

Thermoelectric PEDOT:PSS and Single-walled Carbon Nanotubes composites for Printing Applications

J. Leisten, L. Stepien, A. Roch, I. Dani, C. Leyens

E-MRS 2016 Spring Meeting

04.05.2016
Symposium W
Thermoelectrics 2

Content

1. Gliederung

- Punkt 1
- Punkt 2
- Punkt 3
- ...

Motivation

Using waste heat as abundant energy sources

Industry 4.0

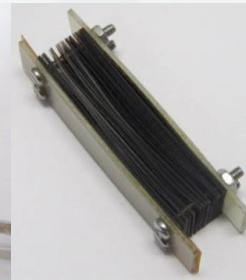
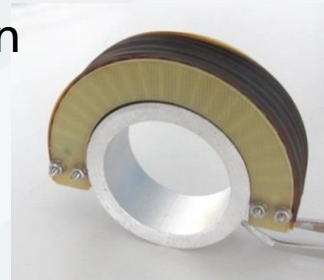
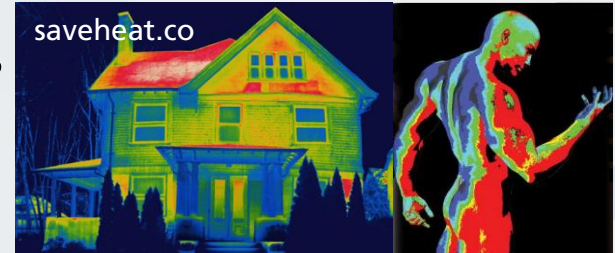
Big Data

Manifold applications

→ sensing
structure health monitoring
wearables

Our approach

→ cost efficient mass fabrication
use of printing technology
flexible materials

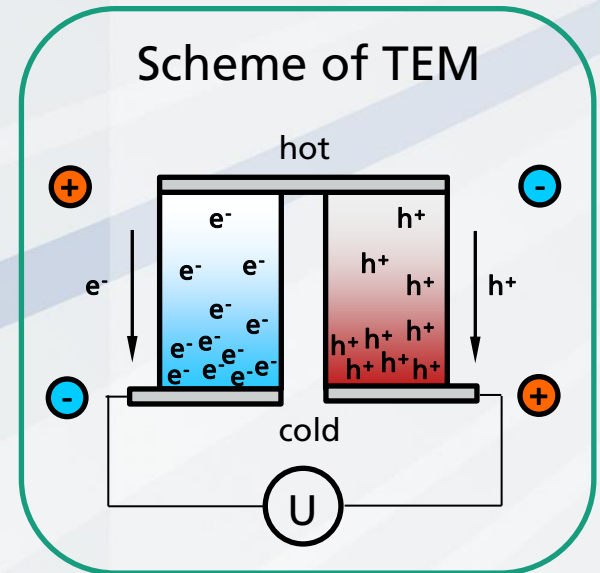
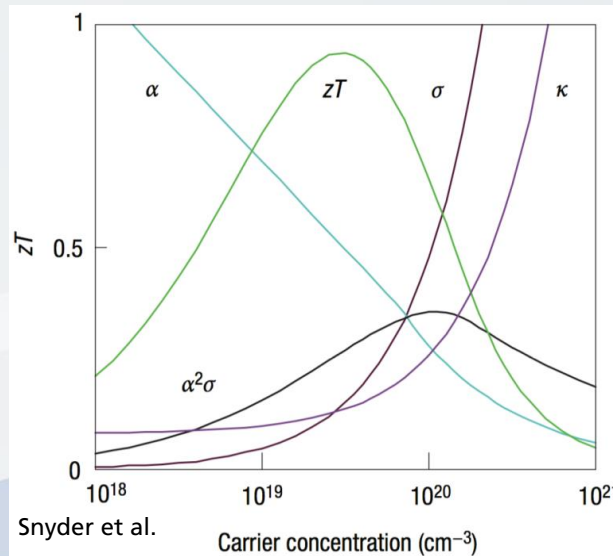


