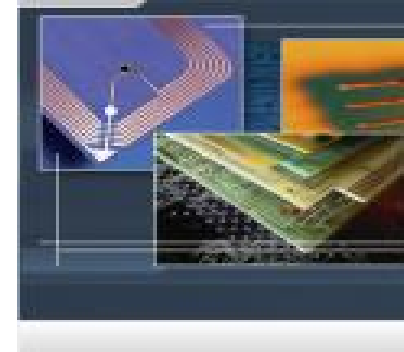
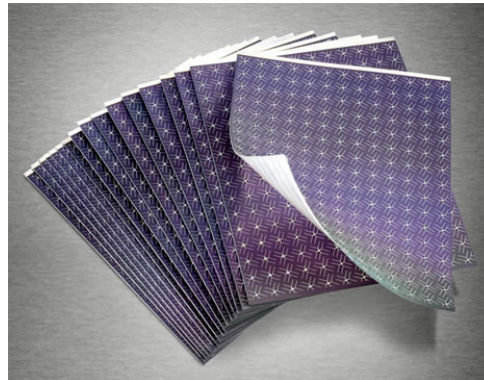
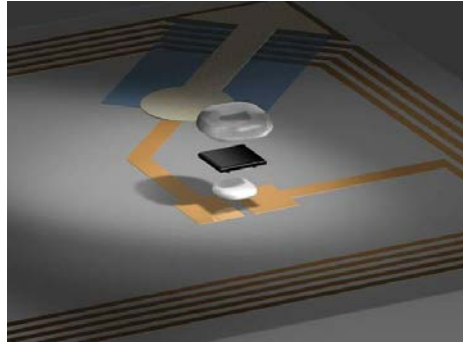


Applications and Material Sets for Printed Electronics

Dan Fenner
Henkel Electronic materials

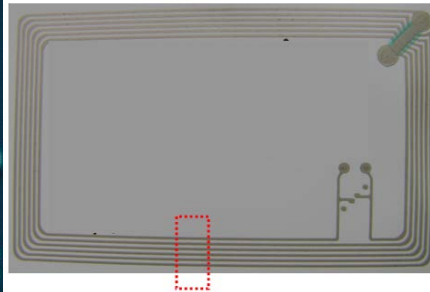
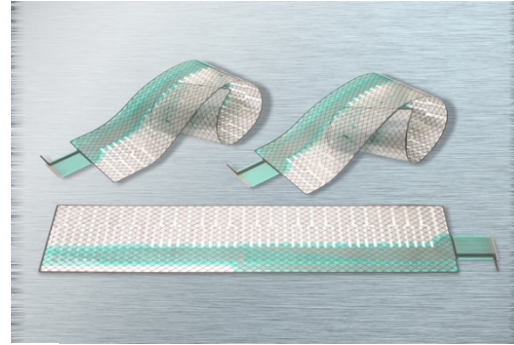
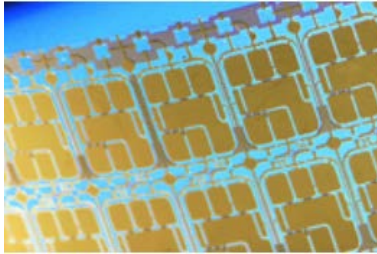
| Outline

- Print methods
- Substrates
- Conductive inks
- Resistive inks
- Dielectrics inks
- Specialty inks



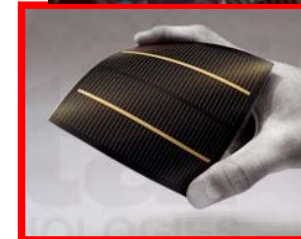
| What is printed electronics?

The ability to put functionality into a substrate through printing.



Examples where printed solutions are currently being used

- **Smart cards** Ink in RFID antenna
- **Displays** Capacitive touch switch
- **EL Lighting**
- **Solar Cells** Buss bar printing
- **IME** In-mold electronics



Application Methods

- Screen printing
- Flexographic printing
- Rotogravure printing

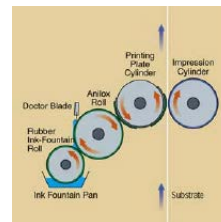
With screen printing it is possible to apply thick layers (5-25 μm), but it is a slow printing process in comparison with flexographic or rotogravure printing.



