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Performance Vs Price in Conductive Inks



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Outline of Talk

- Resistivity
- Flexibility testing
- Costing of Silvers
- Conductive Fillers
- Conclusions



What is Conductivity & Resistivity?

- Not to be confused with electrical conductance, a measure of an object's or circuit's ability to conduct an electric current between two points, which is dependent on the electrical conductivity and the geometric dimensions of the conducting object.
- **Electrical conductivity** or **specific conductivity** is a measure of a material's ability to conduct an electric current. When an electrical potential difference is placed across a conductor, its movable charges flow, giving rise to an electric current. The conductivity σ is defined as the ratio of the current density to the electric field strength :
- It is also possible to have materials in which the conductivity is anisotropic, in which case σ is a 3×3 matrix (or more technically a rank-2 tensor) which is generally symmetric.
- Conductivity is the reciprocal (Inverse) of electrical resistivity and has the SI units of Siemens per metre ($S \cdot m^{-1}$) i.e. if the electrical conductance between opposite faces of a 1-metre cube of material is 1 Siemens then the material's electrical conductivity is 1 Siemens per metre. Electrical conductivity is commonly represented by the Greek letter σ , but k or γ are also occasionally used.
- Units for resistivity are ohm M



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Flexibility

- There are many tests for testing the flexibility of conductive films. I have picked a simple membrane touch switch type of test to illustrate the principle of bending the test structure and measuring any changes seen in the track resistance



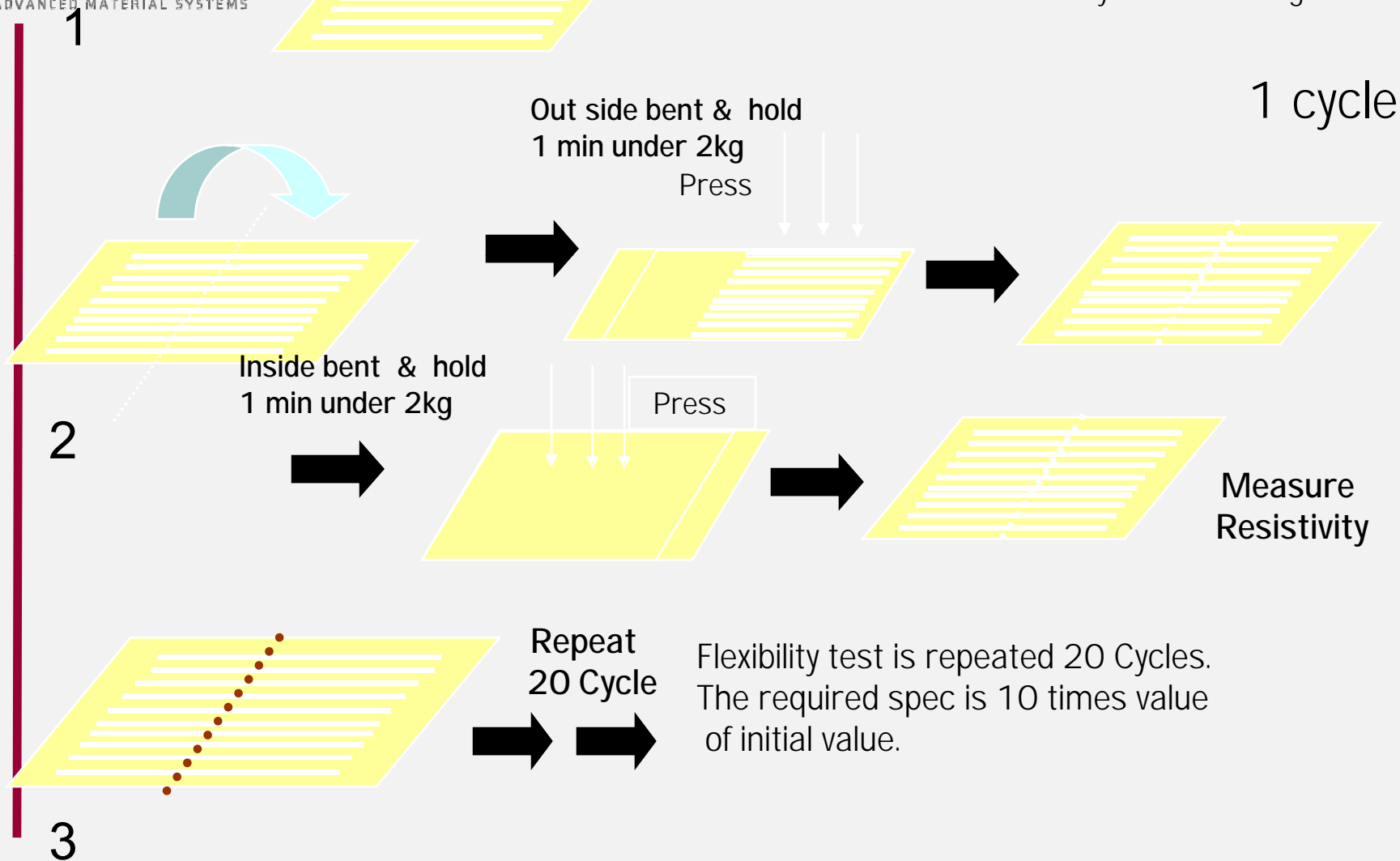
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Flexibility Bend Test procedure