Motivation

Thermoelectric  Transformation of thermal energy in electrical energy

$$zT = \frac{\sigma \alpha^2}{\kappa} T$$

$$PF = \sigma \alpha^2$$



Success of thermoelectric is driven by two major key aspects



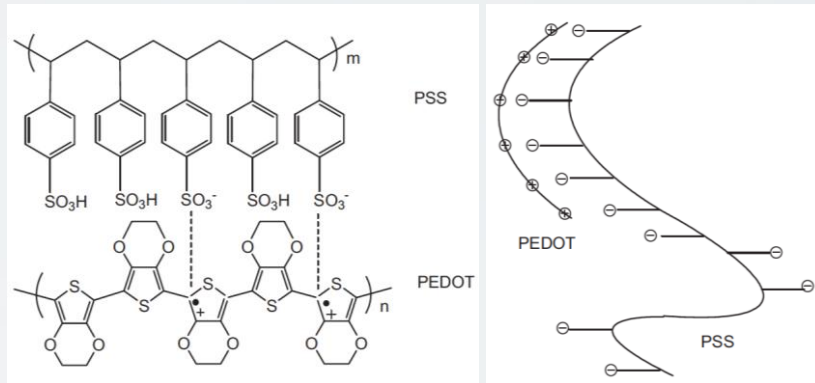
MATERIAL



Fabrication

Material

PEDOT:PSS (Clevios PH1000)



PEDOT:PSS

printable

high electrical conductivity

flexible, in solution

SWCNTs

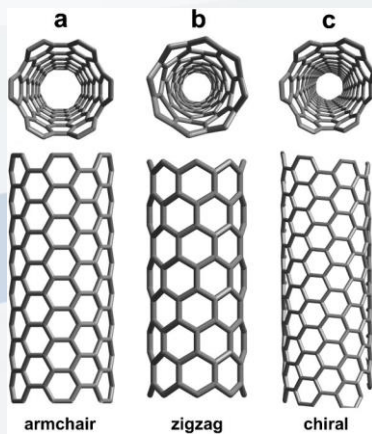
due to quantum structure high zT-value possible

