Tampere University

*Final Webinar of the GRIDABLE Project*
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# DIELECTRIC CHARACTERIZATION OF CAPACITOR INSULATION

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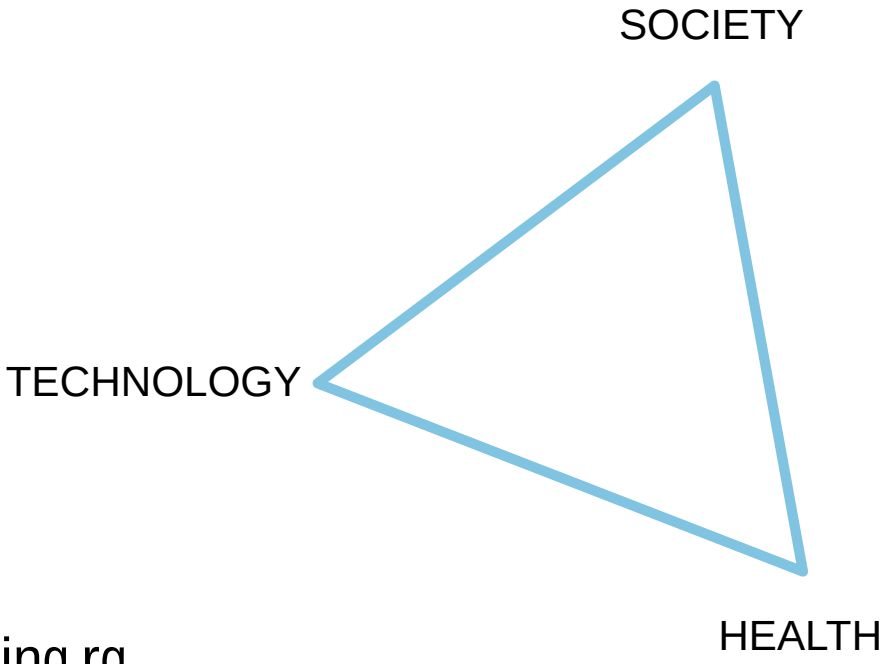
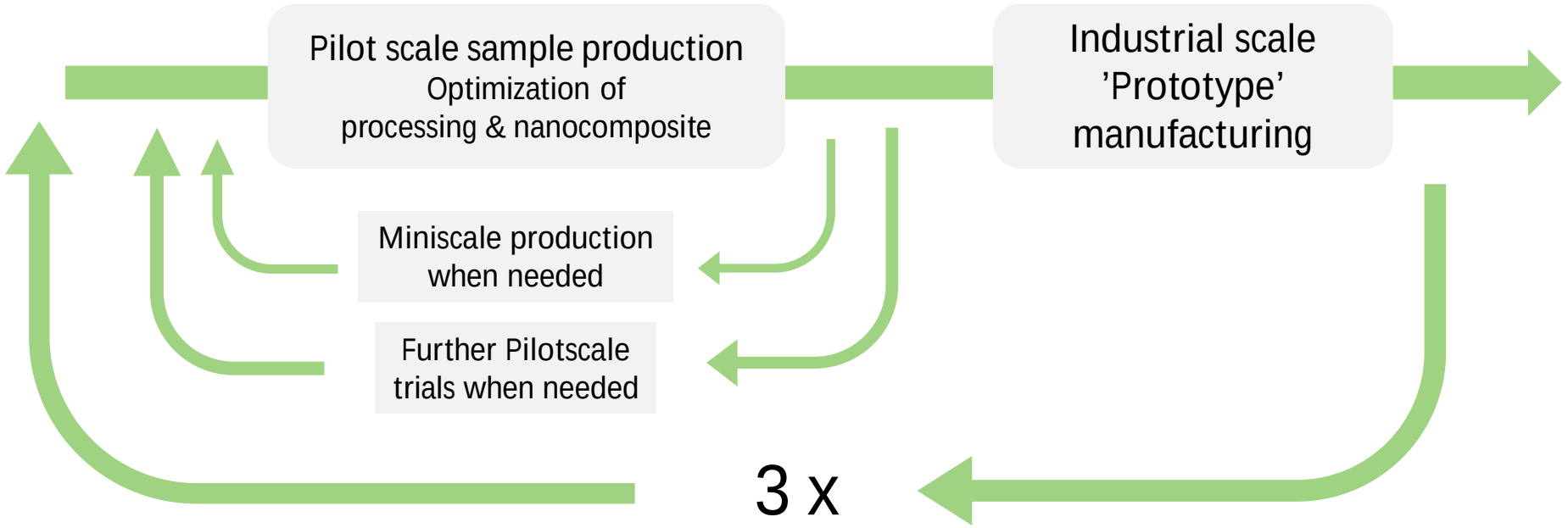
- Second largest university in Finland
  - ~21’000 students, ~300 professors
  - Budget ~320 M€




