SYNTHESIS AND DEPOSITION OF METAL NANOPARTICLES BY GAS PHASE CONDENSATION (GPC) PROCESS

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M. MAICU[1], R. SCHMITTGENS[2], D. HECKER[1,2], D. GLÖSS[1], P. FRACH[1], G. GERLACH[2]

1) FRAUNHOFER INSTITUTE FOR ELECTRON BEAM AND PLASMA TECHNOLOGY FEP, DRESDEN, GERMANY
2) DRESDEN TECHNICAL UNIVERSITY, SOLID-STATE ELECTRONICS LABORATORY (IFE), DRESDEN, GERMANY

ABSTRACT

In this work, the synthesis of Ag and Pt nanoparticles by means of the inert gas phase condensation of sputtered atomic vapor is presented. The process parameters (power, sputtering time, gas flow) were varied in order to study the relation between deposition conditions and properties of the nanoparticles such as their quantity, size and size distribution. The GPC unit can be combined with a PECVD process to deposit nanocomposite coatings consisting of metallic nanoparticles embedded in a thin film matrix material. The tool was used for the deposition of Pt nanoparticles on TiO_2 thin films in order to improve its photocatalytic activity . Moreover, by embedding Ag nanoparticles in plasma polymers based on organosilicon compounds conductive polymers for thin film plasmonic coatings were fabricated.

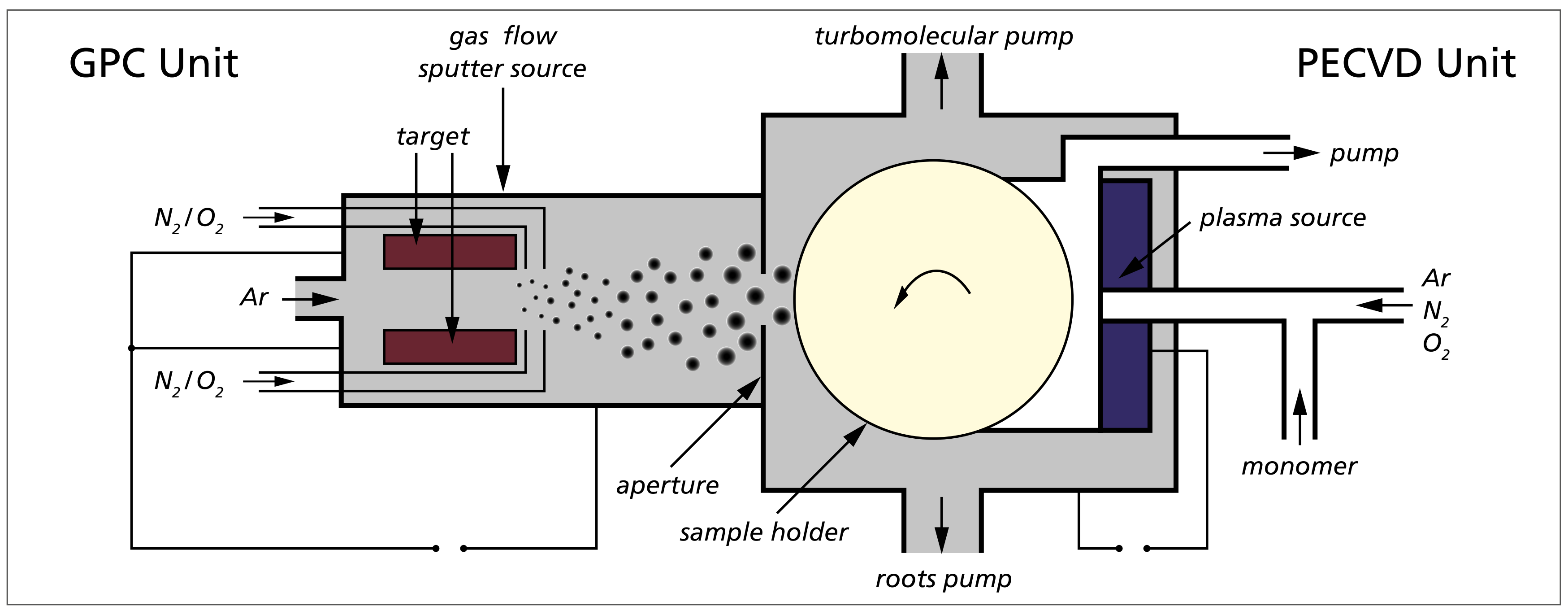
TECHNOLOGY

VACUUM DEPOSITION SYSTEM

The nanocomposite deposition system is composed of a GPC unit for nanoparticles fabrication , a PECVD unit for the matrix material deposition, and a rotating sample holder to transport the sample in-between the two sources.

