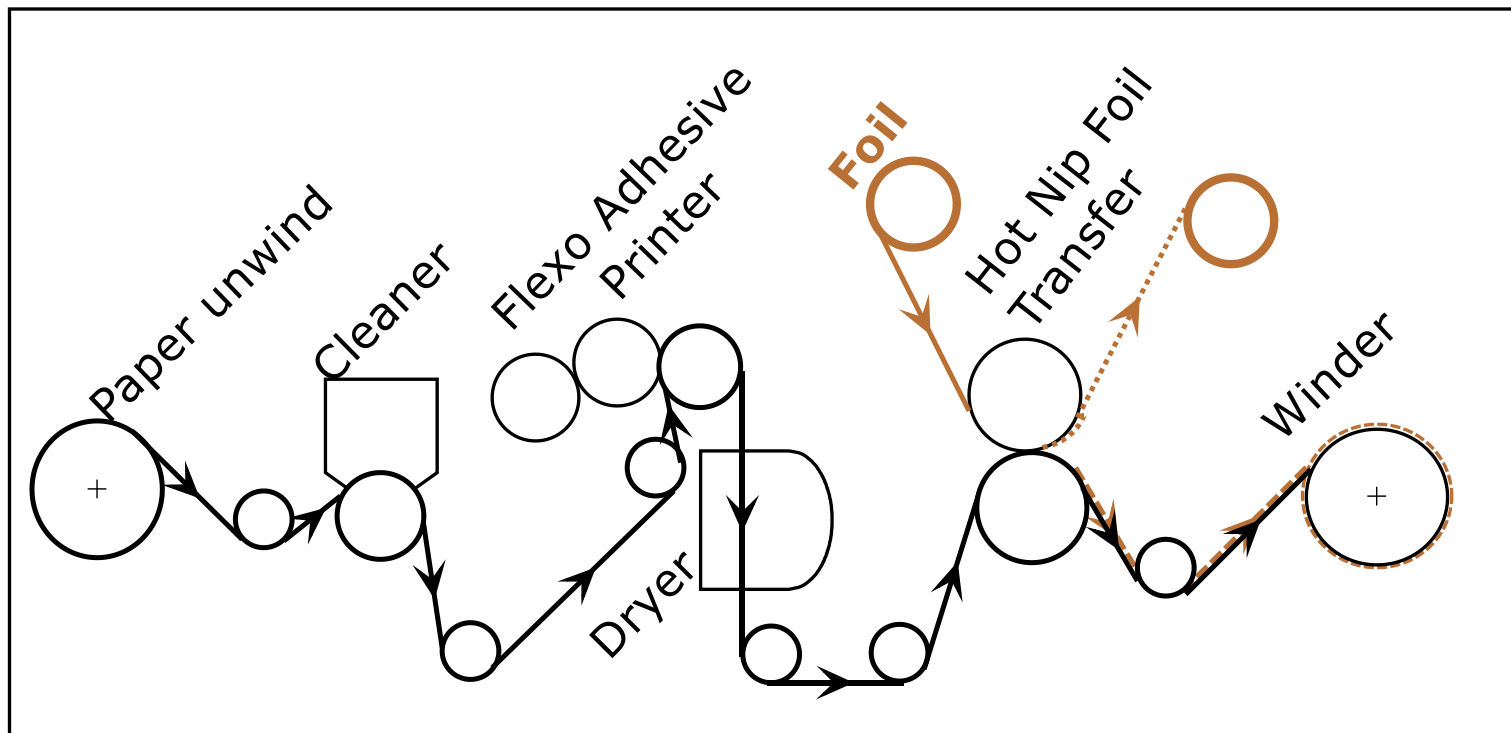
pi



Analog: Hot Foiling with Printed Adhesive

Print thin thermo-plastic adhesive. Cure and dry.