high Seebeck-coefficient

flexible handling in dispersion

→ combining of thermoelectrical properties in composites

SWCNT



Rheological aspects due to printing



Shear thinning



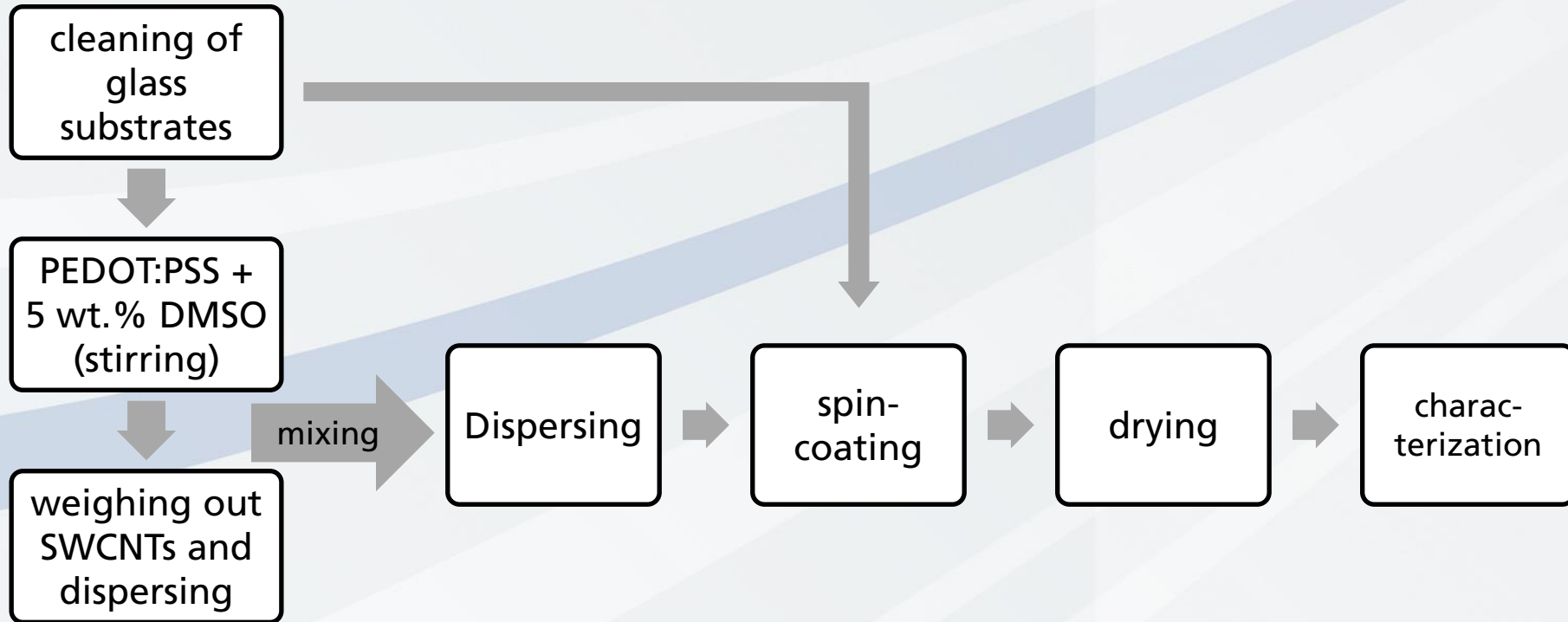
Short thixotropy time

Experimental

Preparation of CNT Dispersion

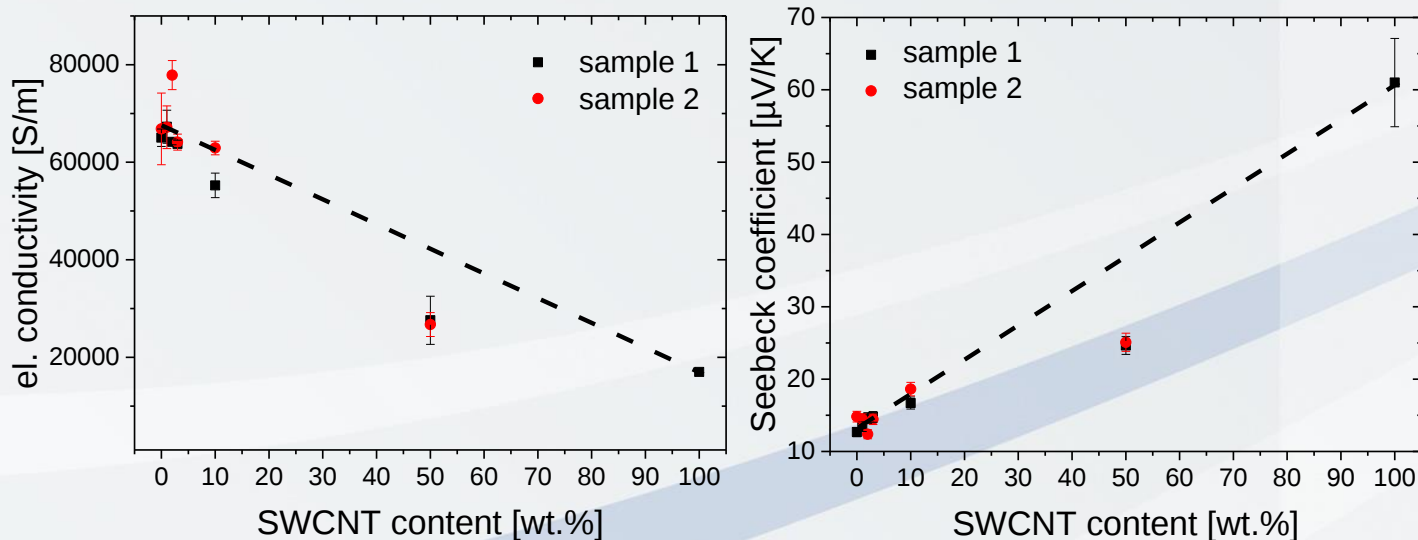
SWCNT TUBALL → 5 mM SDBS → Ultrasonic horn