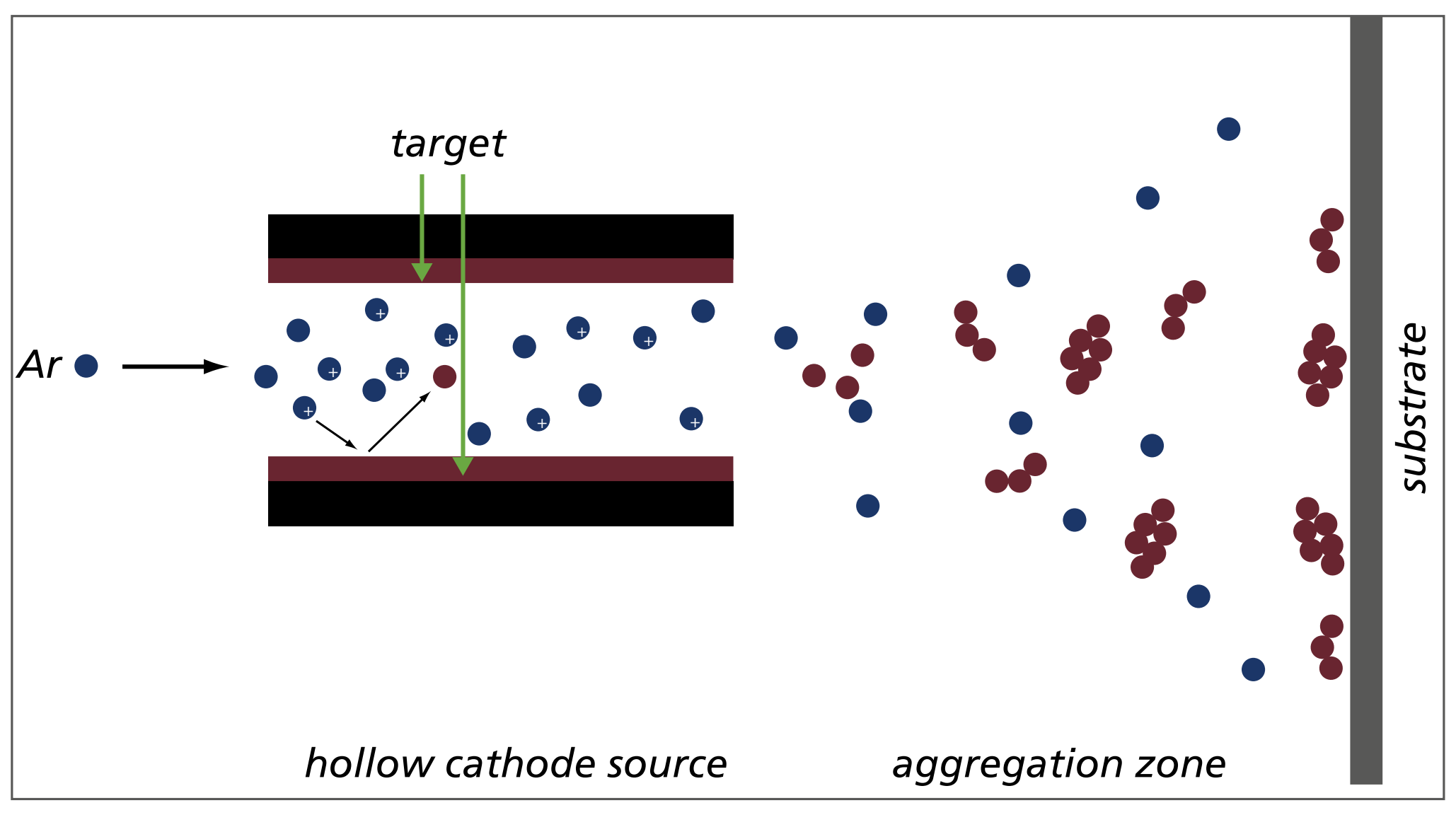
Materials:

- nanoparticles: metals, semiconductors, oxides or other composites, alloys
- matrix: plasma polymers, oxides or other composites
- substrates: flat substrates, polymer foils