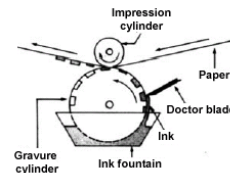
**Flat-bed
screen**



**Rotary
screen**
Printing speed



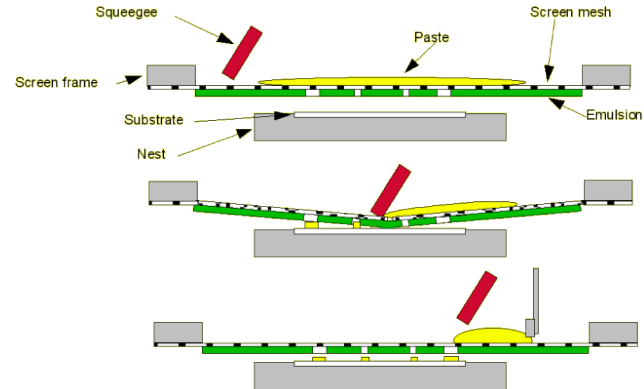
**Flexogra
phy**



**Rotograv
ure**

Flatbed screen printing

- Flatbed printing is arguably the most versatile of all printing processes.



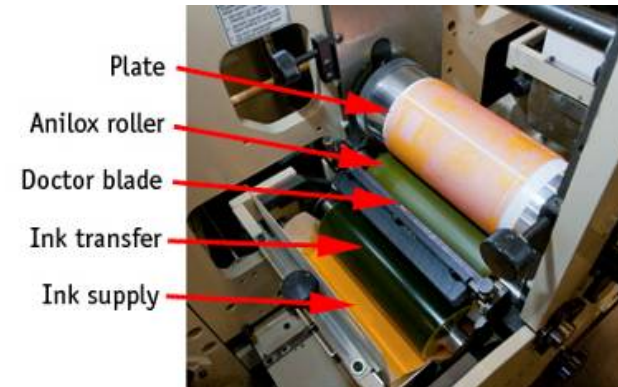
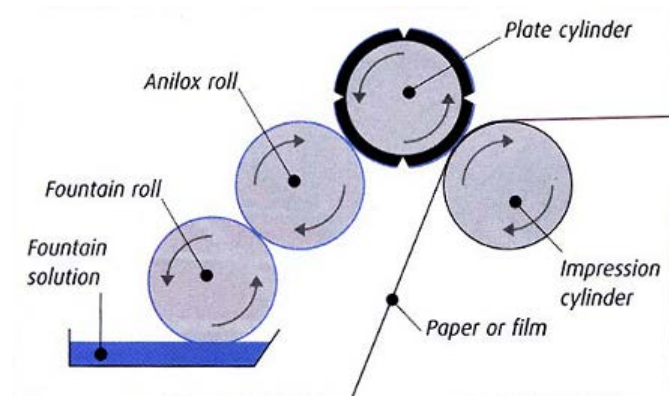
Flexographic Printing

- Flexography is the most common type of printing used for packaging.
- Flexo has seen the most advances in printing capability and versatility in the last several years.



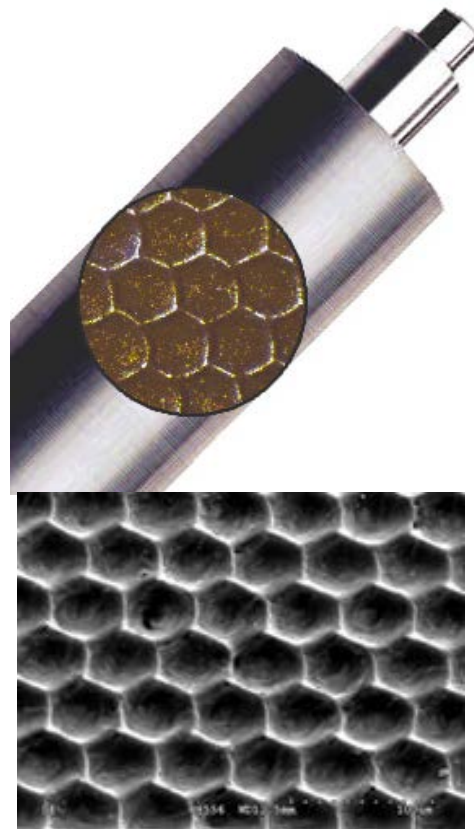
Flexographic printing

- Flexography is like letterpress in that both print from a raised image surface.
- Flexo plates are molded from rubber or imaged from photo-polymer.
- Inks generally are low viscosity, highly fluid and quick drying.



