CNT-based nanocomposites with high conductivity and thermoelectric effect

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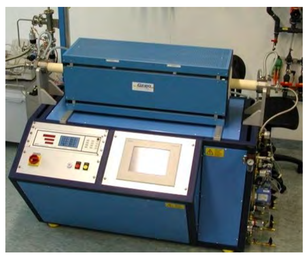
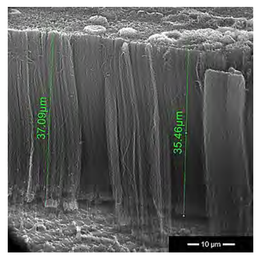
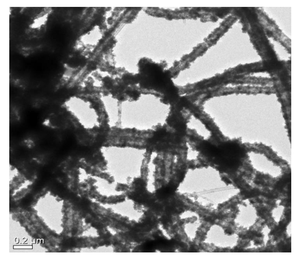
IFW Application Lab – Carbon Nanotubes

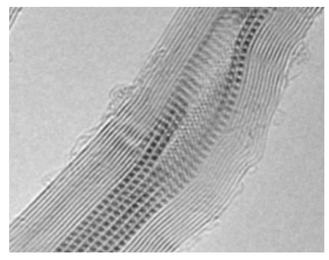


Manufacturing: Several customized production facilities, mainly by Chemical Vapor Deposition (CVD)



Carbon Nanotubes: Tailored, high quality CNT

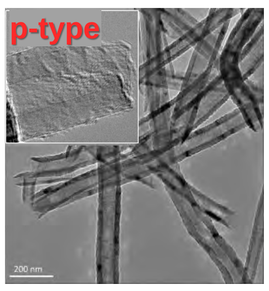




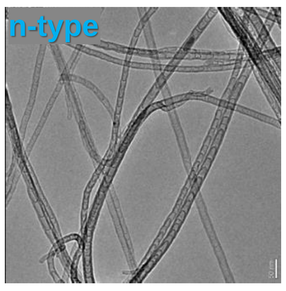
Functionalization: n- & p-doped CNT, coated or filled CNT with metals

Manufacturing of p- and n-type functionalized CNT

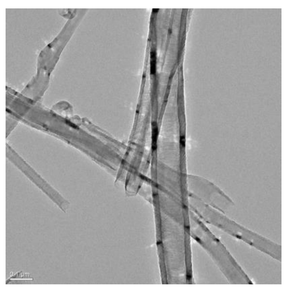
SEM



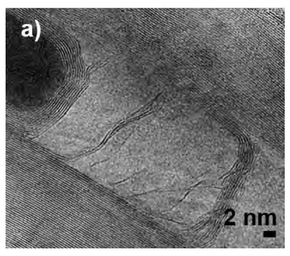
tubular **p-type CNT** produced by fixed bed-CVD method



bamboolike **n-type CNT** produced by aerosol-CVD method (MeCN)

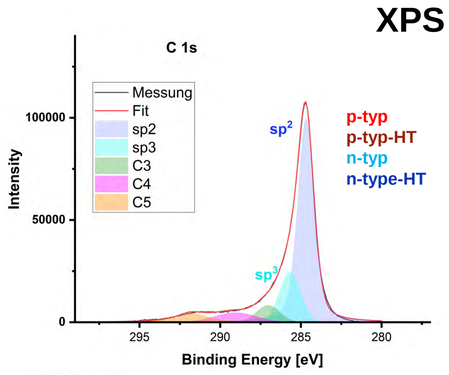


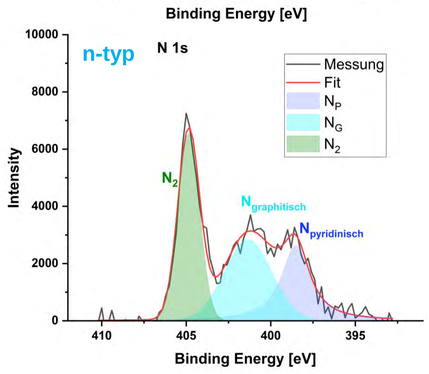
tubular **Heat-Treated p-type** CNT with high crystallinity (T = 2600 °C)