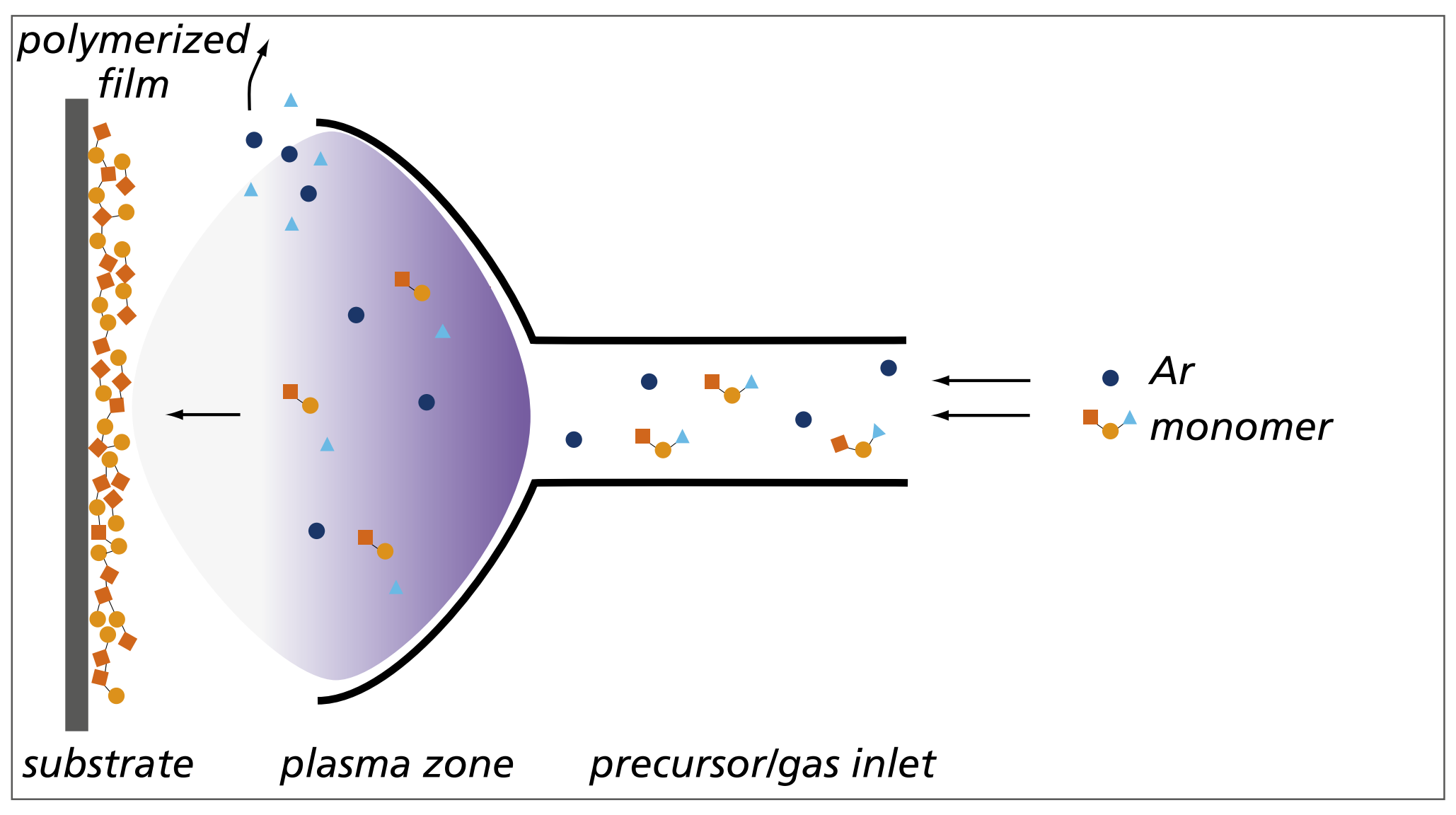


GPC UNIT FOR NANOPARTICLE GENERATION

The gas flow sputter source (GFS) is a specially designed hollow cathode where a stream of inert gas carries the sputtered atoms out of the hollow cathode. The sputtered atoms thermalize in the inert gas atmosphere and condense to form clusters and nanoparticles.



PECVD UNIT FOR MATRIX MATERIAL DEPOSITION



The PECVD Unit consists of a RF capacitively coupled discharge, fed by a 60 MHz generator. An inert gas is used to transport and distribute the gaseous monomer precursor within the source.

