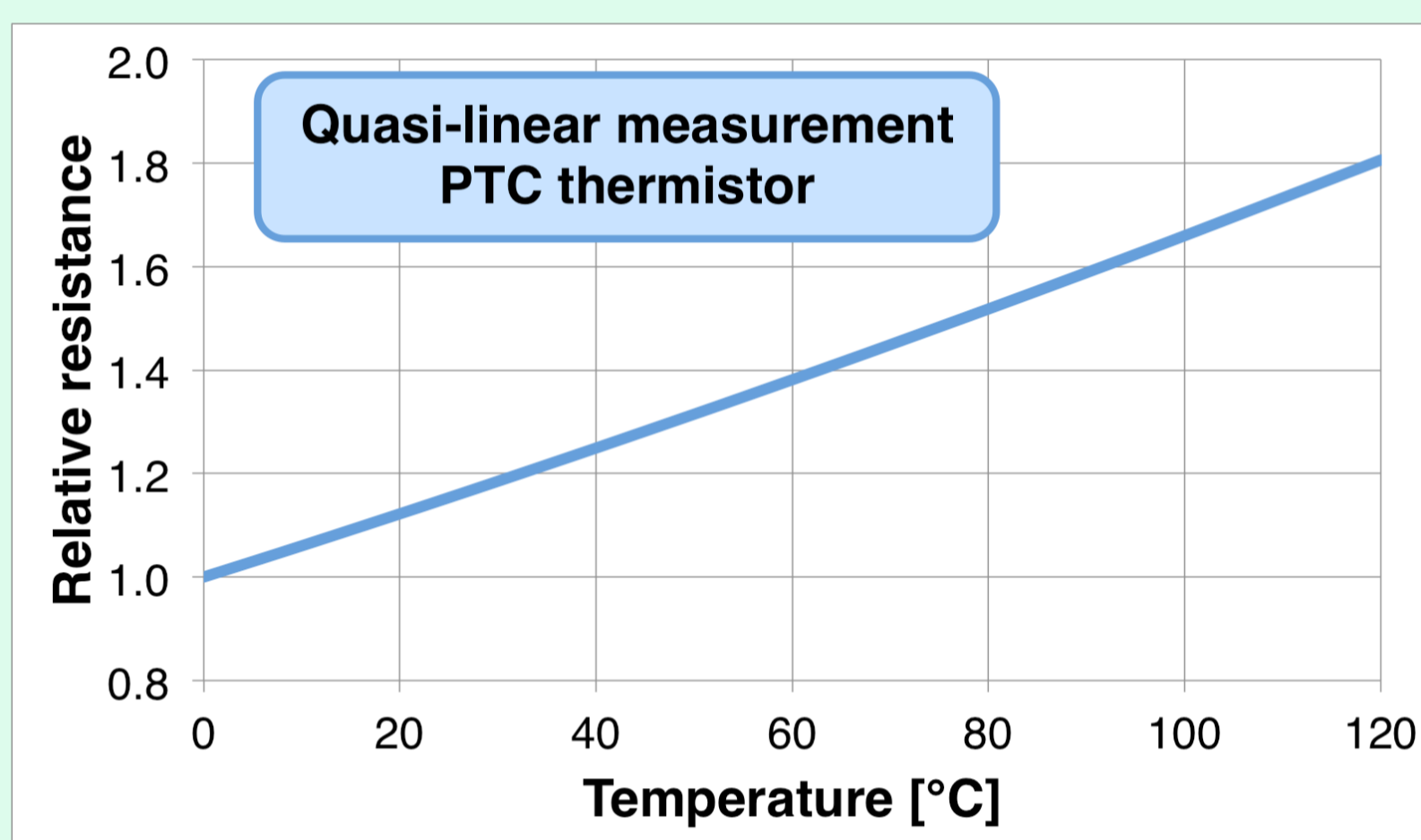