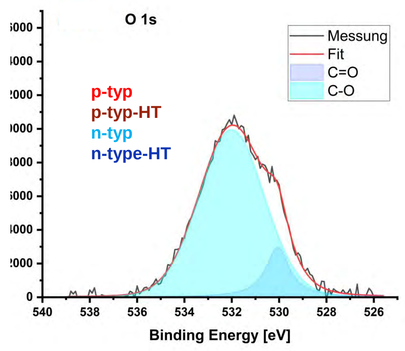


Heat-Treated n-type CNT with less bamboolike structure (T = 2600 °C)

XPS







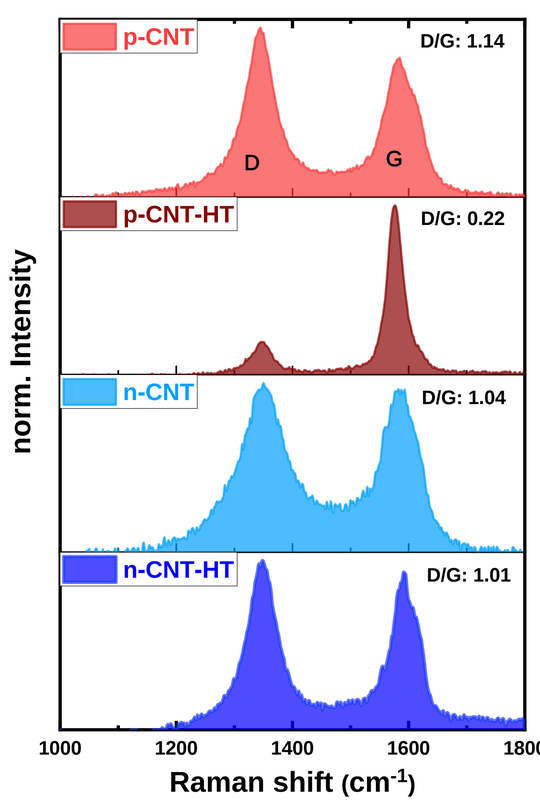
Elemental compostion:

p-typ	C 97.3	O 2.7	
p-typ-HT	C 95.3	O 4.8	
n-typ	C 92.9	O 3.5	N 3.6
n-type-HT	C 99.1	O 0.9	

Chemical states of C, O and N atoms of all CNT-types

C1s and O2s spectra revealed common oxygen and carbon groups (sp2 hybrids, sp3 hybrids, C=O, and C-O) across all CNT-types. N1s spectra showed distinct bonding states (molecular, pyridinic, and graphitic) in n-type CNT. N was not detectable for heat-treated n-type CNT, indicating a disappearance of N in the structure [1].

Raman



n-type and **p-type** CNT show a high degree of defects, the D/G ratio is slightly above 1

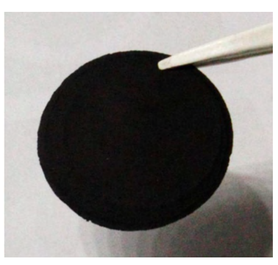
Heat-Treated p-type CNT show increased crystallinity and reduced defects, D/G ratio is strongly reduced to 0.22

Heat-Treated n-type CNT show no difference to the as grown n-type, the same amount of defects and no improved crystallinity

Manufacturing CNT-based nanocomposites for smart textiles

Current studies

1. Synthesis / modification of p- and n-type MWCNTs
2. CNT-based composite manufacturing
   - Buckypaper
   - flexible polymer films
3. Testing the thermoelectric performance
4. Evaluation and optimization of parameters