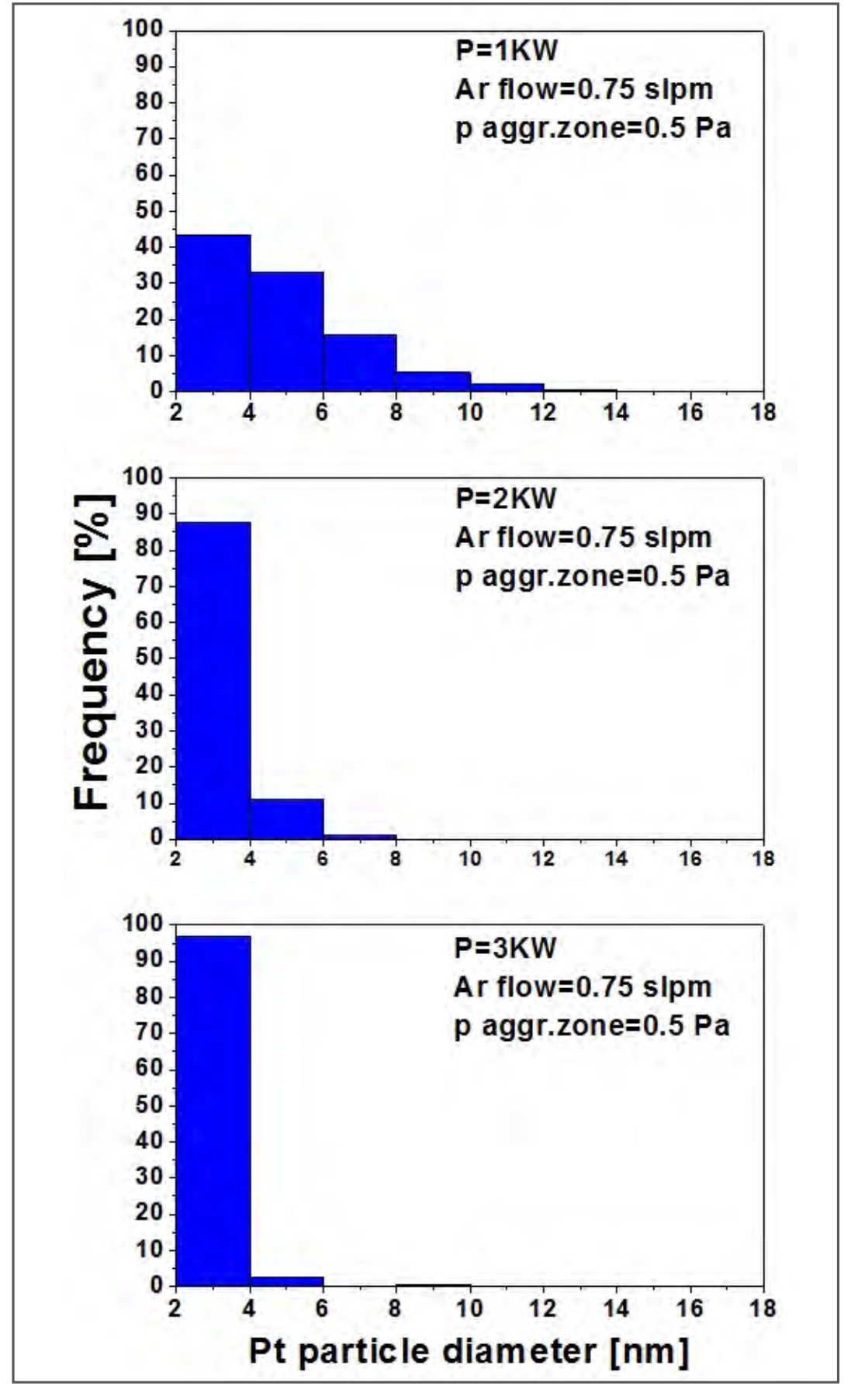
In the plasma region the monomer precursor is transformed into reactive species which polymerize as a thin film on the substrate.