- <u>Main role in the GRIDABLE project</u>
  - Involved partner: High Voltage engineering rg
  - Dielectric characterization of capacitor thin film insulations
    - Short-term performance
    - Long-term performance, reliability
  - Leader of WP 4 ”Quality and validation”

# GRIDABLE approach for capacitor nanocomposite development (PP-$SiO_2$ BOPP film)




Dielectric characterization & material analysis after each step

# Dielectric characterization of PP-$SiO_2$ BOPP films

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- Extensive & optimized characterization
  - Development of characterization methods
- Short-term characterizations
  - 'Large area breakdown strength' distribution
  - Dielectric spectroscopy, ε & loss
  - Conductivity
  - Charging & trapping properties (space charge)
    - Polarization current
    - Thermally Stimulated Depolarization & Polarization currents
- Long-term characterizations
  - Electro-thermal ageing methods
  - Life testing & modelling

Optimal characterization over BOPP film development phases


+ extensive charaterizations at Terichem Tervakoski and Electronicon for industrial Prototypes

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# Dielectric characterization of PP-$SiO_2$ BOPP films

- Extensive & optimized characterization
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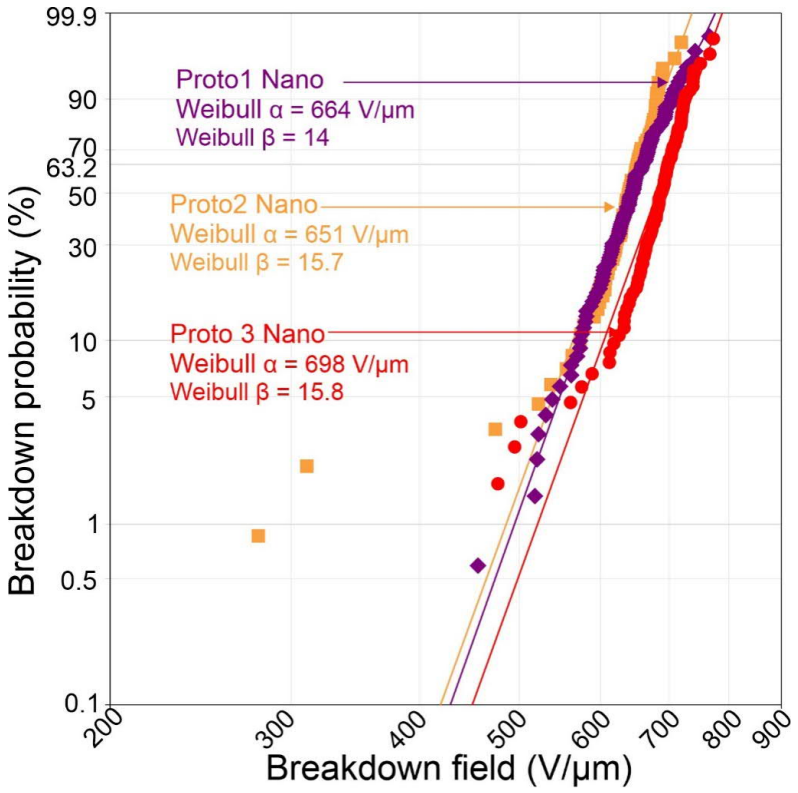
  - Life testing