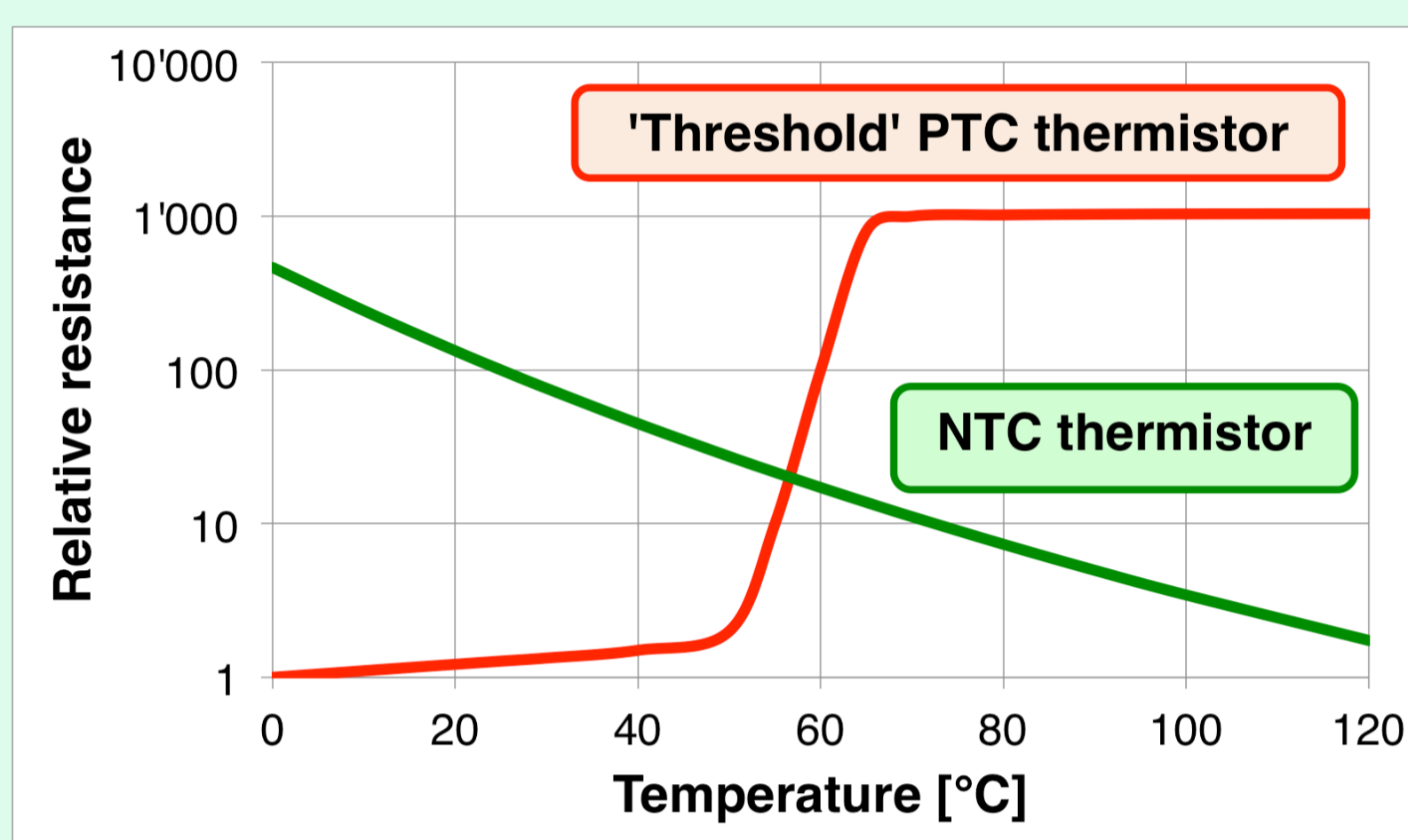