RESULTS

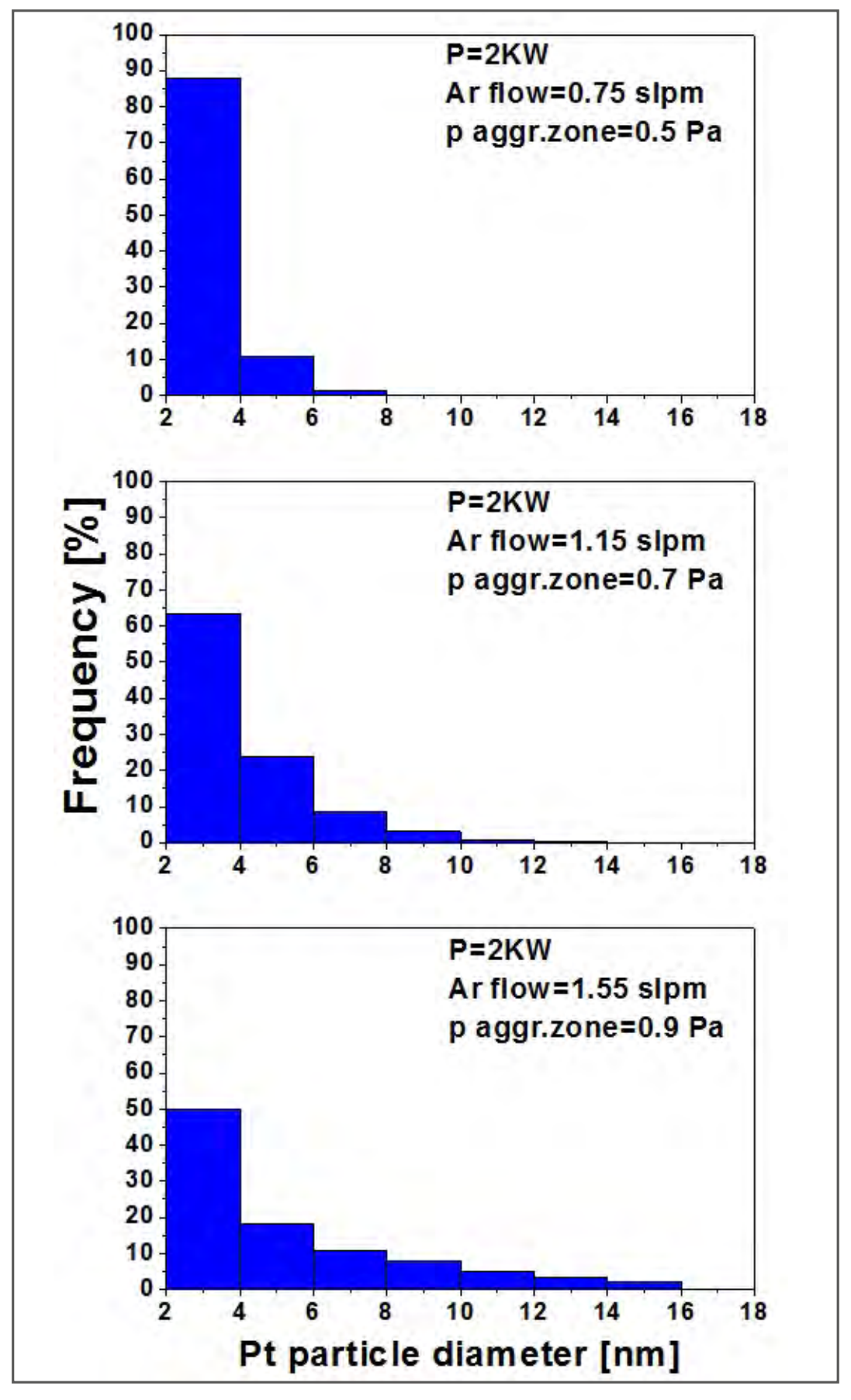
ANALYSIS OF THE DEPOSITION CONDITIONS

The size of the nanoparticles can be adjusted by changing the pressure in the aggregation zone or by tuning the discharge power. The graphs show the dependence of the NPs size from the deposition parameters for the Pt. The size distribution of the particles was estimated by using SEM pictures of samples deposited on Si wafers.