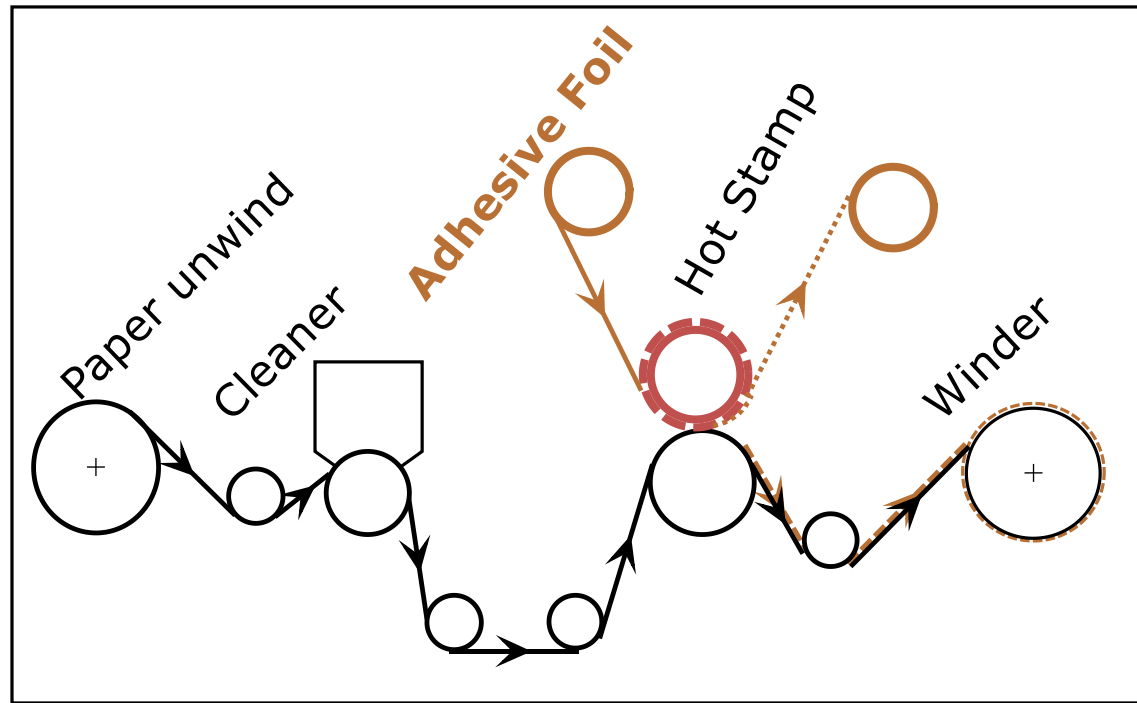
Nip to glue-less Metallograph® ribbon. Separate. Wind. 100 fpm design permitting



Analog: Rotary Hot Stamp

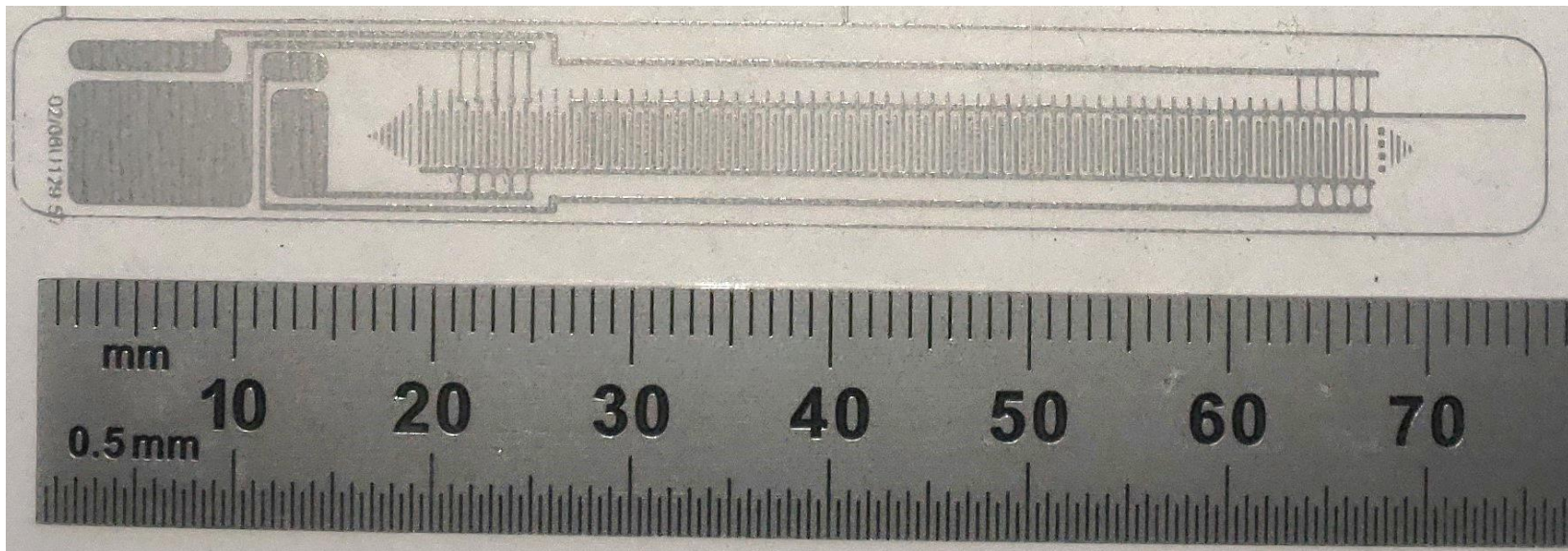
Thermal transfer style ribbon – coated with thermo-plastic adhesive.

