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 “Metalo Organic Decomposition” (MOD) compound (soap)
  - Silver neodecanoate

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

Microstructure

Cross section of printed line.
Top of printed line
Close-up of cross section

Cross section of printed sample on paper
Top of printed sample on paper
Characterization

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

Coloring 101

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

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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Support

Questions