Power dependence

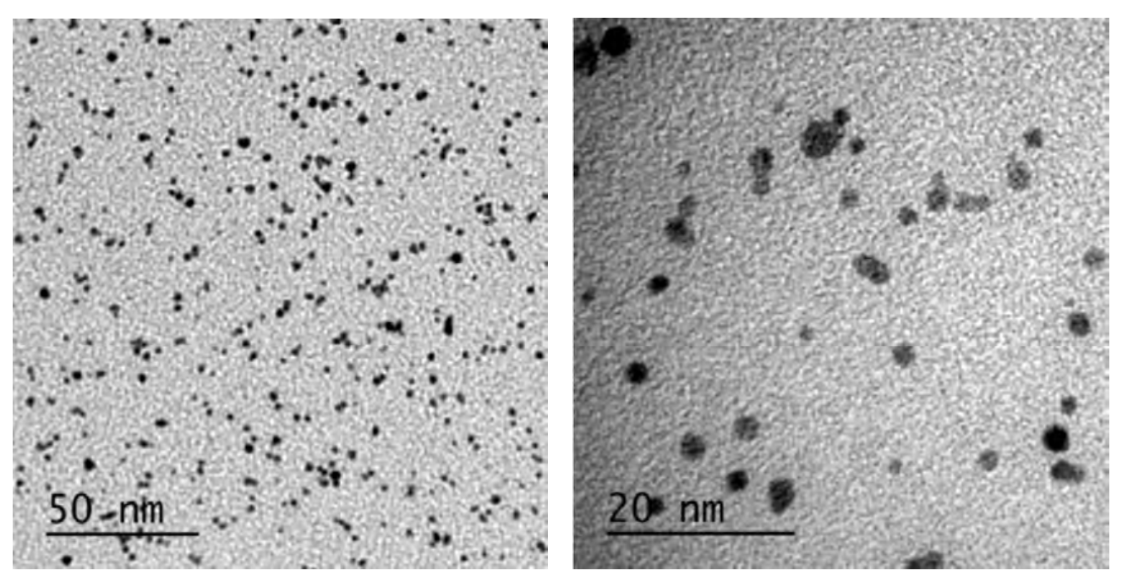


Pressure dependence



DEPOSITION OF Pt NPs FOR PHOTOCATALYSIS

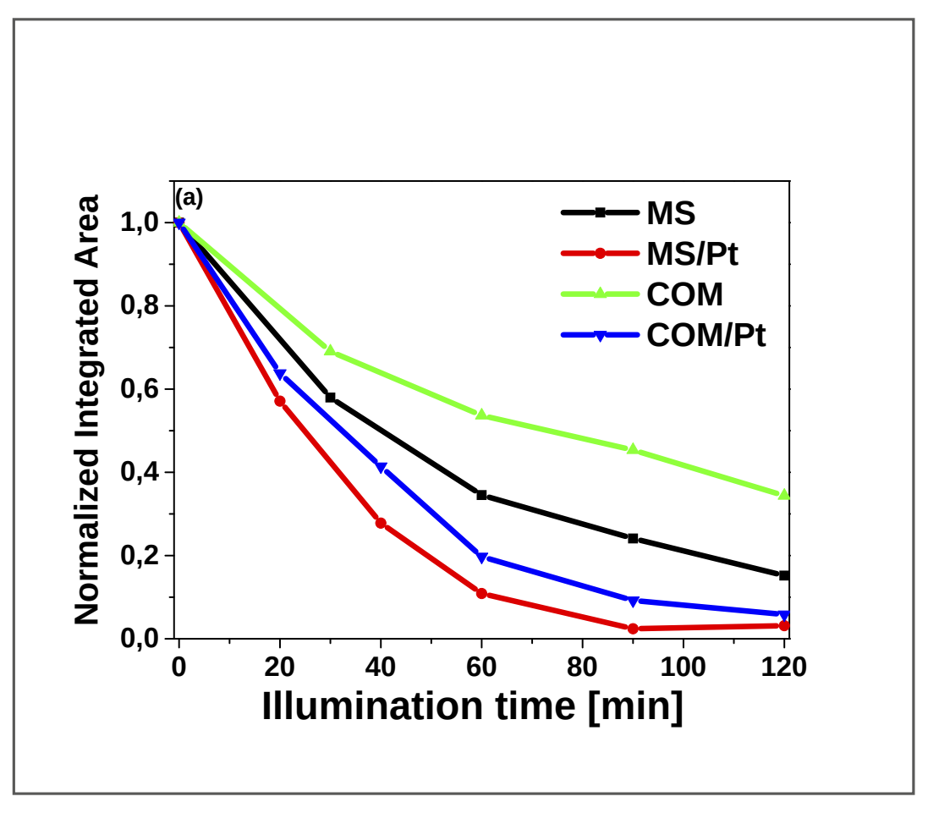
The deposition of Pt by GFS on photocatalytic glasses based on TiO_2 was successfully used in order to improve their ability to decompose stearic acid (SA) with UV-A illumination (a). The degradation of thin films of SA deposited on the glasses was evaluated by following the evolution of the typical SA peaks with the illumination time through FTIR spectroscopy (b). The integrated area under the peaks was then used to calculate the decomposition rate.

