Topic:

Investigation of nanocrystalline diamond films for artificial photosynthesis

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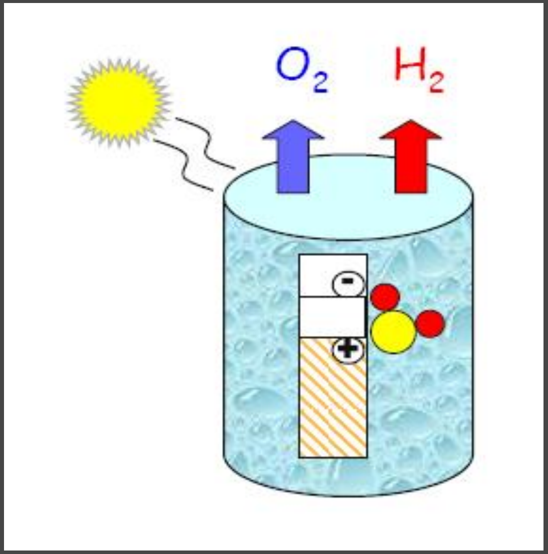
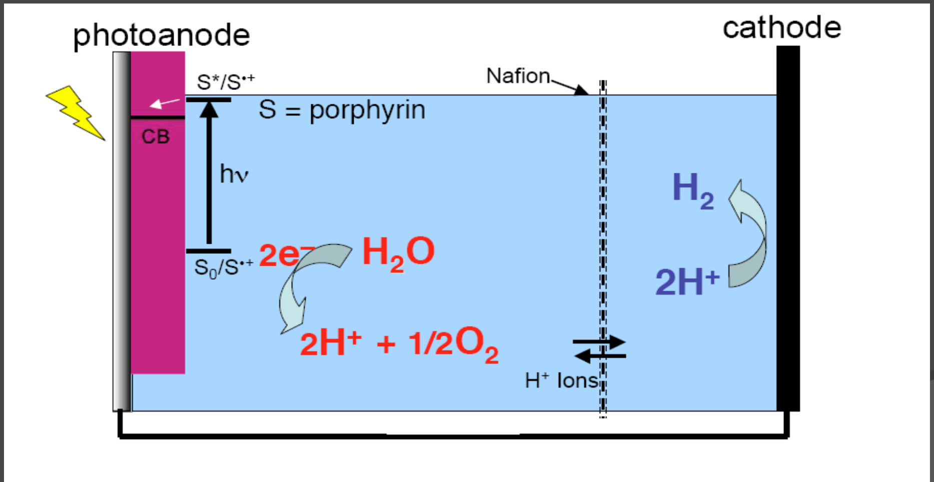


Artificial photosynthesis：

- Replicates the natural process of photosynthesis
- Fuel from sunlight and water (H_2, CH_4, CH_3OH)
- Phthalocyanine (catching the sunlight)



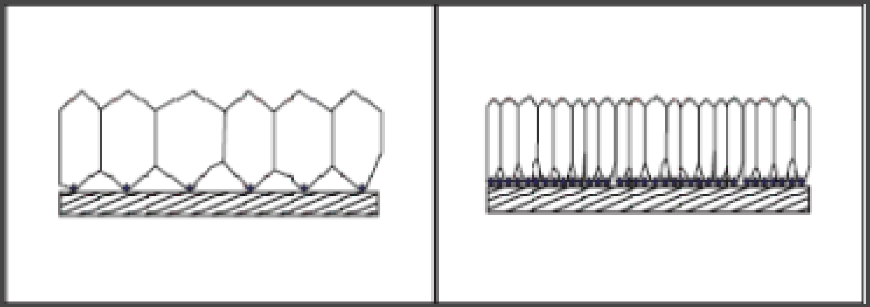
Diamond – general properties:

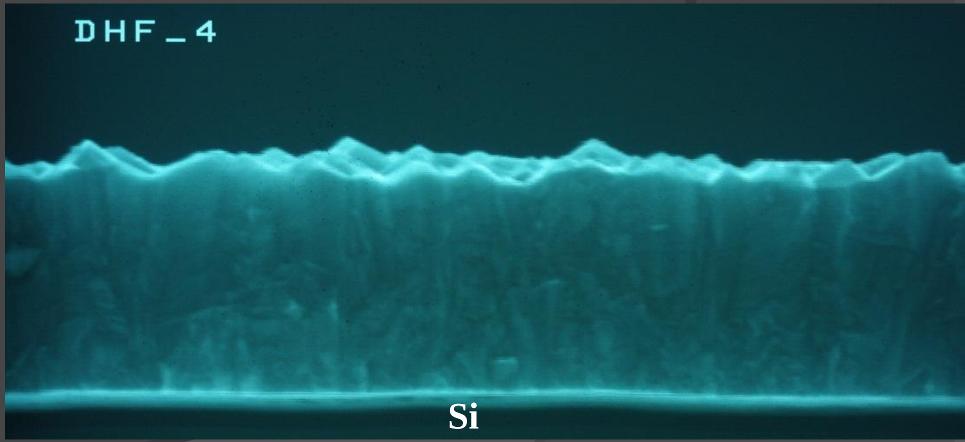
- ✓**the hardest known material**
- ✓**chemical inert**
- ✓**biocompatible**
- ✓**large electrochemical window**
- ✓**low coefficient of rubbing**
- ✓**high thermal conductivity**
- ✓**transparent**

→ Material with unique properties

Nanocrystalline Diamond Films

- polycrystalline diamond films, deposited on substrate
- substrate : - diamond (homoepitaxial)
  - other material, e.g.Silicium (heteroepitaxial)
- they have many of the diamond’s properties





Subjects of the project:

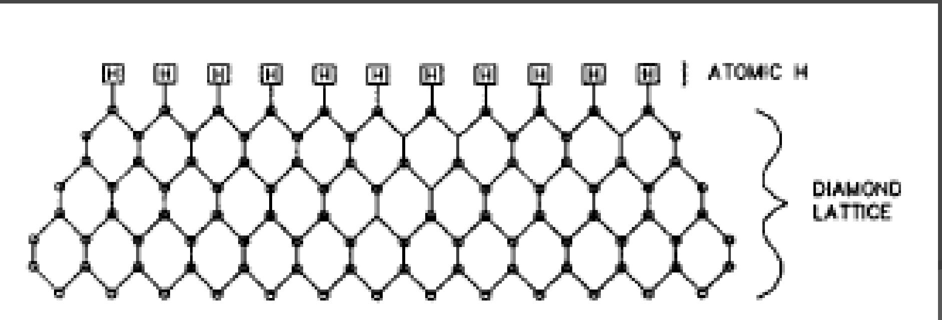
1. Investigation of nanocrystalline diamond films as a platform for effective conversion of solar energy
2. Investigation and optimization of the properties of nanocrystaline diamond films, like size of the crystalls, morphology, topography and others
3. Receiving new knowledges about the interaction between diamond surface and organic molecules (e.g. Porphyrinen)

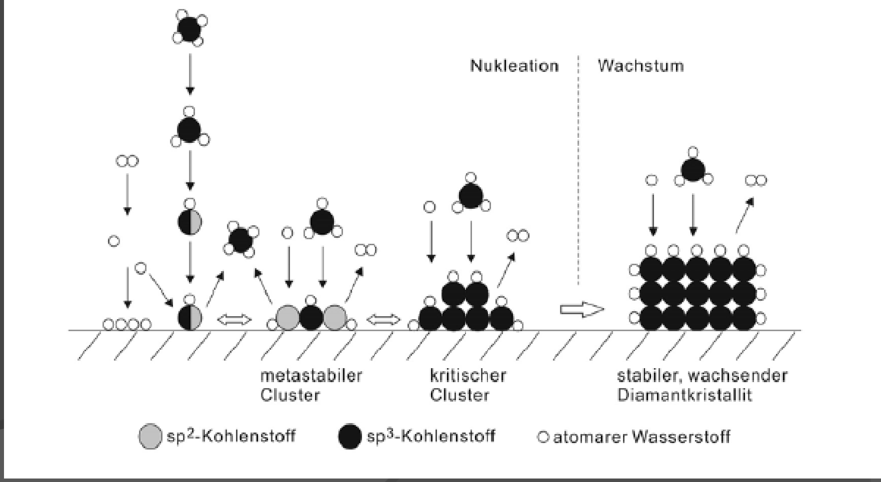
Chemical Vapour Deposition (CVD)