Rotary hot stamp - 60 fpm design permitting



Other Applications for Metallograph®

- “Lab on a Chip” electrode array for counting white blood cells using an impedance cytometry method
 - 0.25 micron Al thermal transfer printed on a 300 dpi Zebra 140 Xilll
 - 250 micron lines and spaces in array

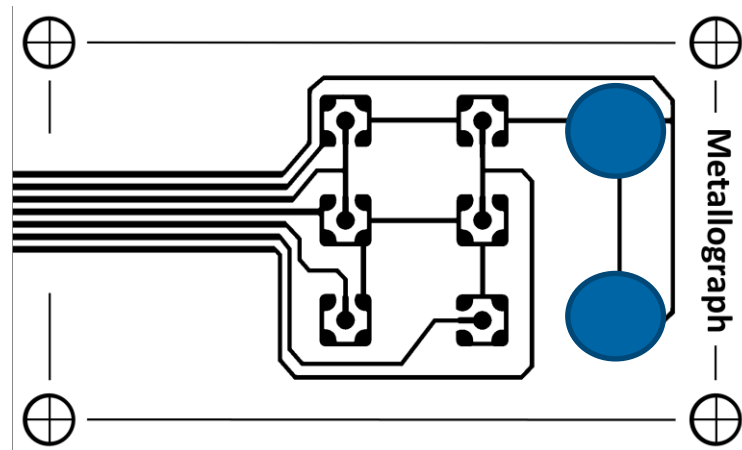


Touchscreens and Sensors

Gaps & conductors 0.010"



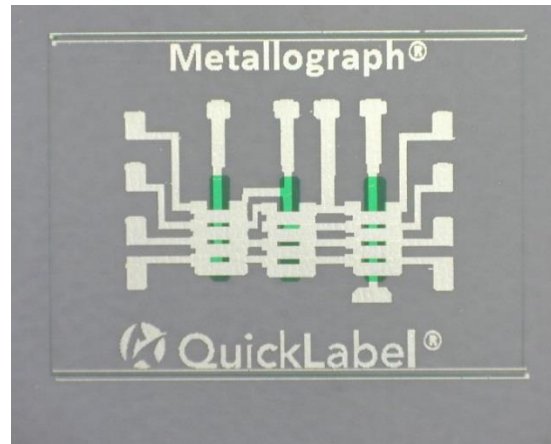
Key is resistance or capacitance overprint or pad