Preparation of composite



Results

Influence of SWCNT content in PEDOT:PSS



- ➔ No percolation threshold detectable
- ➔ No synergetic effects can be observed
- Negative deviation from linear rule of mixture

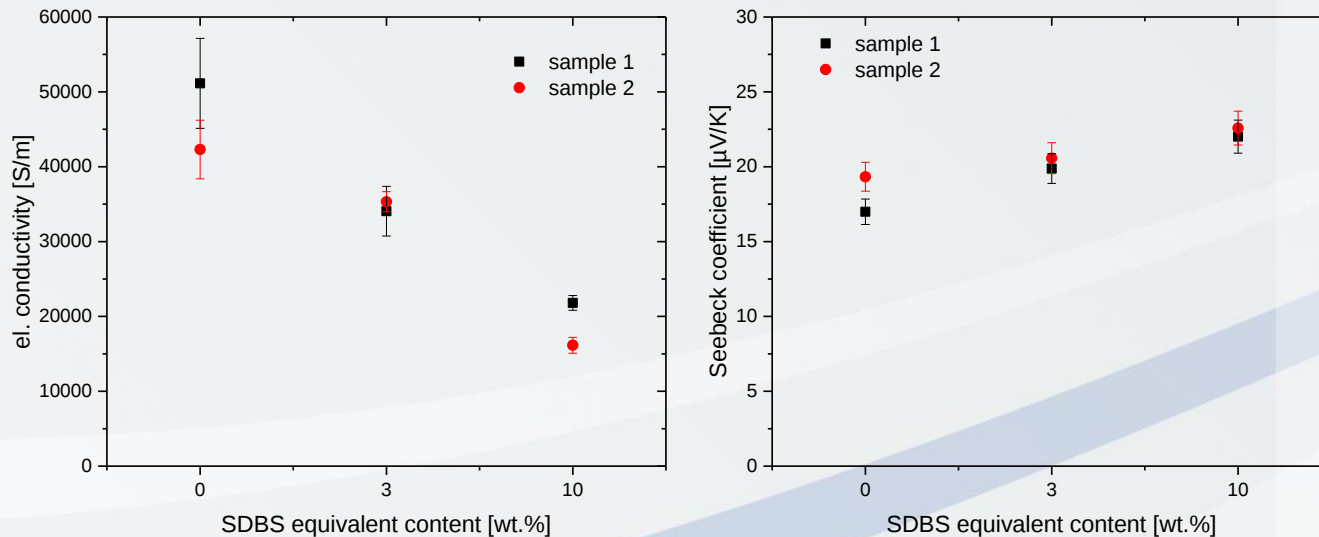
Rule of Mixture

$$P_{AB} = P_A \cdot x_A + P_B \cdot x_B$$

Reasons for bad interaction?

