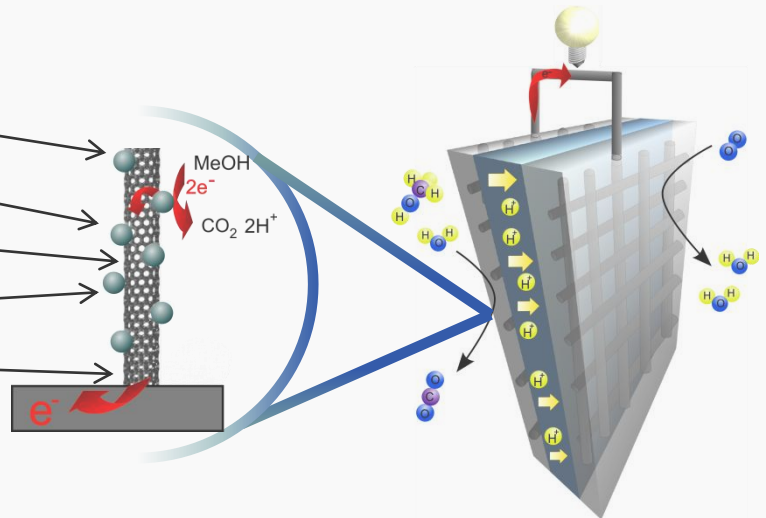


## Catalyst material for fuel cells

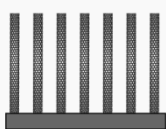
The improvement of catalyst activities in direct methanol fuel cells is of great interest. Therefore the properties of carbon nanotubes as supporting material are combined with those of nanoparticles. Their high electron conductivity as well as their chemical and thermal inertness make carbon nanotubes to an ideal supporting material. The accessibility of the nanoparticles surface for reactants is optimal if the particles are arranged on the surface of an open structured carbon nanotube network. In this case particle agglomeration and embedding of nanoparticles in pores of the supporting material are impeded. If the carbon nanotubes are directly contacted to an conducting substrate the electron pathways are ideal and the catalytic properties for usage in direct methanol fuel cells should be enhanced.

### Catalyst concept

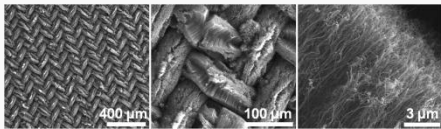
- Nanoparticles:  
Large surface
- Fine dispersion of the nanoparticles:  
Good accessibility of the catalyst for reactants
- Carbon nanotubes:  
Inertness, high surface area, ballistic electron conductivity
- Direct contact between nanoparticles and carbon nanotubes:  
Low electron resistance path
- Carbon nanotubes grown on a conducting substrate:  
Good electron transfer



### CVD growth of carbon nanotubes on a conducting substrate

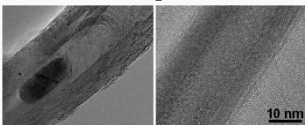


SEM-images



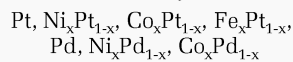
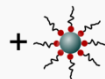
Open structure with a large surface

TEM-pictures

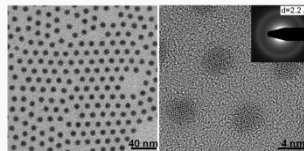


Fe-Ni alloys serve as catalyst for the formation of multiwalled carbon nanotubes

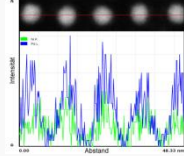
### Synthesis of platinum- and palladium-based nanoparticles



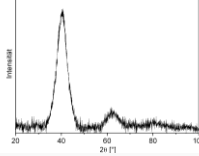
TEM-images Ni<sub>50</sub>Pd<sub>50</sub>



EDX

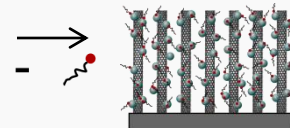


XRD

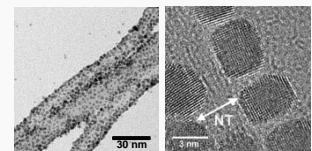


Monodisperse nanoparticles with homogeneous composition in fcc-structure

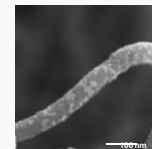
### Formation of nanoparticle-carbon nanotube-composites



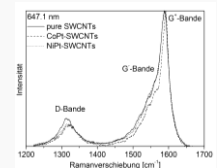
TEM-images



SEM-images



Ramanspectra



Formation of hybrid structures with direct contact between nanoparticles and carbon nanotubes preserving the sp<sup>2</sup>-configuration

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