- activation of plasma → Microwave Plasma CVD
- thermal activation → Hot Filament CVD
- carbon source → ethylen, acetylen, methane and others
- atomic hydrogen

  - selective etching of graphite

  - saturation of the surface

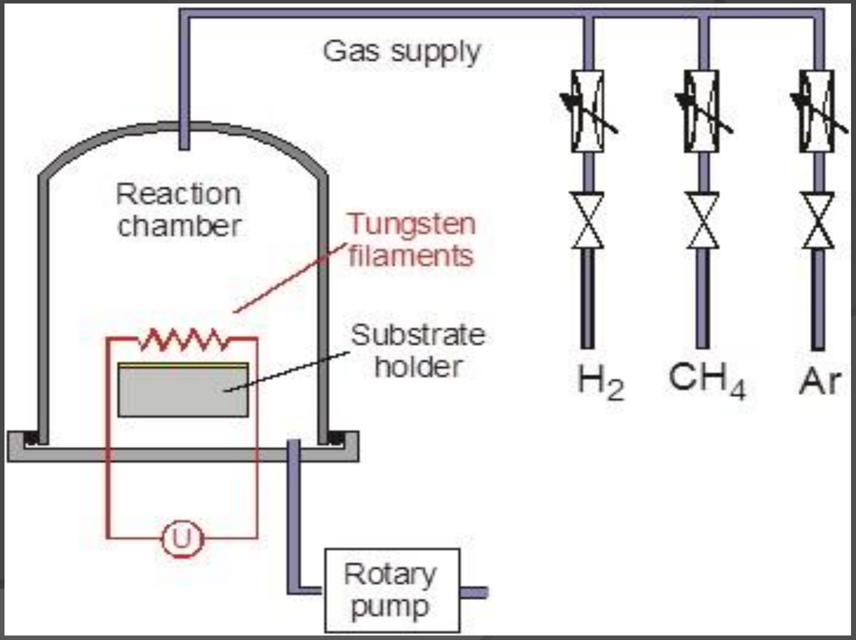




Hot Filament CVD

- filaments with temperature above 2 000°C → dissociation of carbon and obtaining of atomic hydrogen
- substrate heating → using the filaments

  with additional resistive heating



1. Changing the technological parameters

- substrate temperature
- nucleation density
- deposition time

2. Determine how the morphology, topography and the phases of the diamond films change by:

- low substrate temperature
- low nucleation density

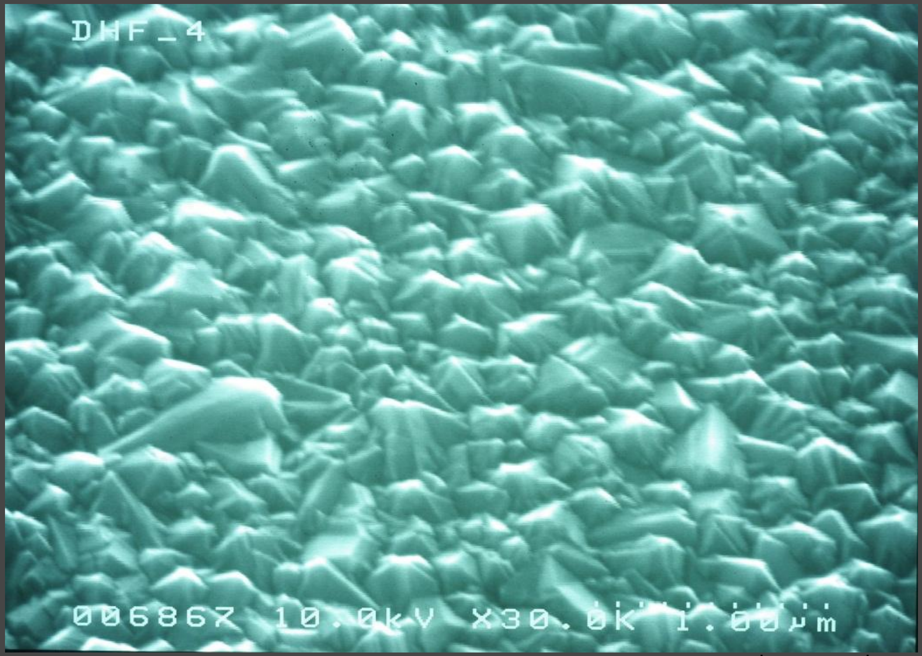
3. Apparatuses for investigation:

  - Scanning Electron Microscopy (SEM)
  - Atom Force Microscopy (AFM)
  - Raman Spectroscopy

Deposition parameters

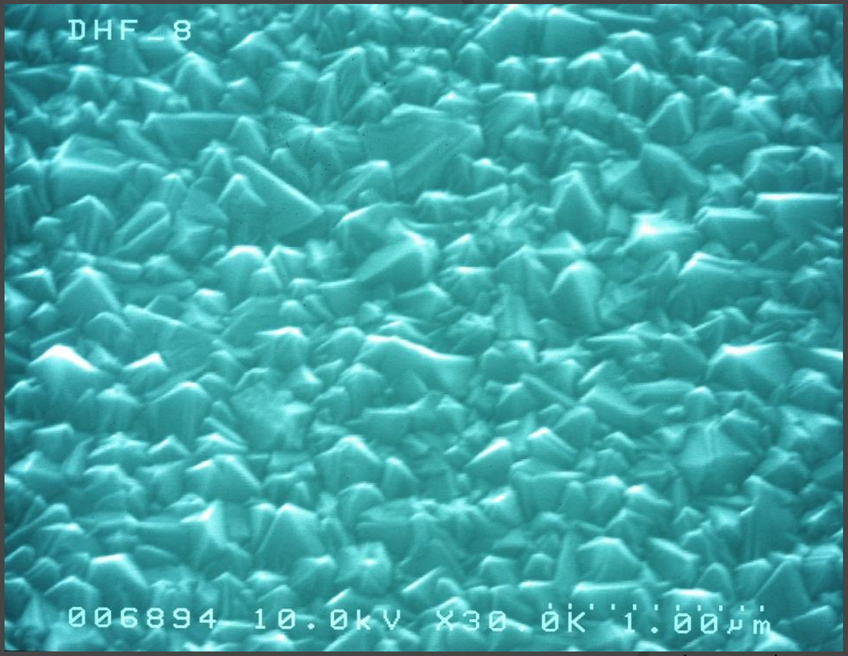
- CH_4 / H_2 : 1 / 100
- Current Ifl (A) : from 50 to 70 (filaments)
- Tension U(V): 0 – 120 (substrate heating)
- Pressure : 25 mbar
- Substrate temperature : from 503 ºC to 930 ºC
- Deposition time : 15 or 180 min
- Pre-treatment : standard or with Slurry-solution

Scanning Electron Microscopy (SEM)



1,00 μm

DHF_04 (Ts = 930 ºC)



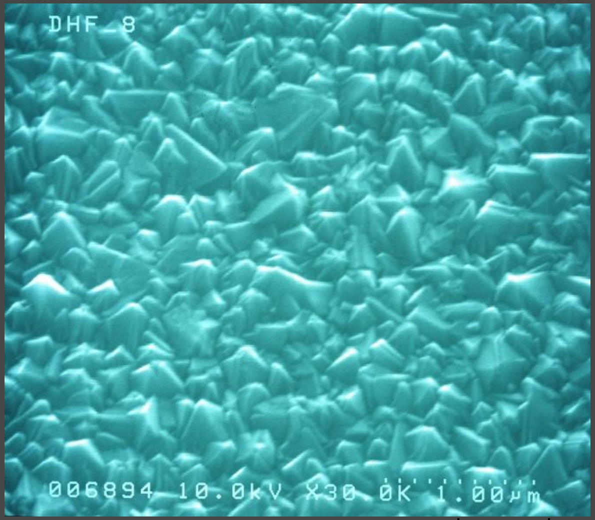
1,00 μm

DHF_8 (Ts = 870 ºC)