Anilox rolls

- Historically anilox rolls have been etched for graphic ink applications. These systems incorporate much smaller size pigments
- Conductive inks present a challenge with large particle size and highly pigmented dense systems



Anilox Rolls

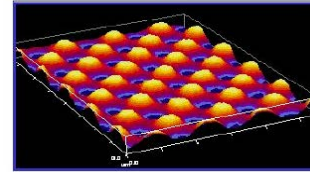
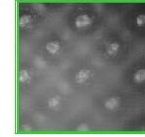
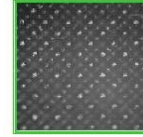
- New anilox technology for conductive printing.
- Closed cell shapes limit the amount of capillary action as well as the amount of ink that can be transferred from the cell.
- New open walled designs greatly improve ink transfer for better thickness deposits.

ART cell shape 45°

Anilox Reverse Technology

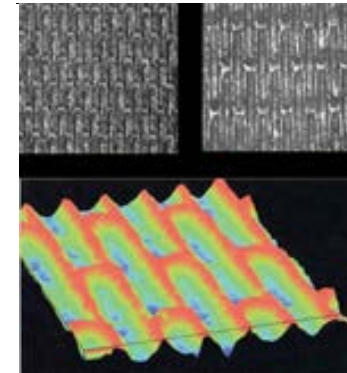
80 li/cm

16,0 cm³/m²



200 li/Inch

10,3 BCM



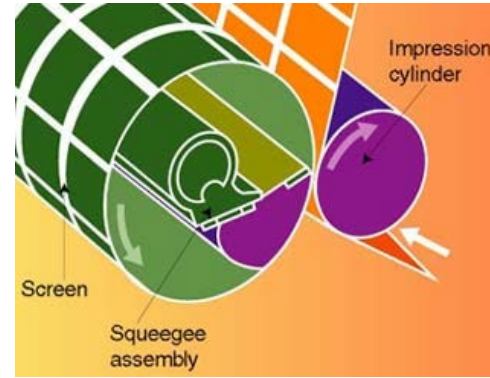
Flexographic printing Rotary screen

- Flexographic presses can also be outfitted with various types of print equipment such as rotary screen heads.



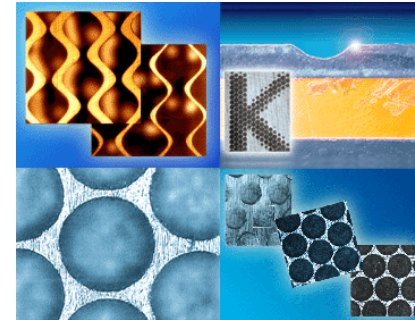
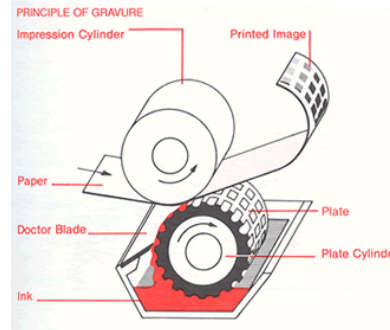
Rotary Screen

- Rotary screen presents a opportunity to provide screen printing characteristics in an inline application
- Film thicknesses three times higher can be applied over standard flexo plates.
- Rotary screens fill the gap between high speed flexo presses and flatbed printing



Gravure Printing

- Gravure Printing is the fastest type of printing
- Use for largest runs Millions/Billions parts.
- Most expensive for setup