Use polymeric structures with pressure sensitive resistance



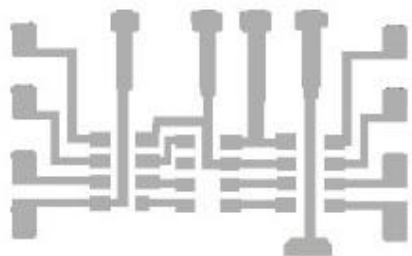
Multilayer Structures Printed QLS



1 Alum

2 Resin

3 Alum



Metallograph®



QuickLabel®

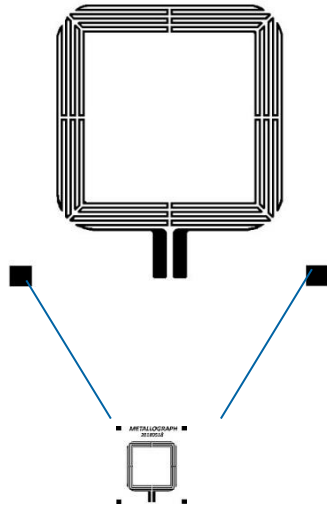


Three layers produced at 2 ips – no drying, no rewinding

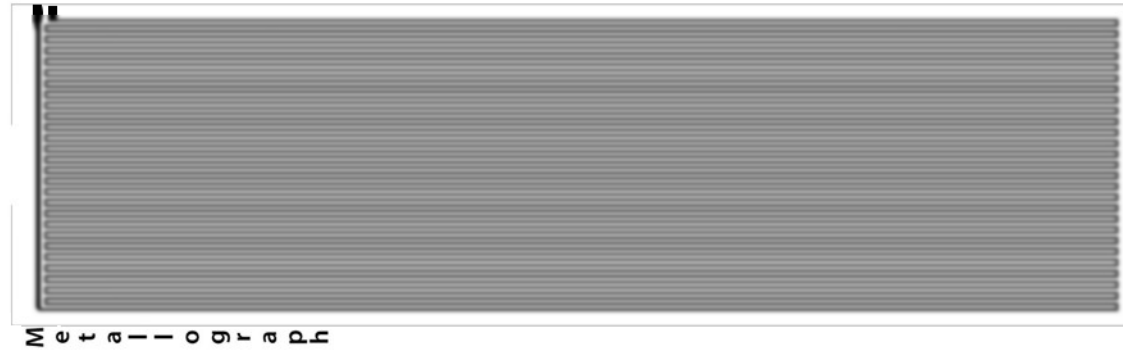
Short-run low voltage heaters

25 x 25 mm, 500 ohm, low voltage heater

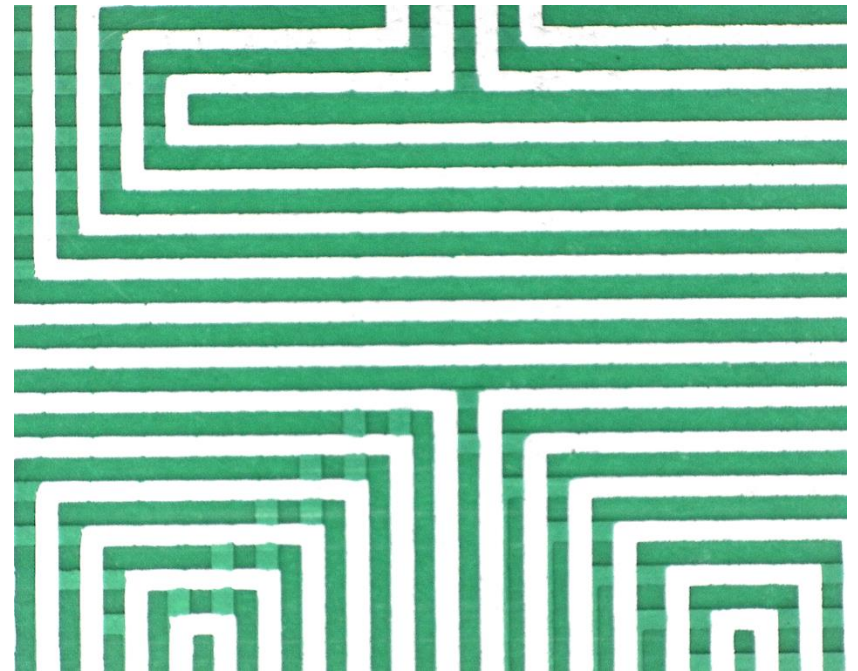
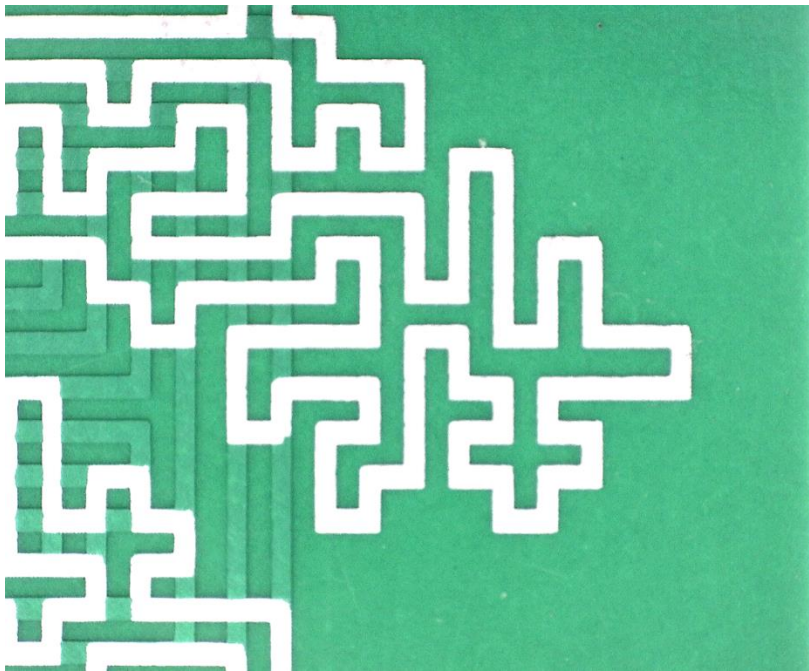
■ **METALLOGRAPH** ■
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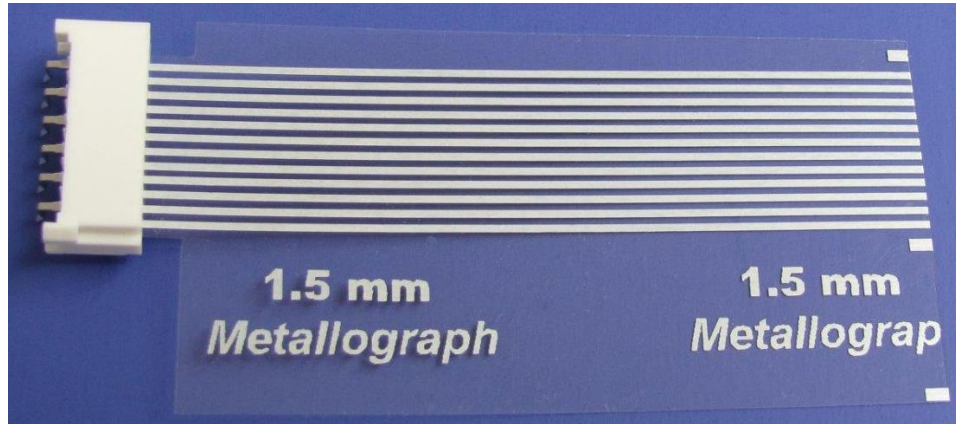
600 x 200 mm, 5500 ohm flat panel high voltage heater



Three Layer Composite 0.001" Registration



Flex circuits and connectors



Distributed RFID Production Value Proposition

- Direct antenna printing onto product or package is enabled with Metallograph® Conductive Thermal Transfer
 - Direct to Packaging Materials
 - No inlay expense & waste
 - Customized antenna design with low MOQ
 - Low equipment cost and competitive supply costs
 - Digital or analog printing options



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

www.iimak.com

www.metallograph.tech

www.spf.com/metallograph

www.flexcon.com

www.GraphicMS.com

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