PET Substrate, 75-100 um thick

Ag pattern

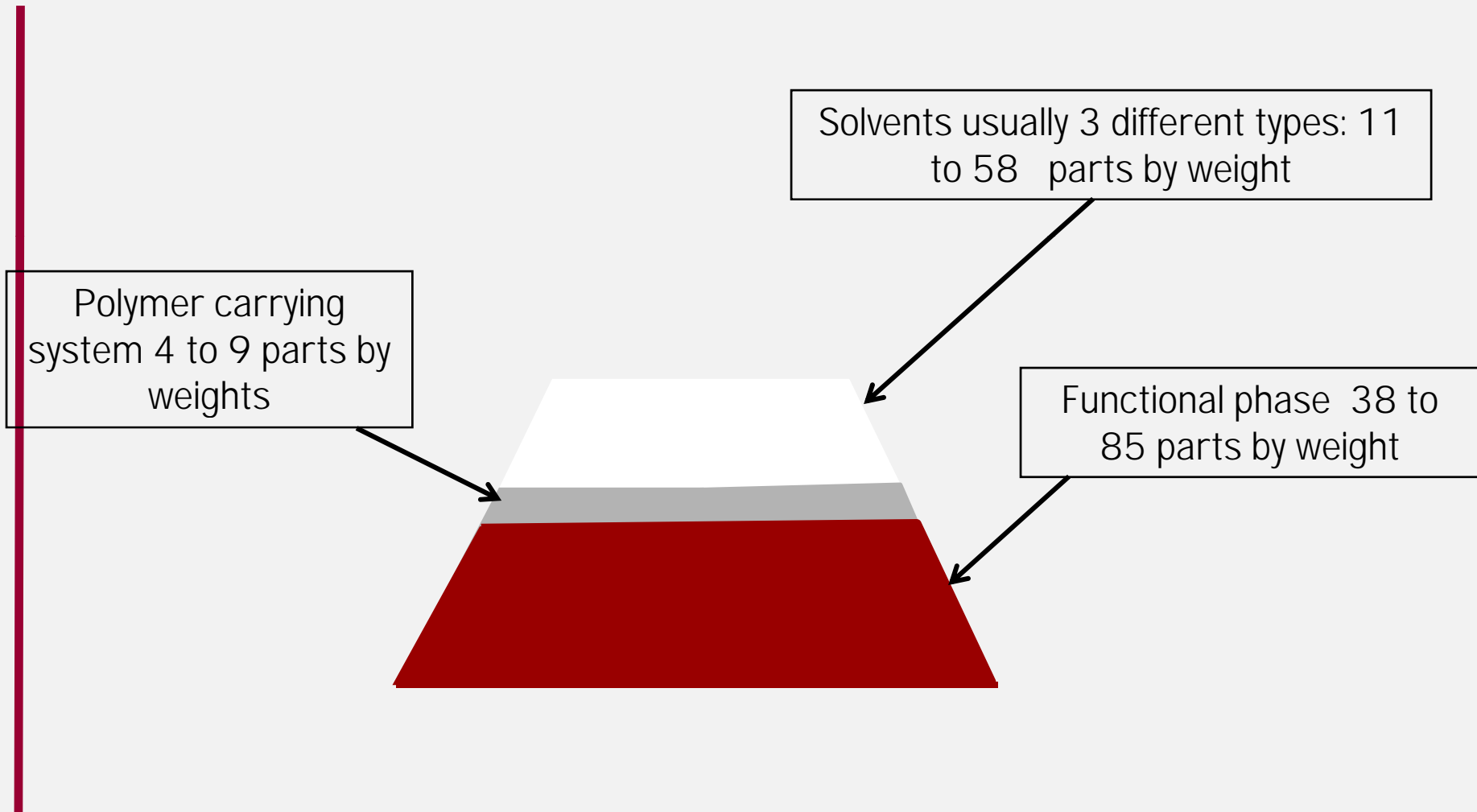
Measure Sheet Resistivity before bending test