Roto Gravure Printing

- The gravure process utilizes a metal printing cylinder onto which the image is etched
- The image areas consist of honey comb shaped cells or wells that are etched or engraved into a copper cylinder
- Cylinders are then chrome lined to extend the life of the cylinder



| Substrates

- Flexible

- Polyester
- Paper
- vinyl
- polycarbonate

- Rigid

- Glass,
- FR4,
- Aluminum,
- Stainless steel

| Electronics inks and how they are used

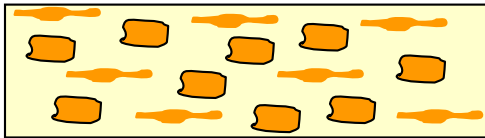
- **Conductive inks**, Carry electrical charge to components, software.
- **Dielectric inks**, Protect/insulate traces and components
- **Transparent conductors**, for use in displays and lighting
- **Electroluminescent** inks for lighting
- **Resistive inks** for sensors, printed resistors, potentiometers.
- **PTC inks** Positive thermal coefficient inks for heaters
- **Medical inks** used in EKG, glucose sensors, drug delivery

Needs of inks vary by application.

- **Adhesion to substrate.** PET, paper, Sputtered ITO
- **Flexibility/Elongation** what the bend radius? Does it need to crease?
- **Low or high Resistance**
- **Curing** Thermal, UV
- **Environmental performance**
- **Contact resistance**
- **Printability** Printing method

| Function of Printable Conductive Inks

- Conductive inks generate conductivity from close interparticle contact
- Products are applied wet to a surface
- Drying/curing procedures remove solvents
- Coating shrinks to a fraction of wet thickness
- Interparticle contact generates a conductive path



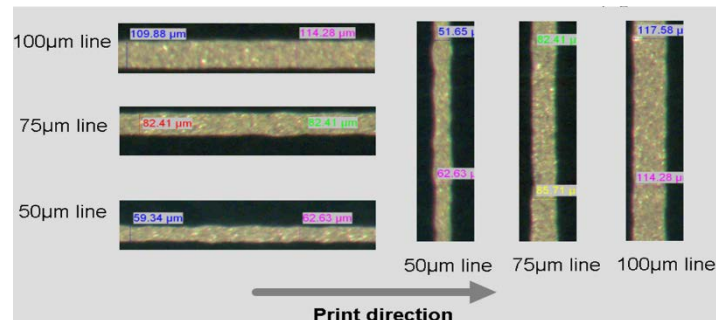
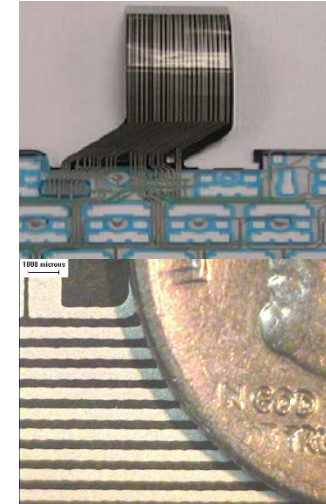
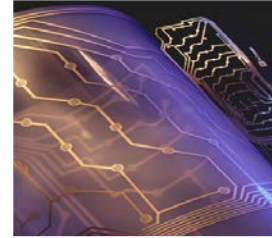
Before Processing



After Processing

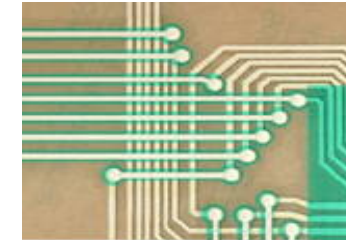
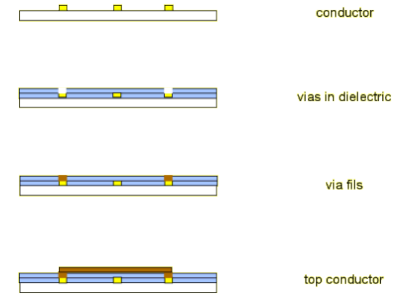
Conductive inks role

- Conductive inks are the conduit for carrying electric current to the other components
- As components get smaller the need for finer printing inks is becoming more important

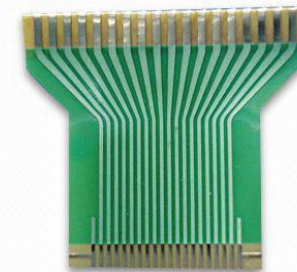


Dielectric inks

- Dielectric inks are used for protection of the printed circuit.
 - Shorting
 - Moisture barrier
 - Silver migration
 - Makes multilayered printing possible