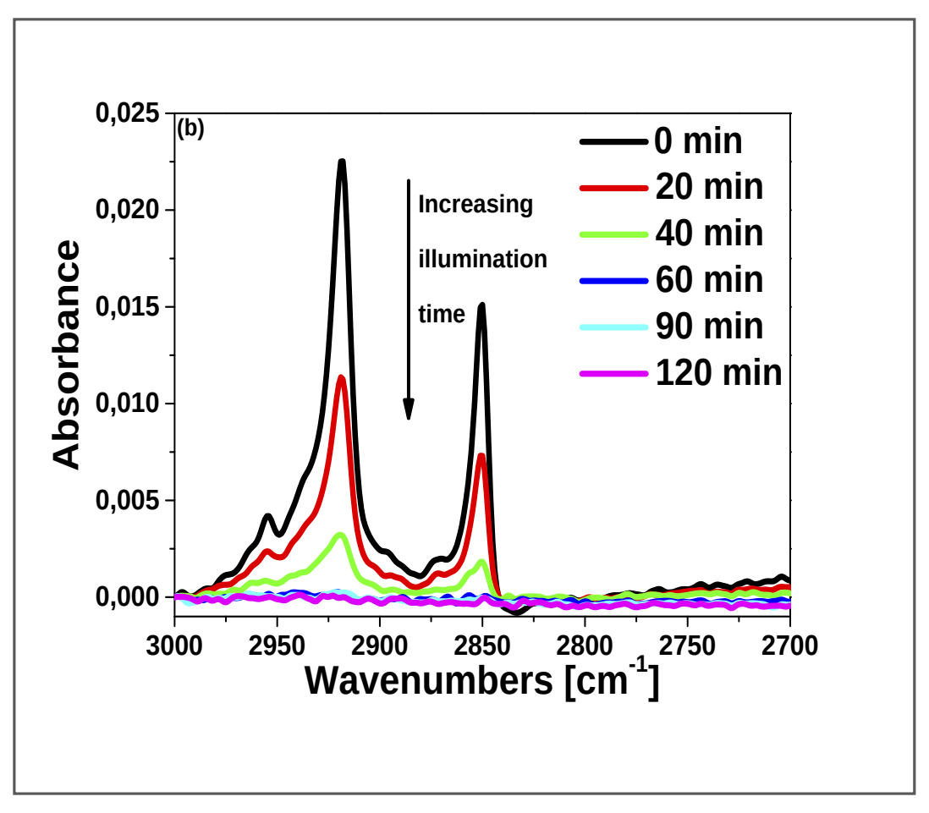


TEM image of Pt NPs

Deposition conditions:

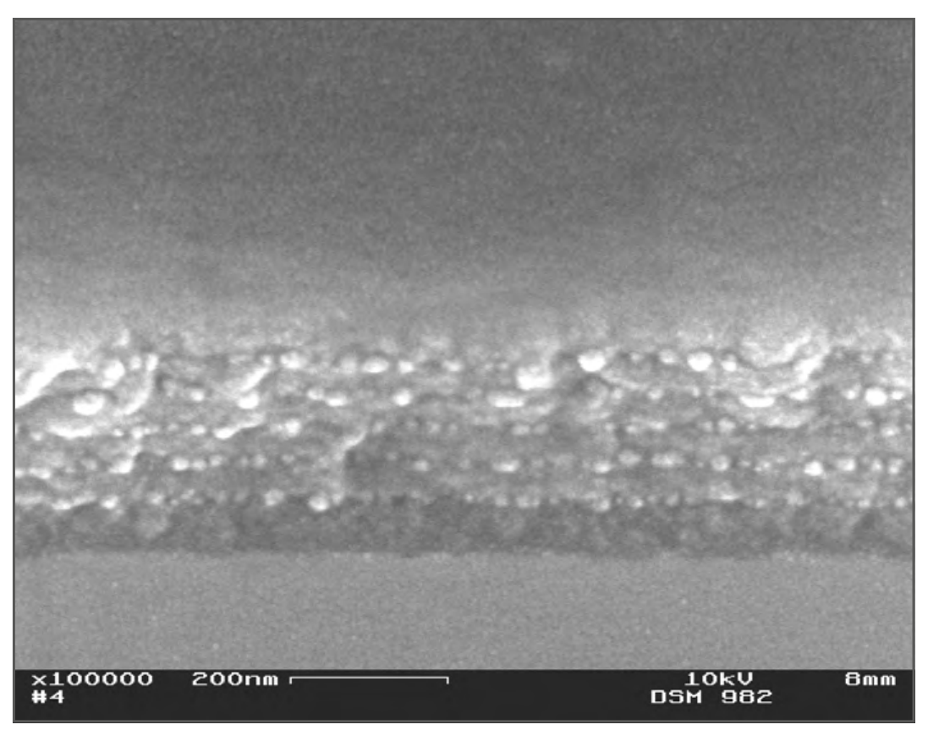
- P= 3KW
- Ar flow= 0.75 slpm
- p. aggr. zone = 0.5 Pa