- identical surfaces
- the diamond crystals has the form of a pyramid

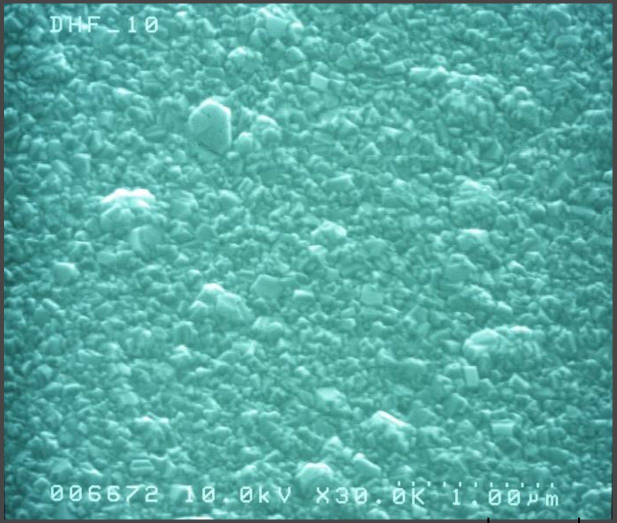
SEM

DHF_08 (Ts = 870 ºC)



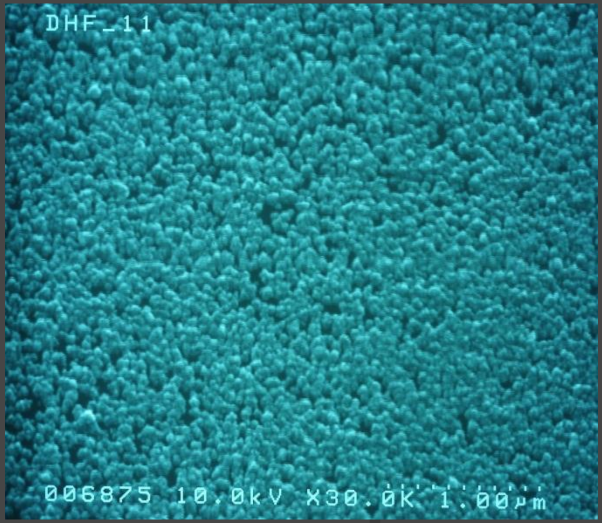
1,00 µm

DHF_10 (Ts = 607 ºC)



1,00 µm

DHF_11 (Ts = 503 ºC)