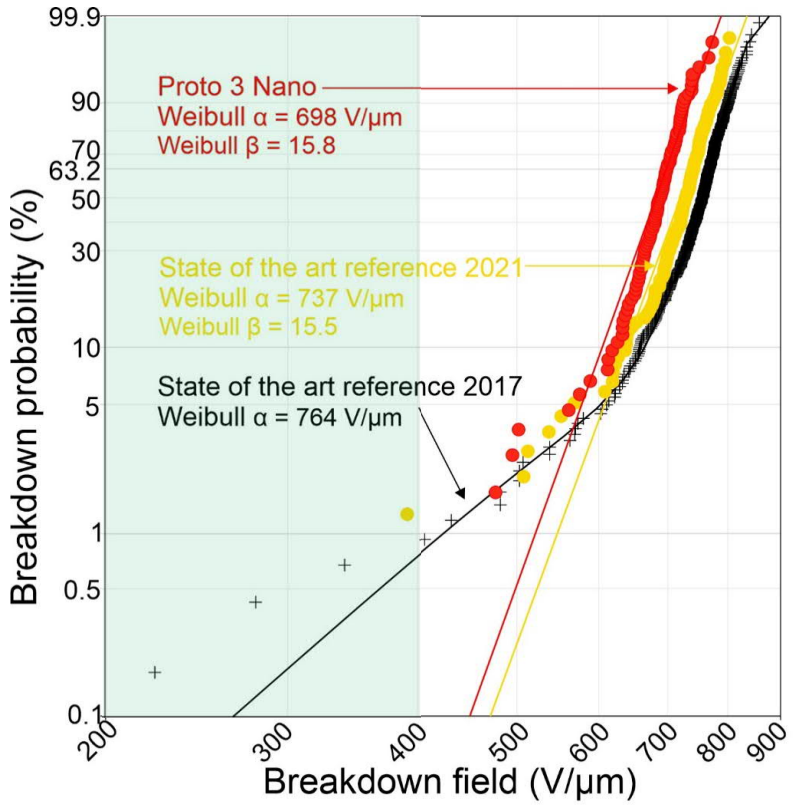
Cable insulation vs. capacitor insulation
- Bulk vs. oriented thin film (~5 – 15 µm)
- ~20 kV/mm vs. 200-250 kV/mm

→ truly critical application for a nanocomposite

+ extensive charaterizations at Terichem Tervakoski and Electronicon for industrial Prototypes

