

Printing Radio Frequency Identification (RFID) Tag Antennas Using Inks Containing Metal Nanoparticles

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RIT

- Imaging and Photography
 - Largest (and best) Photography school
 - Imaging Science
- uE
 - First BS in uE
 - FAB
- Packaging

Printing

- School of Print Media
 - Printing Applications Lab
- Sloan Printing Industry Center
- Process Expertise
 - Offset lithography
 - Sheet-fed and web
 - Conventional and waterless plates
 - Flexography
 - Gravure

Project Goals

- **Design and print test patterns and antennas for RFID applications**
- **Determine printing process capabilities for printing devices**
- **Study physical and electrical properties of printed features**
- **Fabricate a working device using printed antennas**

Printable Electronics

- Use of traditional printing processes for production of circuits.
- Uses process-specific conductive inks to print circuits directly.



Printing Advantages

- Inexpensive (compared to FAB)
- High volume
- Prevalent equipment
- Wide variety of substrates available
- Additive process

Printing Methods

- Screen printing and inkjet are most commonly used for printing devices
 - Can use small amounts of (expensive!) materials
 - Economical for production of limited quantities

Screen and Ink-Jet Disadvantages

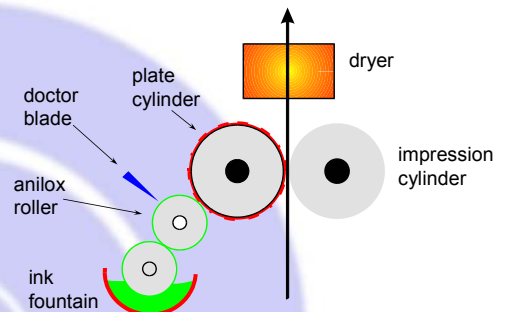
- Slow
- Limited volume.
- Resolution
 - Screen dependent
 - Ink Jet Satellites
- Screen printing lays down a relatively thick layer of ink

Our solution

- Use small scale (proofing) versions of printing techniques which can be used in large scale
 - Flexographic
 - Gravure
 - Lithographic



Flexographic Printing

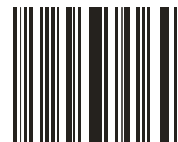


Mark Andy Flexographic Press



Barcodes

- Pros:
- Inexpensive
 - Do not require specialty inks
 - Can be printed on almost any substrate
- Cons:
- Line of sight
 - Limited data capacity



Radio Frequency Identification

Pros:

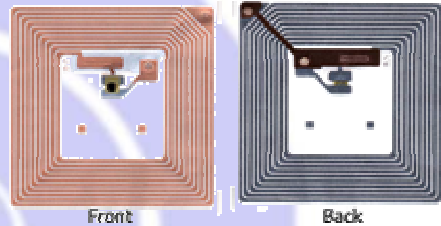
- Large data capacity
- Can still be scanned even if visually obscured
- Allow inventory management and theft detection.

Cons:

- Expensive
- More complex to produce

RFID

- Antenna coil
- Si micro chip

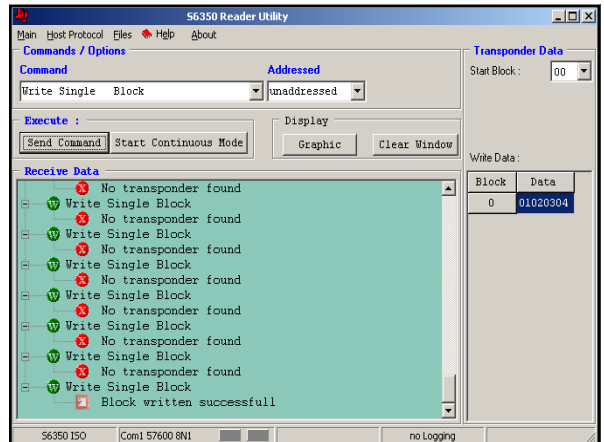
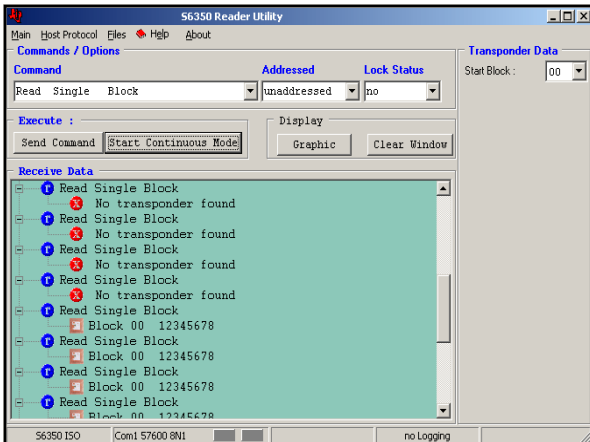
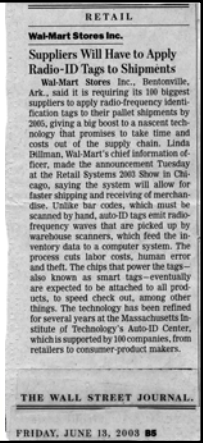