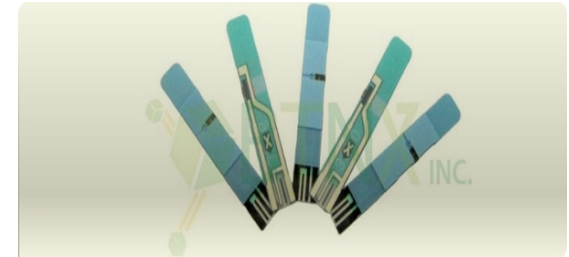


Switch cross-over or
printed via



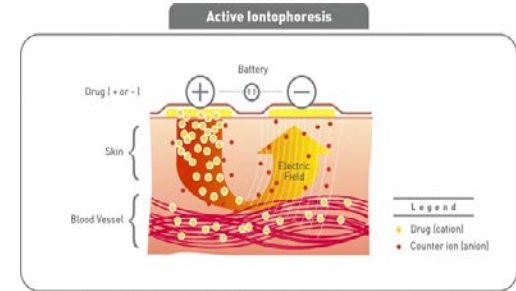
Inks Medical

- Ag/AgCl inks, are used extensively in Medical sensors
- Typical uses
 - Tens/EKG pads
 - Glucose sensors
 - Blood thinner sensors
- These sensor inks record the current or “potential” generated by the reactions of different substances
- From this the concentration of the targeted substance can be calculated



Inks Medical (Iontophoresis)

- With printed Ag/AgCl electrode, a small current is applied to activate human's skin and ionize drug molecules, enhancing the delivery of drug or nutrition.
- Increasing current can increase delivery rate

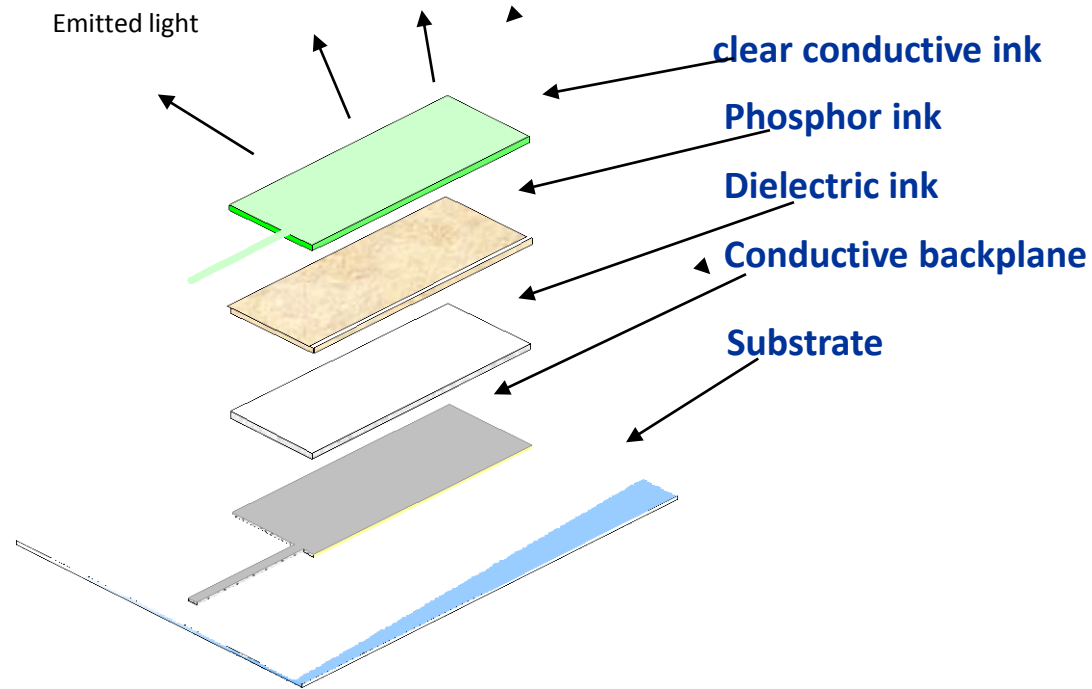


Inks EL lighting

- A “lossey” parallel plate capacitor with a light emitting phosphor between conductors.
- One of the parallel plates must be transparent or semi transparent to allow light transmission.
- An AC current is applied to the circuit creating a field effect in the Z axis.
- This field excites photons in the phosphor which produces light.
- LEC - Light Emitting Capacitor