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Major constituents of an ink



Solvents usually 3 different types: 11 to 58 parts by weight

Polymer carrying system 4 to 9 parts by weights

Functional phase 38 to 85 parts by weight



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Raw Materials Costs

- Silver metals costs £232/Kg
- Polymer costs £12/Kg
- Solvent costs £0.5/Kg



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Simplified raw material cost

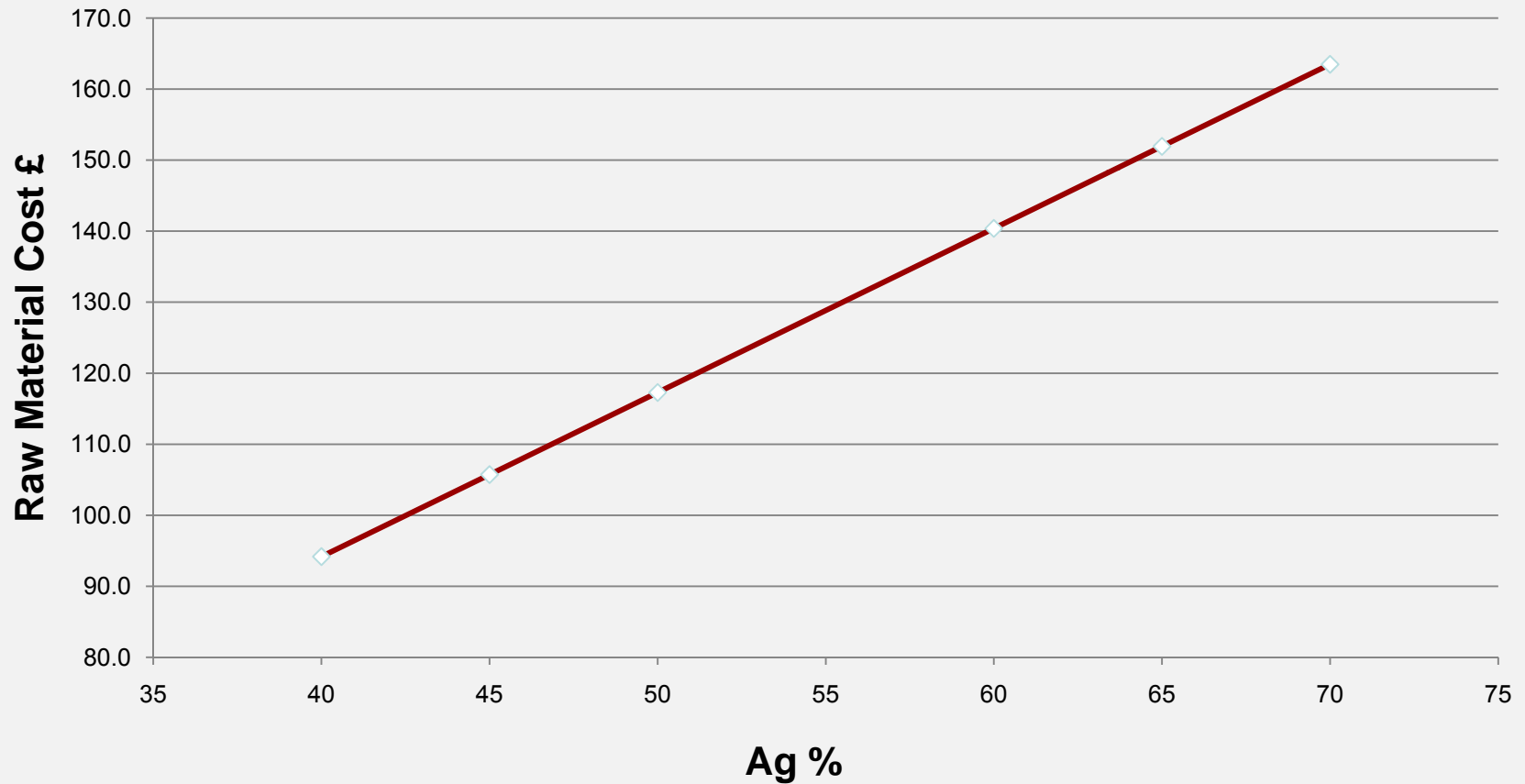
| Material | % | £ | % | £ |
|----------|-----|-------|-------|--------|
| Metal | 45 | 93.12 | 65.00 | 151.32 |
| Polymer | 6 | 0.79 | 3.85 | 0.46 |
| Solvent | 49 | 0.27 | 31.15 | 0.16 |
| Total | 100 | 94.2 | 100 | 151.9 |