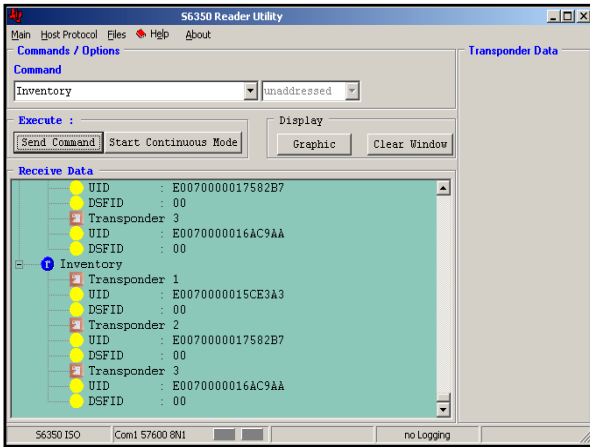
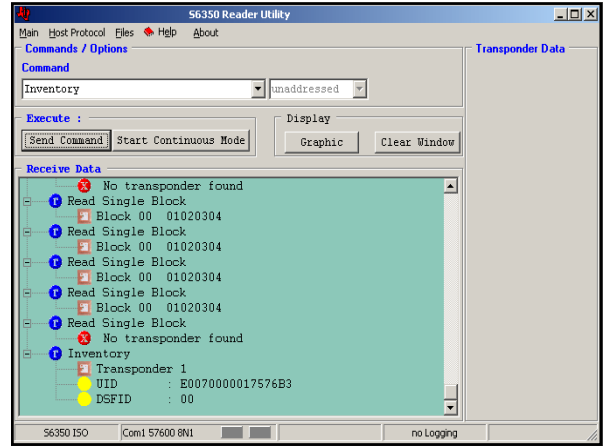
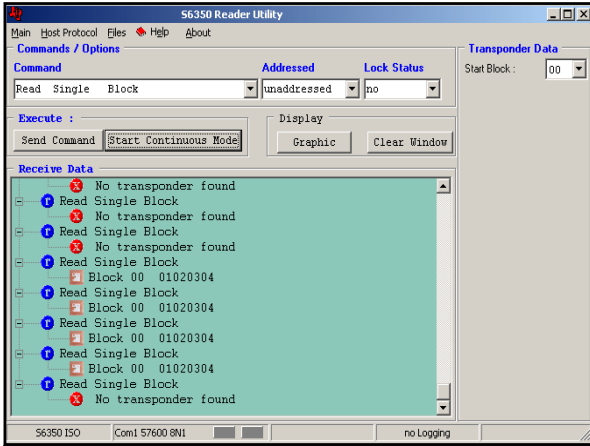
How does RFID work

- Reader sends out RF signal
- Tag receives RF signal via antenna
- Two type of tags
 - Passive tags
 - RF signal is rectified and used to power chip
 - Active tags
 - Tag powered by battery
- Chip sends information back out antenna
- Reader receives information

Wal-mart!

- 100 largest suppliers to apply RFID to pallet (and case?) shipments by 2005
- All suppliers by end of 2006

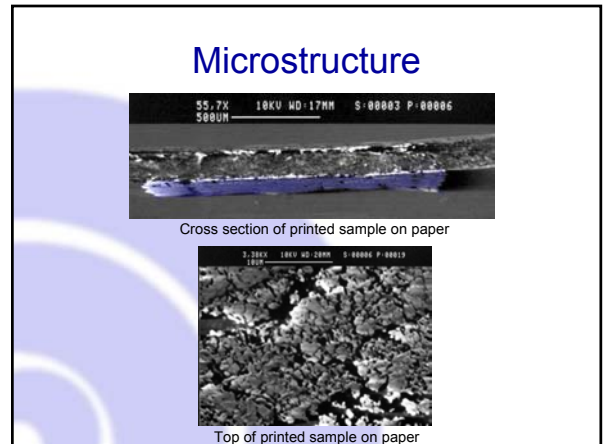
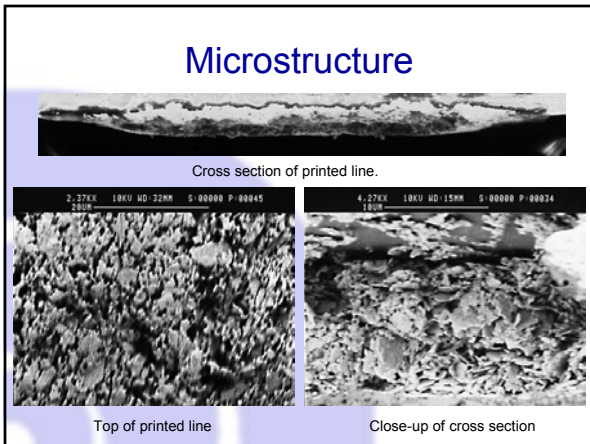