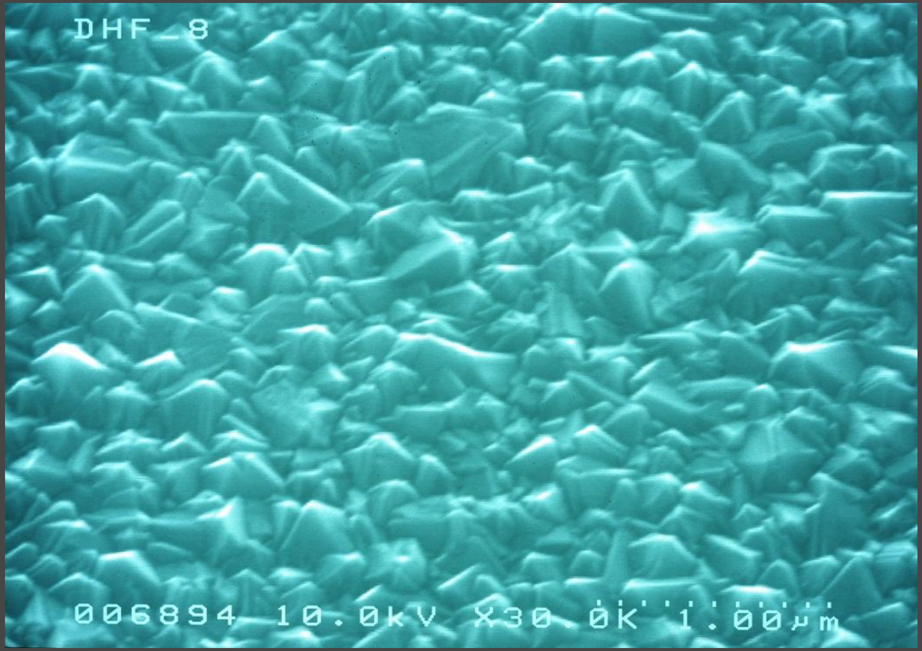


1,00 µm

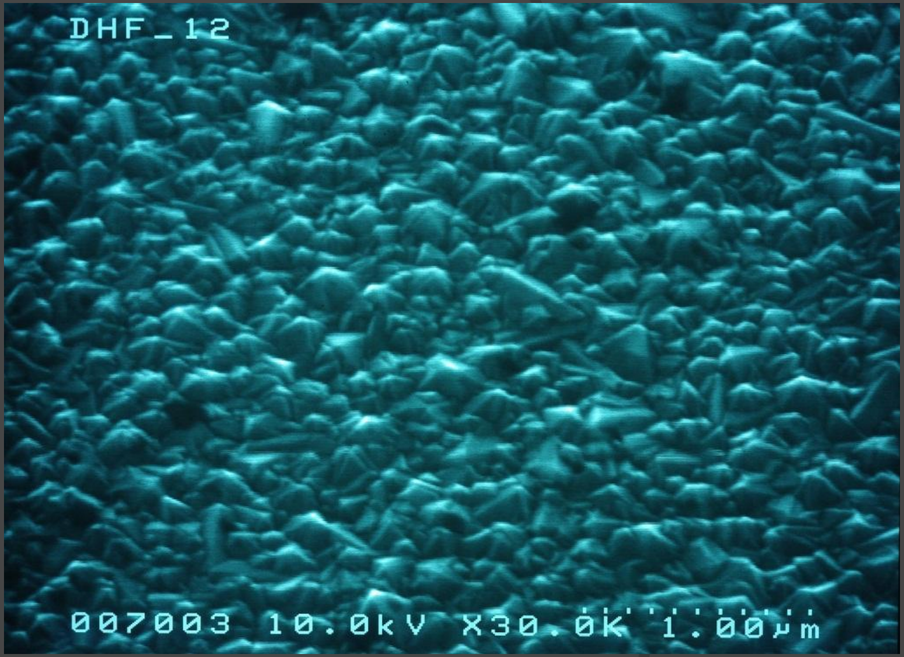
- the crystals changed
- transition from nano- to ultrananodiamonds

SEM

DHF_08 (Ts = 870 ºC) standard



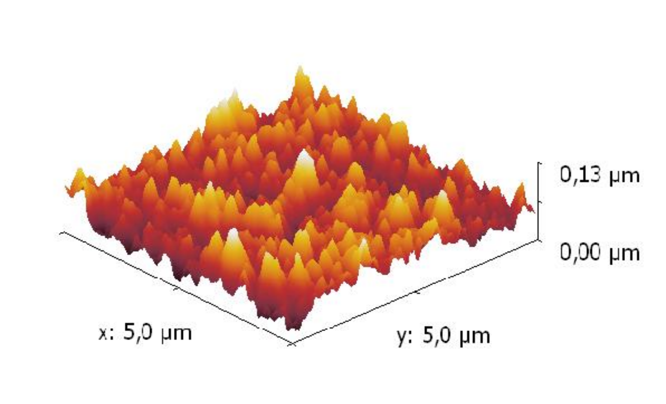
DHF_12 (Ts = 925 ºC) Slurry solution



- the crystals are still facetted
- bigger crystals

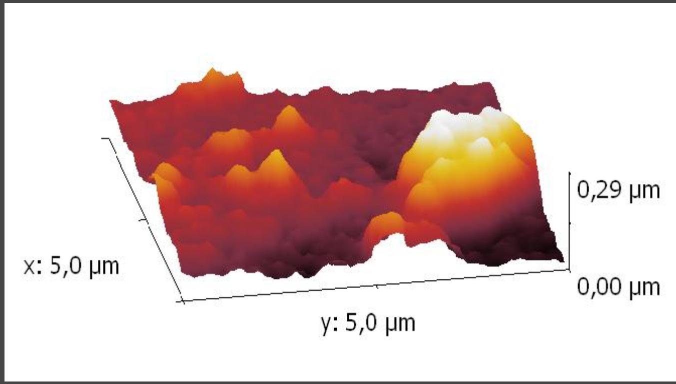
- the nucleation density is lower

Atom Force Microscopy (AFM)