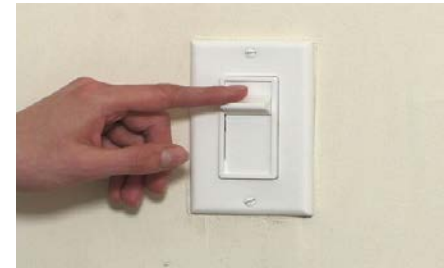
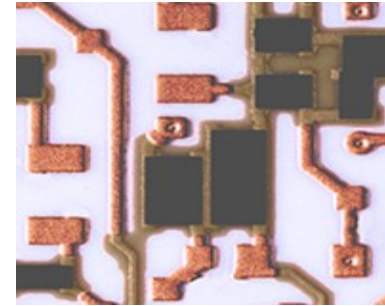


Inks EL lighting



Inks Sensors

- Heaters
- potentiometers
- printed resistors
- Potentiometers are printed with resistive inks in circular or linear shapes. A wiper moves across the trace recording resistance change.



Inks Sensors

- PTC ink (Positive temperature coefficient)
- As these inks get hotter they also get higher in resistance. This allows them to regulate the current supplied to them.
- FSR inks (Force sense resistor)
- As pressure is applied these ink become more conductive.



| Ink Displays

Transparent conductors

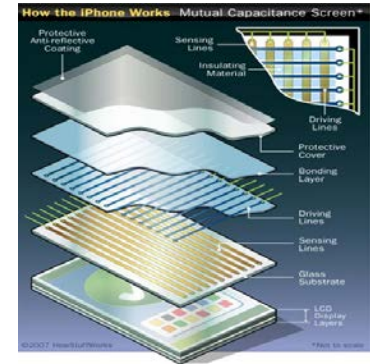
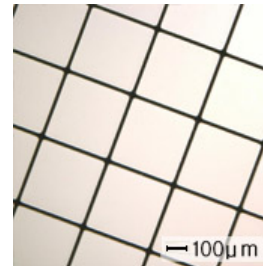
- Silver nano wire
- Conductive polymers

Translucent inks

- ATO conductive ink
 - Give a frosted look when printed
 - Can be used effectively for backlighting and EL displays

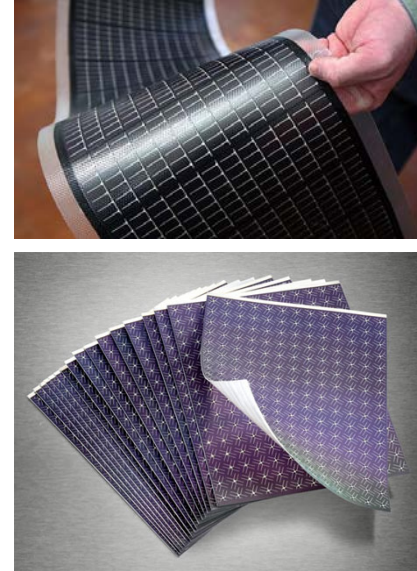
Ultra fine line printable silver.

- Can be used as the conductive grid for Capacitive touch screens



Solar inks

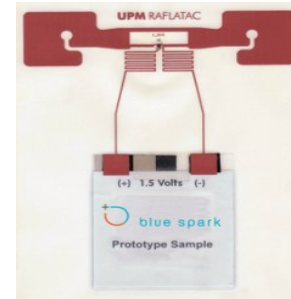
- Most current opportunities for PE in solar cells is in the flexible CIGS types of cells
- This is a multi layered process that consists of 7 or more printed layers.
- At present there is a great deal of IP surrounding these PV materials
- There are currently only a few suppliers of a totally printed photovoltaic cell.
- The PV material is typically printed over a conductive CTO layer or a metal foil.