Tuneable PTC effect in polymer-wax-carbon composite resistors

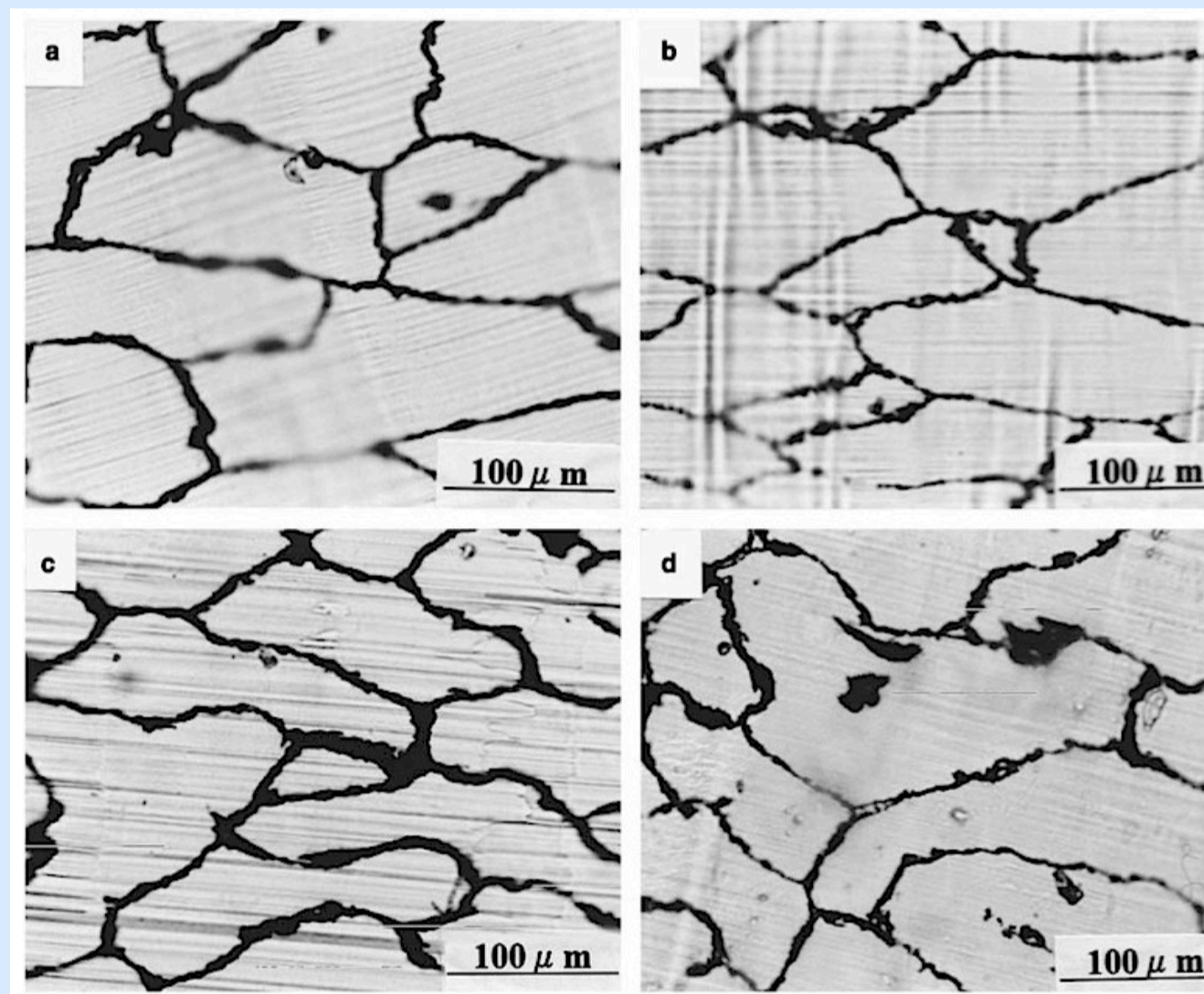
Thomas Maeder, Caroline Jacq, Ludivine Ammon and Peter Ryser