Parmod™ Inks

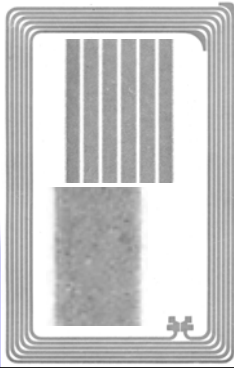
- Silver flakes
- Silver nanoparticles
- Silver “Metallo Organic Decomposition” (MOD) compound (soap)
 - Silver neodecanoate

US Patents
5,882,722; 6,036,889; 6,379,745



Characterization

- How do you judge print quality?
- How else do you drive quality improvement?
- Electrical characterization
 - Resistance
 - S_{11}
 - RLC



All I really need
to know I learned in
kindergarten



Coloring 101

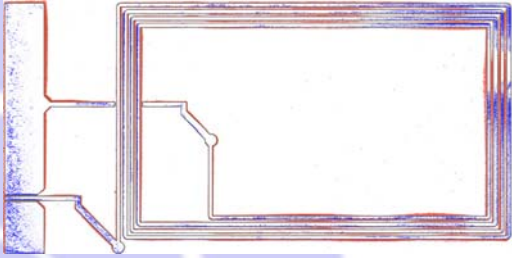
Coloring 101

- Don't color outside the lines!

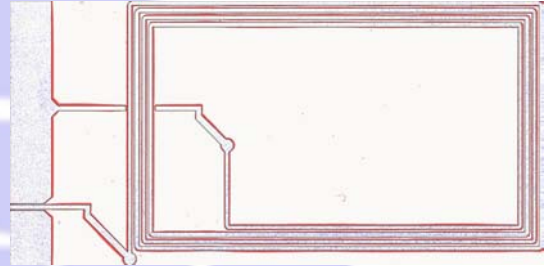
Coloring 101

- Don't color outside the lines
- Fill the areas you are trying to color completely

Mylar



Paper



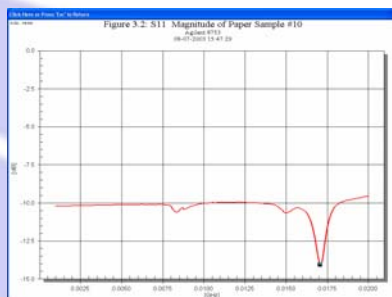
Analysis

	% Missing	% Bleed
Mylar	16.13	44.71
Paper	1.33	32.82

Antenna Properties

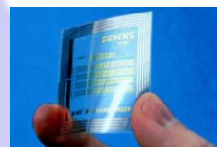
- Coil resistance
 - Currently:
 - 86 Ω / 4 coils
 - 75 Ω / 5 coils
- Line height
 - Average line height:
 - Mylar, 3-4 μm
 - Paper, 6-8 μm

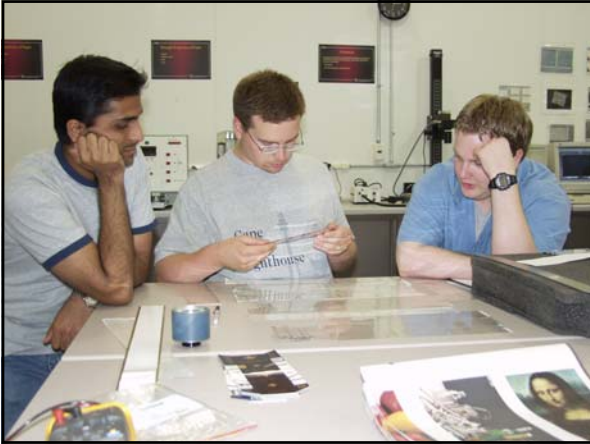
S_{11} for Coil on Paper Substrate



Future Applications

- More complex circuits
- Thin film transistors
 - All printed RFID tag
 - Backplanes for displays
- Sensors
- Other multi-layered devices
- Micro Electro-Mechanical Systems (MEMS)





Team Members

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SCHOOL OF PRINT MEDIA
Rochester Institute of Technology



Questions