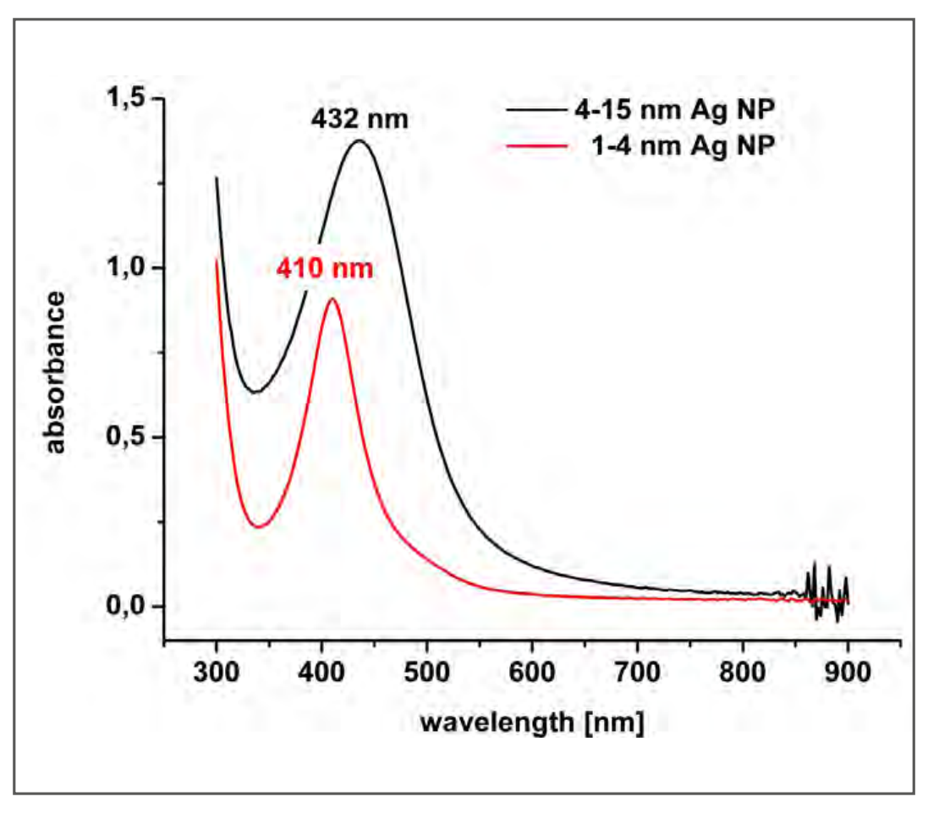


DEPOSITION OF Ag NPs FOR PLASMONIC COATINGS

Materials made of metallic nanoparticles embedded in dielectric matrices can exhibit selective light absorption and scattering due to plasmonic effects of the nanoparticles



The SEM image shows a layered structure of a nanocomposite consisting of Ag nanoparticles sandwiched between $Si_wC_xO_yH_z$ thin plasma-polymer films. The film was deposited by combining the GFS and the PECVD processes.



UV/Vis spectra show the typical plasmonic absorption peaks of Ag nanoparticles embedded in a plasma-polymer matrix. It can be seen that the absorption maximum depends on the particle size.

CONCLUSIONS

The production and deposition of metal nanoparticles was successfully realized using an inert gas phase condensation process, and the influence of deposition parameters on the properties of the particles were studied. The GFS process was combined with a standard PECVD for matrix deposition in order to produce nanocomposite thin film materials. Potential applications of the as generated metal nanoparticles for photocatalytic applications and of nanocomposites for the production of plasmonic coatings were successfully demonstrated.

CORRESPONDING CONTACT

Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik FEP

Winterbergstraße 28
01277 Dresden, Germany

www.fep.fraunhofer.de

Dr. Marina Maicu
marina.maicu@fep.fraunhofer.de

Phone +49 (0) 351-2586-382

Corresponding Contact

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