École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland

Thermistor types



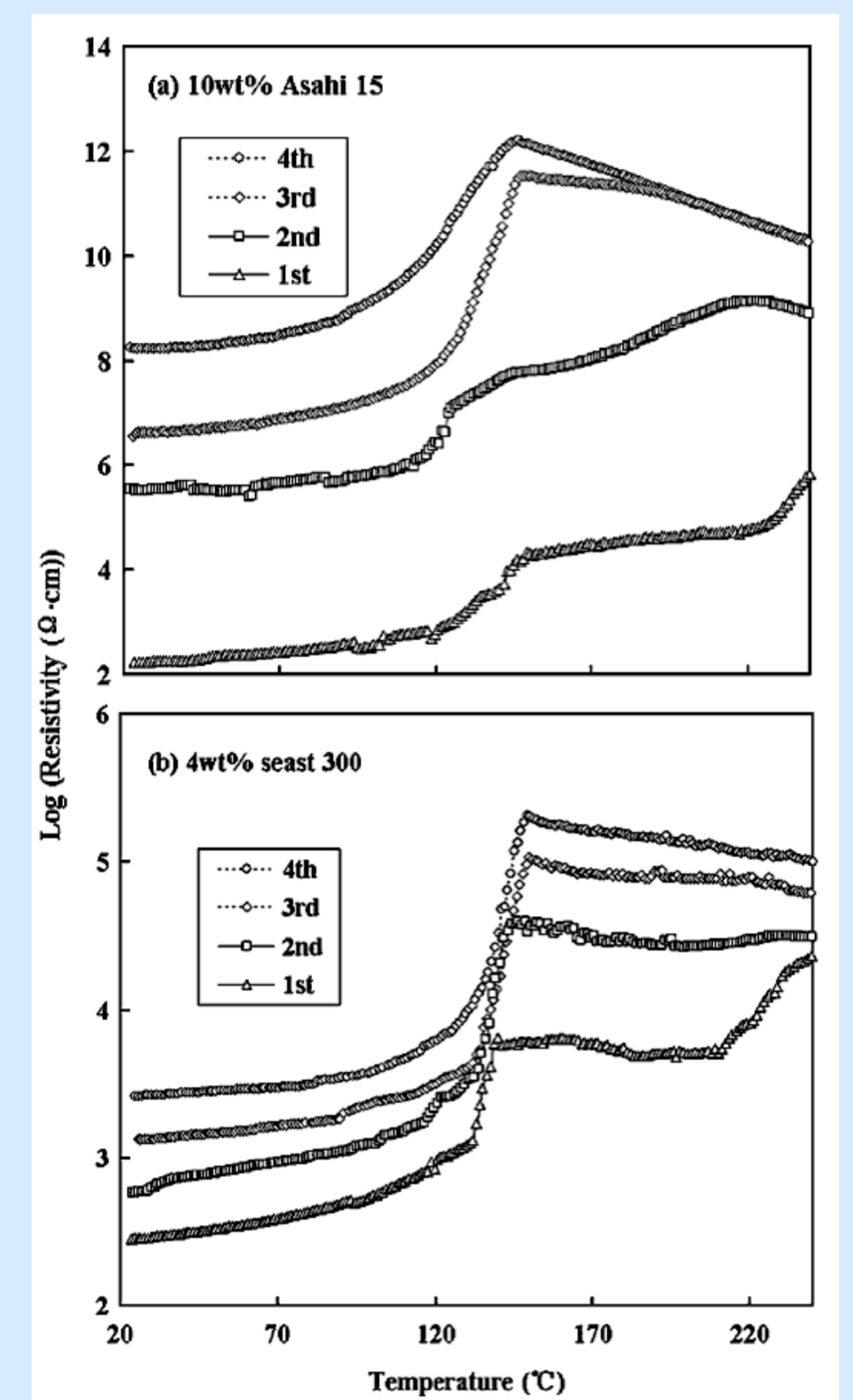
Common PTC type: PE - carbon



Zhang-C Ma-CA Wang-P Sumita-M, "Temperature dependence of electrical resistivity for carbon black filled ultra-high molecular weight polyethylene composites prepared by hot compaction", Carbon 43 (12), 2544-2553, 2005

PTC effect linked to:

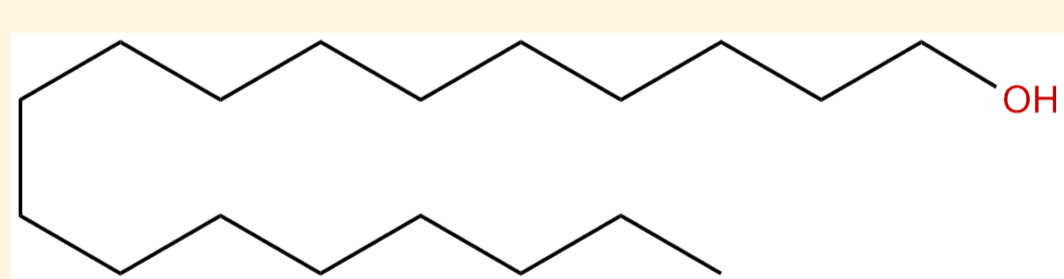
- Matrix continuous thermal expansion
- Matrix melting: expansion
- Matrix melting: filler rearrangement



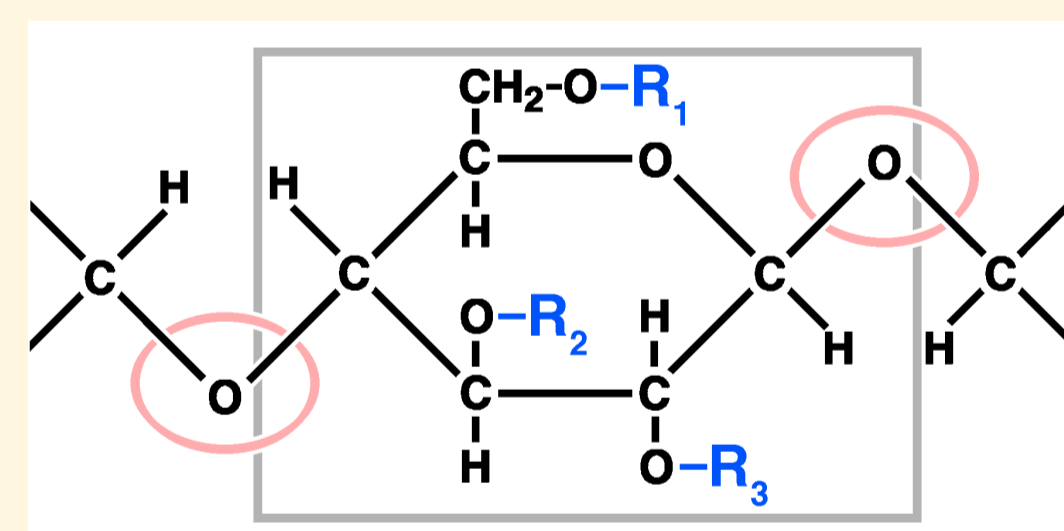
Goal: develop tuneable polymer-wax-filler system – 'hot-melt' type formulation

- One single polymer matrix – compatible with both bulk & screen printing for thick-film devices
- Transition temperature independently tuneable by wax melting point
- Carbon filler – here graphite (4 μm – TIMCAL KS4)

Binder & waxes



1-Octadecanol (wax)