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Simplified raw material cost

RM costs of flexible silver inks





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Resistivity of flexible inks

- 45% silver ink

Resistivity in the range 30-45 milliohms/square at 10 microns.

- 65% silver ink

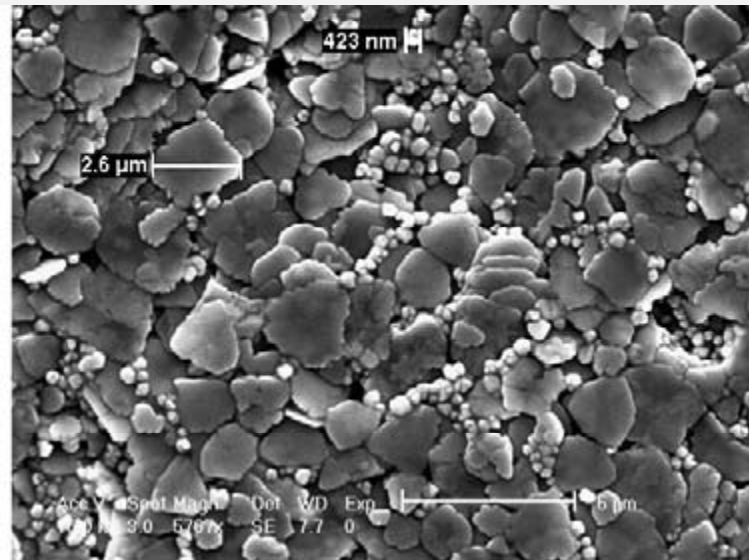
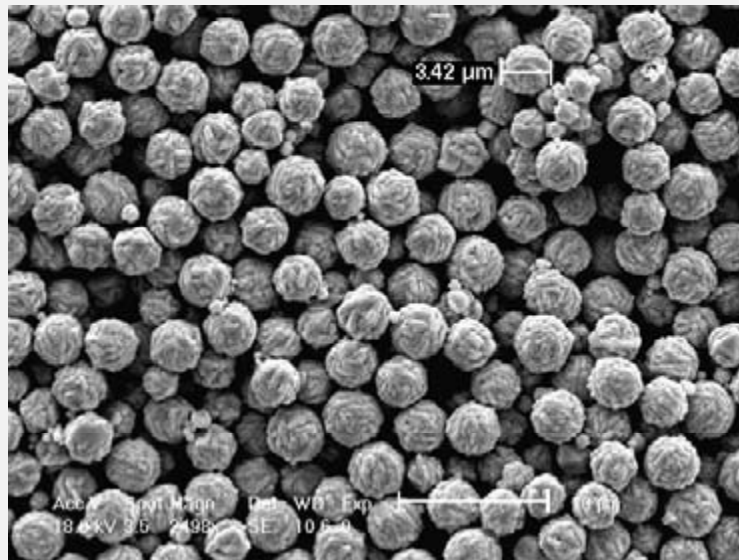
Resistivity in the range 30 milliohms/square at 10 microns.



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Size and shape of conductive Fillers

- For the lowest resistivity flake material are used rather than spherical particles





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Size and shape of conductive Fillers

- For the lowest resistivity at lower metal percentages larger flakes are used.
- Smaller flakes are more resistant to changes in resistance when flexed.



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Size and shape of conductive Fillers



Small flakes
coherent silver
film



Large flakes
broken silver
film



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Common Myths

- High Silver percentages are needed for conductive Flexible films.
- 180 or 360⁰ bend tests are needed for all flexible films
- European manufactures always lose orders due to cheaper labour rates



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Conclusions

- Make sure you set specifications that are fit for purpose
- At this time my company are selling 10 X more lower % Silvers in the Far East
- We only sell higher % Silvers in Europe ?
- Europeans are buying product using low % Silvers as finished goods



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