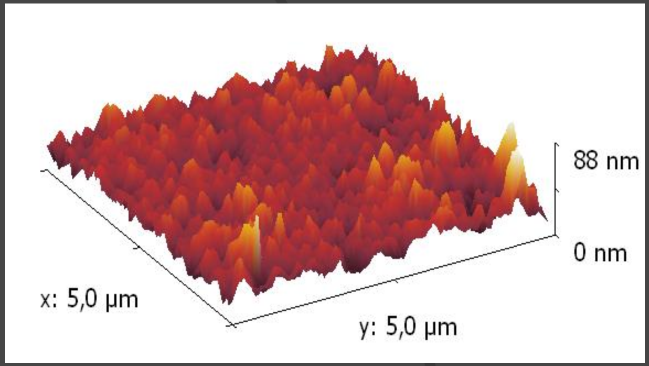
DHF_01 (Ts = 840 ºC)

- the film is closed
- crystals in form of pyramids



DHF_10 (Ts = 607 ºC)

- areas with no diamond crystals
- some big structures

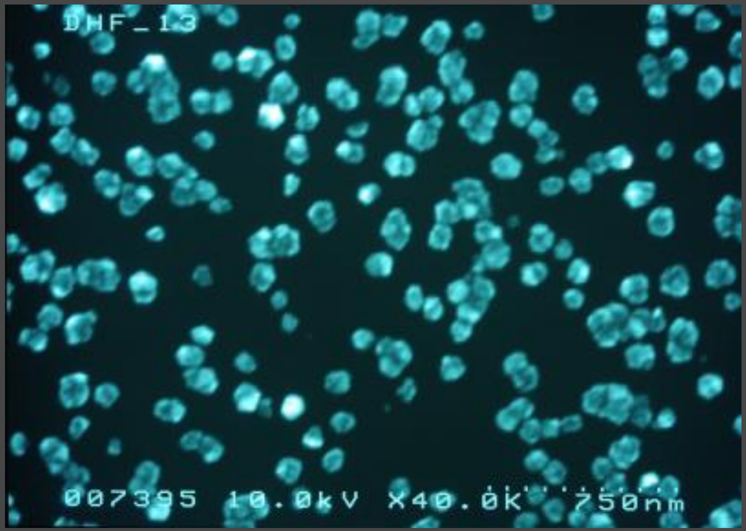


DHF_11 (Ts = 503 ºC)

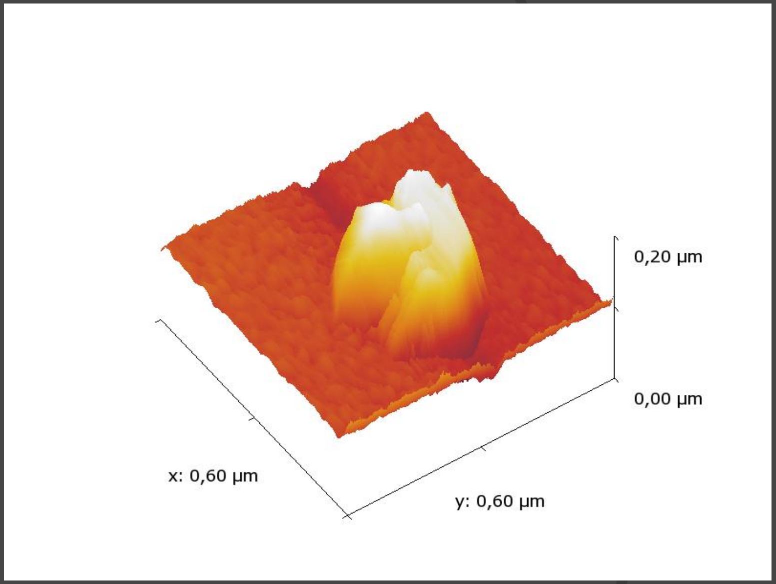
- the crystals are smaller
- transition from nano- to ultrananodiamonds