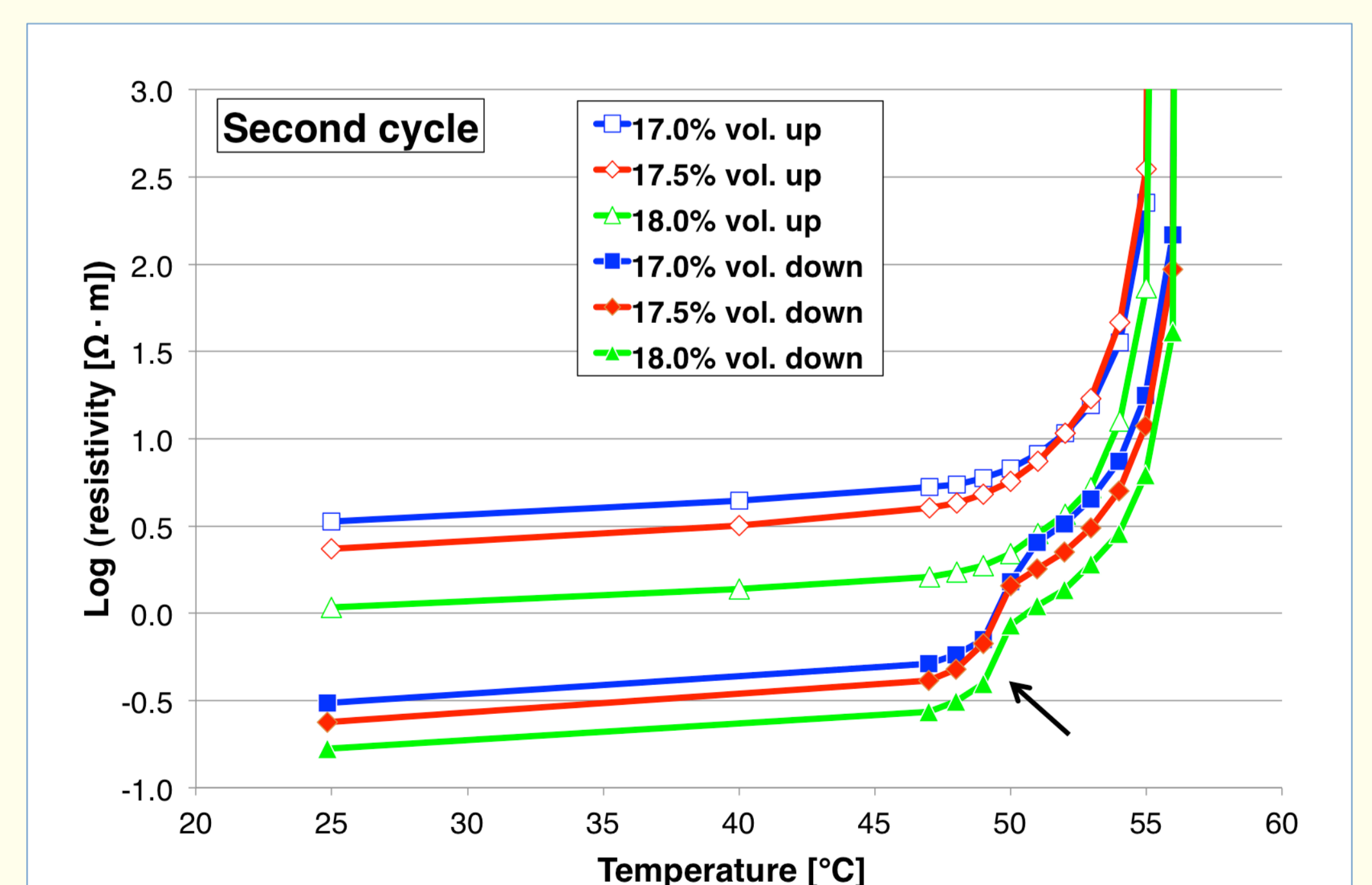
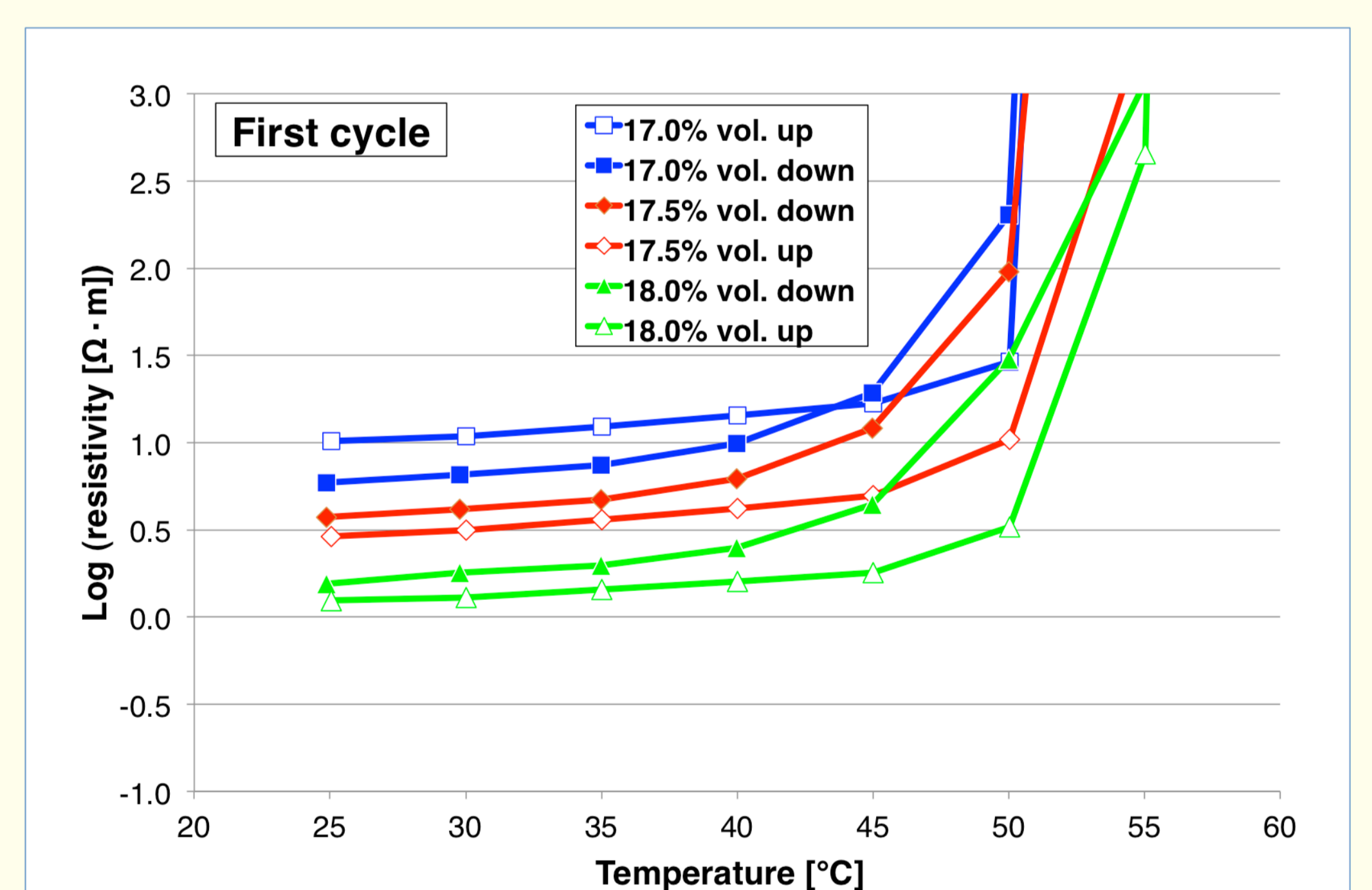


Ethylcellulose (binder polymer)

| Code | Description | Melting point | Solubility for EC above M.P. | Crystallisation from EC at low temperature |
|--------------|---|---------------|------------------------------|--|
| So-16 | Sorbitan monostearate / hexadecanoate | 48°C | Yes | Yes (soft) |
| C18E2 | Brij-S2 ; diethylene glycol octadecyl / stearyl ether | 44°C | Yes | Yes (soft) |
| C14E0 | Myristyl alcohol / tetradecanol | 38°C | Yes | Yes (soft) |
| C16E0 | Cetanol / hexadecanol | 49°C | Yes | Yes |
| C18E0 | Stearyl alcohol / octadecanol | 59°C | Yes | Yes (hard) |
| TBz | Tribenzoin / Glyceril tribenzoate | 75°C | Yes (viscous) | No / slow (?) |

Some possible waxes

Results



Conclusions & outlook

- PTC effect observed
- Transition \approx wax M.P.
- Delayed effects
- Further studies needed with more systems