2a Buckypaper

Suspension, filtration, drying

100% CNT, thickness 90-500 µm; d=4cm

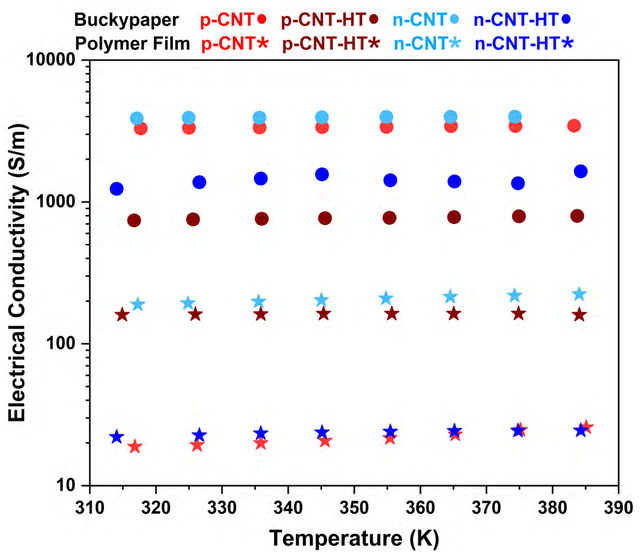
2b Polymer films

Multistep process; FILK Freiberg

3-10 % CNT, thickness 50-150 µm, polyurethane

Thermoelectric performance

Electrical Conductivity

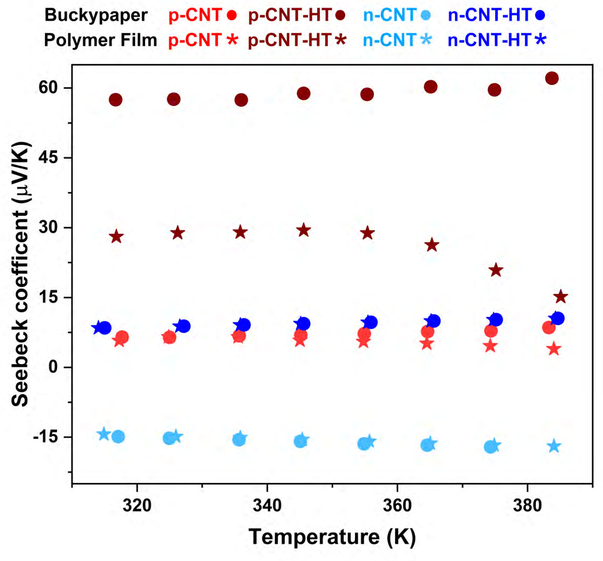


Buckypaper with high electrical conductivity for **n-type** and **p-type** CNT

n-typ-HT CNT have reduced electrical conductivity due to disappearance of N

Compared to buckypaper CNT-Polymer films show lower electrical conductitvity

Heat treatment shows only for **p-type-HT** based polymer films an effect



Seebeck Coefficent

p-type-HT buckypaper have high Seebeck coefficient especially compared to **p-typ**

p-type-HT based polymer films reveal best performance of all polymer films

Similar performance of **p-typ** and **n-typ-HT** CNT buckypaper and polymer films reconfirming the loss of N (after HT) and consequently the negative doping

n-type CNT buckypaper and polymer films have comparable negative value

We examined various types of CNTs including p-type, n-type (as grown and heat-treated) as buckypaper and CNT-based polymer films. Very good thermoelectric performance was found in p-type-HT and in n-type polymer films, which could be used to create flexible and conductive composite materials e.g. for smart textile applications.

Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

Leibniz Gemeinschaft

FILK Freiberg Institute

[1] K. Fujisawa, t. Tojo, H. Muramatsu, A.L. Elias, S.M. Vega-Diaz, F. Tristan-Lopez, J.H. Kim, T. Hayashi, Y.A. Kim, M. Endo, M. Terrones: Enhanced electrical conductivities of N-doped carbon nanotubes by controlled teat treatment, Nanoscale, 2011, 3, 4359