SEM and AFM

DHF_13 (Ts = 950 ºC), deposition time 15 min → single crystals

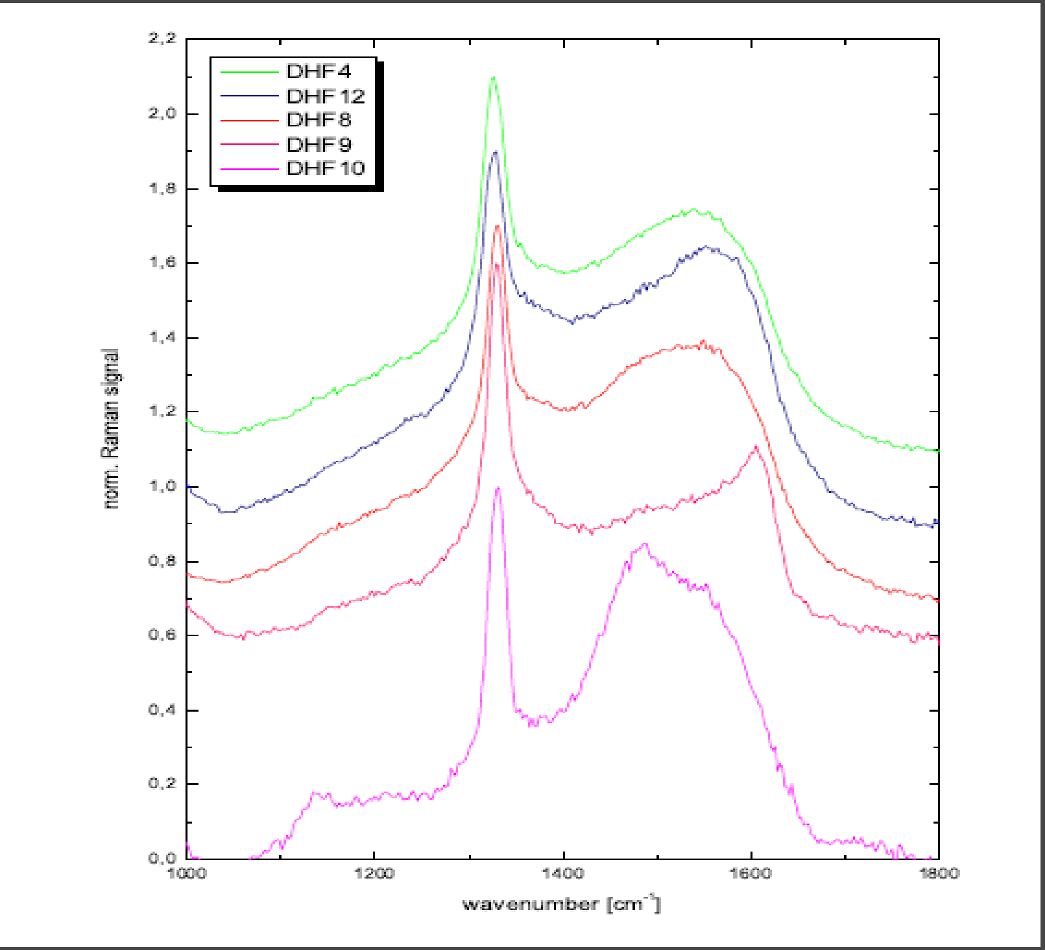


750 nm



- low nucleation density
- the film is not closed → single crystals (15min)

Raman Spectroscopy



930 ºC

925 ºC

870 ºC

705 ºC

607 ºC

- Diamand peak by 1332 cm-1
- G-Peak by 1570 cm-1
- identical substrate temperatures → identical spectra
- Peaks by 1150 cm-1 and 1480 cm-1
- Formation of *trans*-Polyacetylen
- Transition from Nano- to Ultrananodiamonds

Summary:

- preparation and investigation of the properties of nanocrystaline diamond films by:
  - different substrate temperature
  - different pre-treatment of substrate
  - different deposition time
- by low substrate temperature → smaller crystals, not facetted
- with standard pre-treatment → lower nucleation density
- by low deposition time → single crystals

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Thank you for your attention !