Other inks and Markets

Energy storage (Printed batteries)

- Cathode, Anode Lithium/ion inks



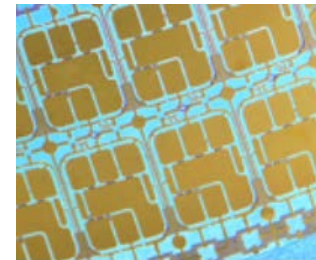
Displays

- Electro and Thermal Chromic inks



Semiconductor

- inks for printed IC

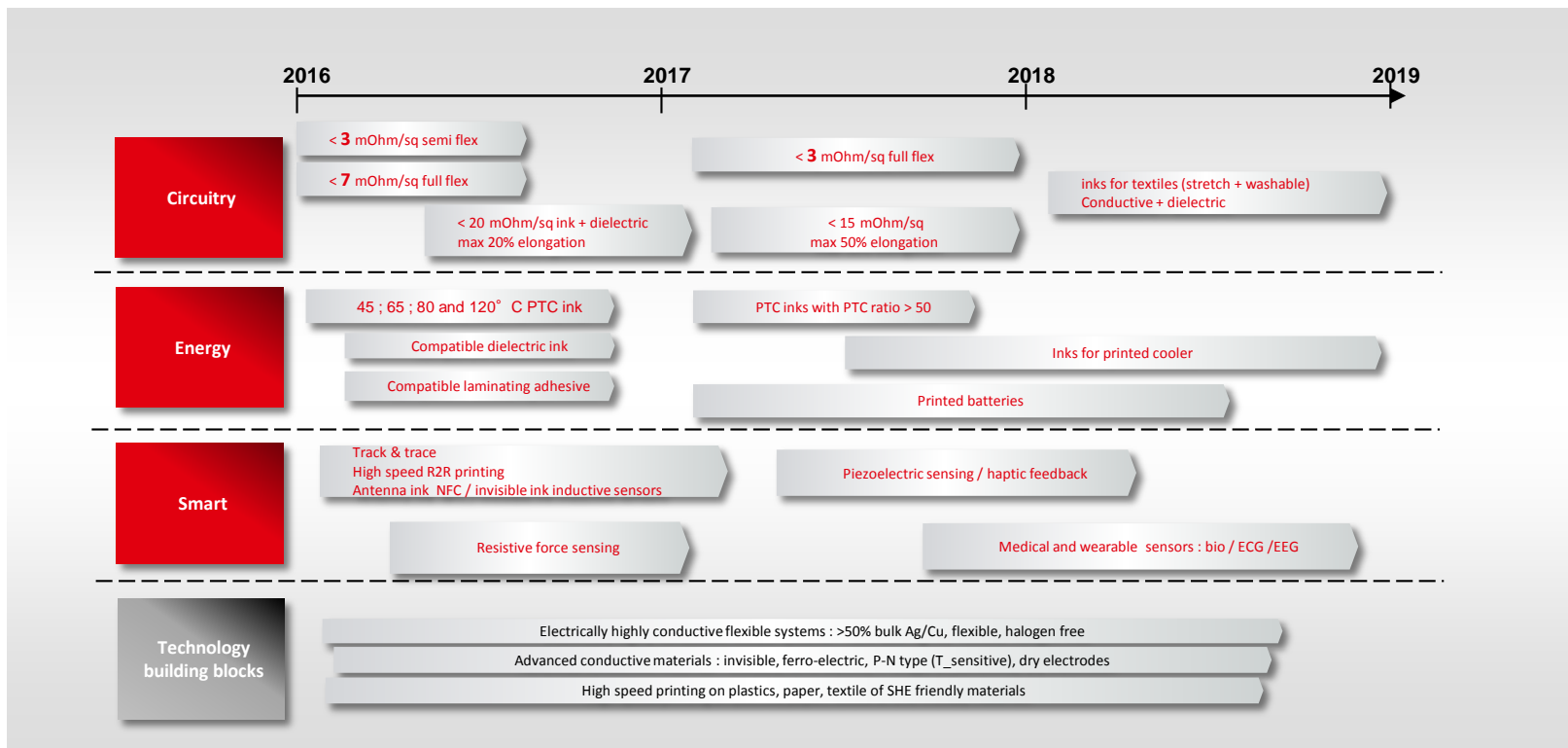


Future opportunities

Printed electronics is in many ways still in its infancy. As more new and novel materials are produced in areas such as Solar, energy storage, and interactive displays PE will be a means of bringing ideas from the drawing board to consumer hands in a low cost high volume way through current and evolving printing processes.



Henkel Roadmap for Printed Electronics



Q&A