Results

Influence of dispersing agent content in PEDOT:PSS



Equivalent content related to CNT wt.% content with 5 mM dispersing agent

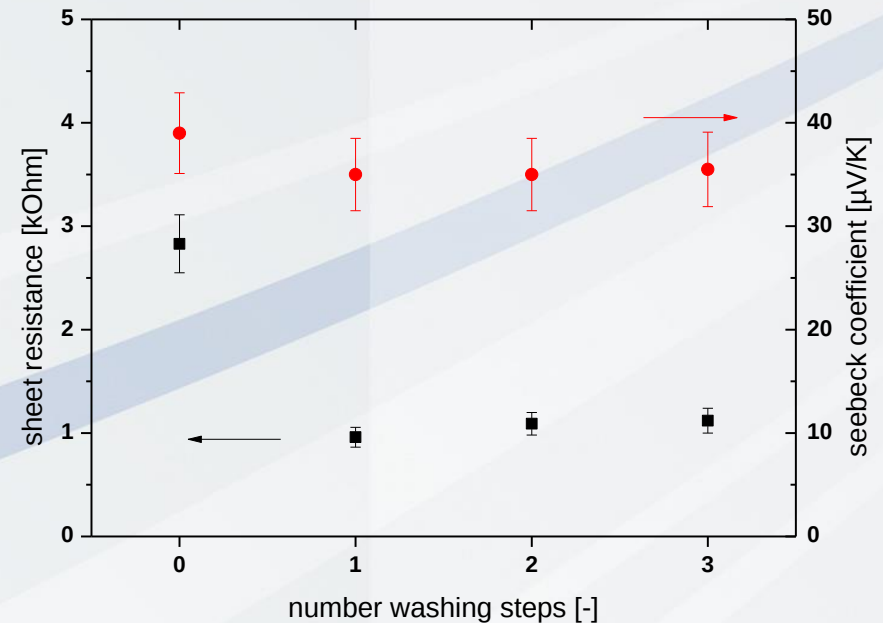
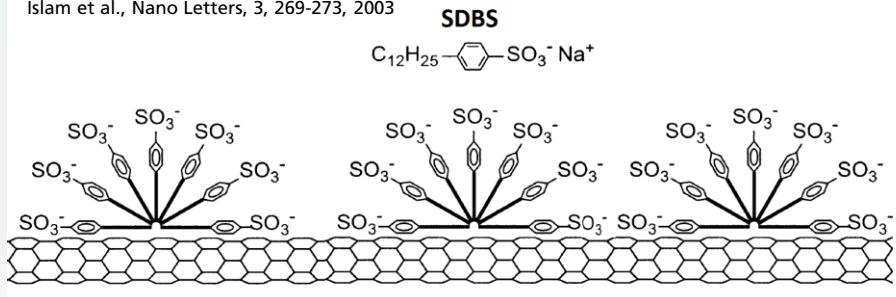
- ➔ Dispersing agent greatly influences the el. conductivity in PEDOT:PSS
 - ➔ Formation of micelles, reducing mobility inside the film
- ➔ Seebeck coefficient is not substantially influenced by SDBS

How can we overcome unfavorable dispersant/PEDOT:PSS interaction?

Results

Influence of dispersing agent on SWCNT films

Islam et al., Nano Letters, 3, 269-273, 2003

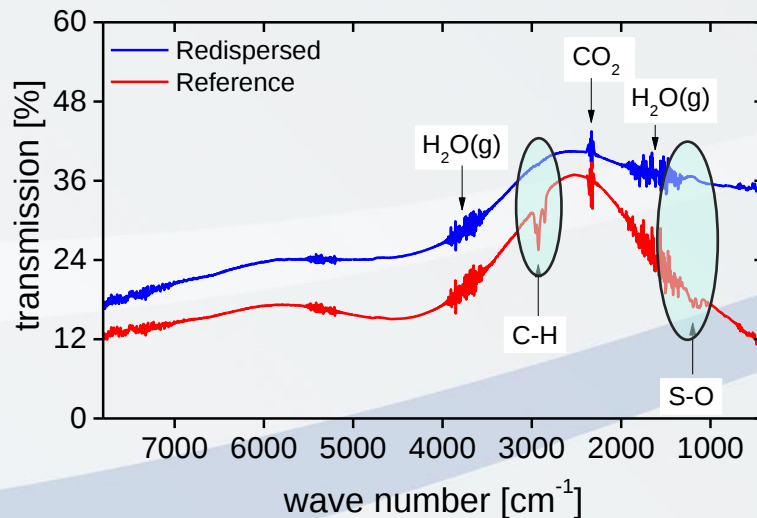


- ➡ Excess amount of dispersant is present in SWCNT dispersion
- ➡ Washing in ethanol bath can regain el. conductivity

Results

Washing and redispersion of SWCNT

Remove excess dispersant and mix with PEDOT:PSS



➡ Poor redispersability --- nearly all dispersing agent was removed

Conclusion



Excess amount of dispersant is present in SWCNT dispersion

Thank you for your kind attention!

Lukas Stepien
Fraunhofer IWS
Winterbergstraße 28
01277 Dresden, Germany

Phone +49 351 83391-3092
Fax +49 351 83391-3300
E-Mail lukas.stepien@iws.fraunhofer.de

www.iws.fraunhofer.de



This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 604647.

Collaborations welcome!