# PP-$SiO_2$ Prototypes, -breakdown strength (RT)

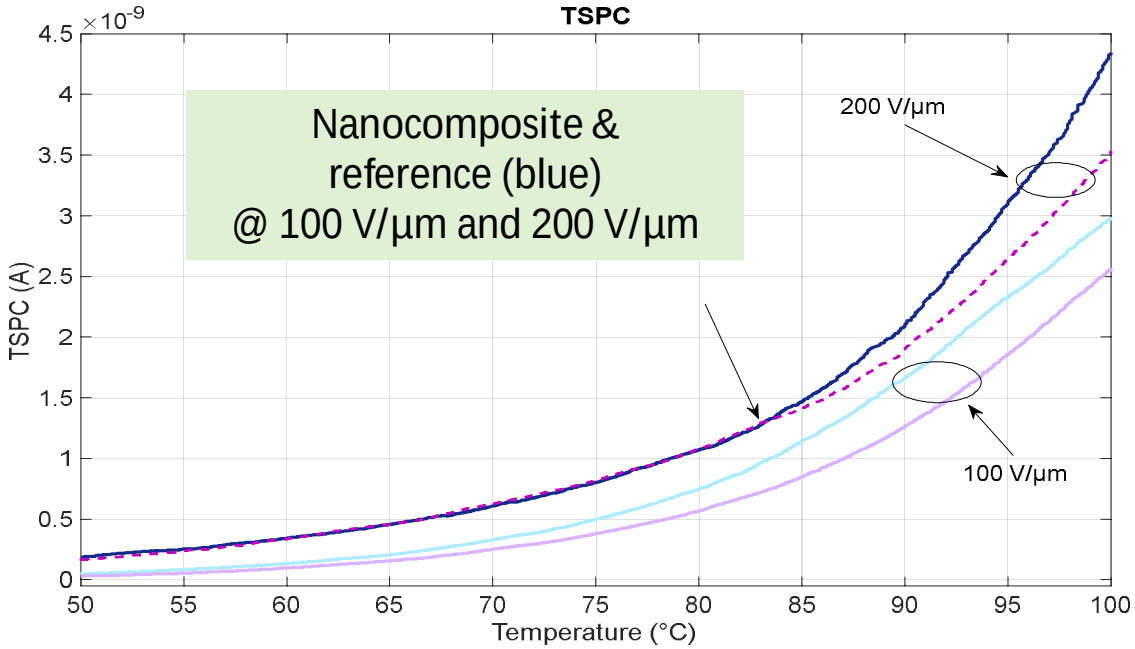


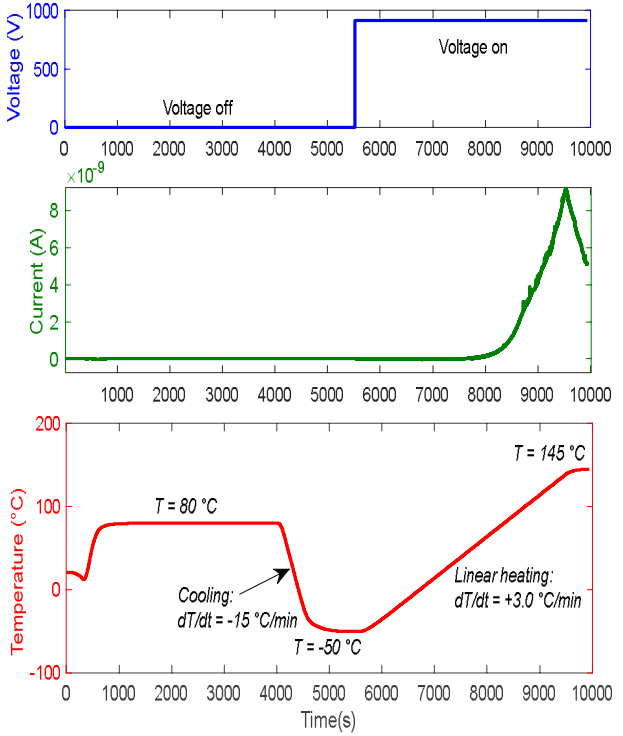




- Improved performance over the project
- Fulfils 'Specific Objective 6' of the project, -no breakdowns < 400 V/µm

# PP-$SiO_2$ Prototype 3, - Charging & conduction

## Thermally Stimulated Polarization current



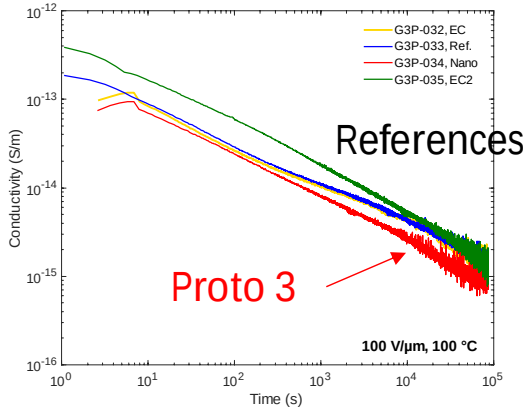



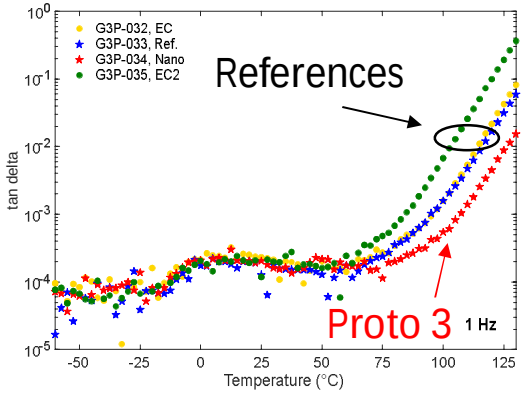

- Improved performance with nanostructuration

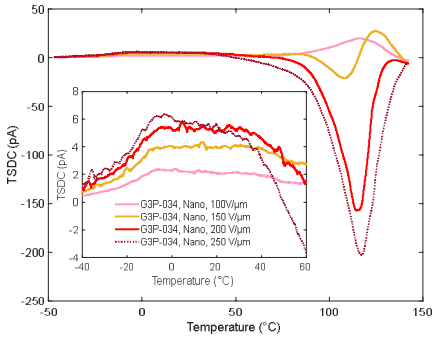
# PP-$SiO_2$ Prototype 3
# - conduction, dielectric loss, trap structure

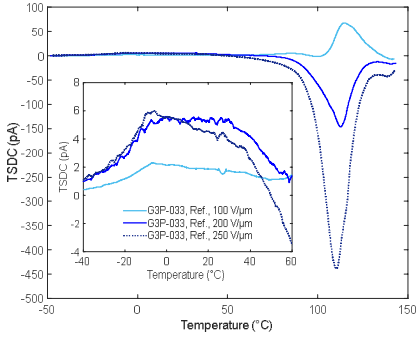
Nanocomposite, compared to reference

- Lower conduction
- Lower dielectric losses at high temperatures
- Improved space charge performance
  - Lower charge injection
  - More even charge distribution



# Summary & main findings

- Excellent dielectric characterization methods developed for thin films
- BOPP film, -extreme application for a nanocomposite
- Dielectric performance of the developed PP-$SiO_2$ nanofilm
  - Improvements in 'bulk' type performance evidenced (conductivity, high temperature dielectric loss, space charge)
  - 'Weak point' / 'extreme stress' performance due to agglomeration problem
    - Limited breakdown strength
      - @ high field stresses
      - @ high temperatures
    - Limited long-term performance at high stress tests (threshold level ~200 V/µm @+60 °C)

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# Thank you for your attention!

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