A NOVEL NANOPARTICLE SOURCE FOR VACUUM-DEPOSITION: TECHNOLOGY AND APPLICATIONS

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ABSTRACT

We present a new vacuum tool for the fabrication of nanoparticles using an inert gas phase condensation (GPC) process. The tool can be combined with standard PECVD processes to produce nanocomposite coatings consisting of nanoparticles in a thin film matrix material. Materials consisting of metallic nanoparticles embedded in dielectric matrices can exhibit selective light absorption and scattering due to plasmonic effects of the nanoparticles. Plasmonic coatings are of potential interest as UV and IR absorbers. Silver nanoparticles were fabricated and embedded in a silicon oxide thin film matrix. The result was investigated by electron microscopy and by UV/VIS measurements.

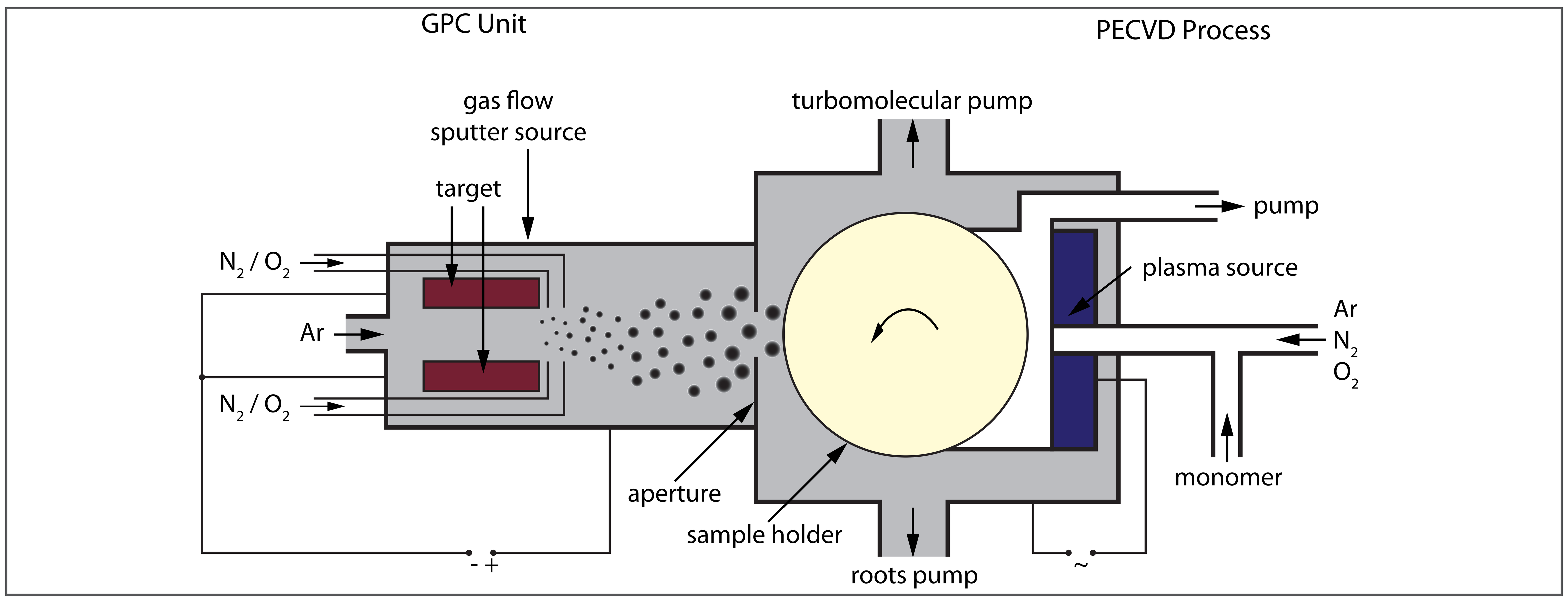
TECHNOLOGY

VACUUM DEPOSITION SYSTEM

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

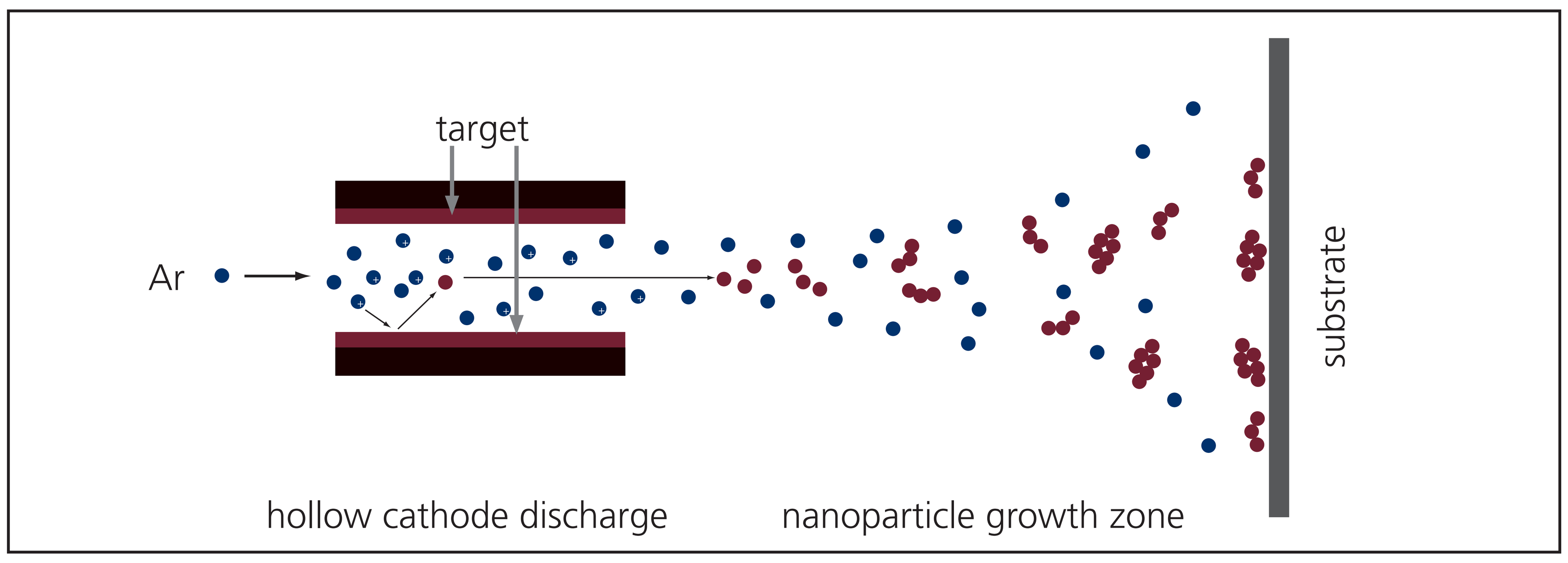
Materials:

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



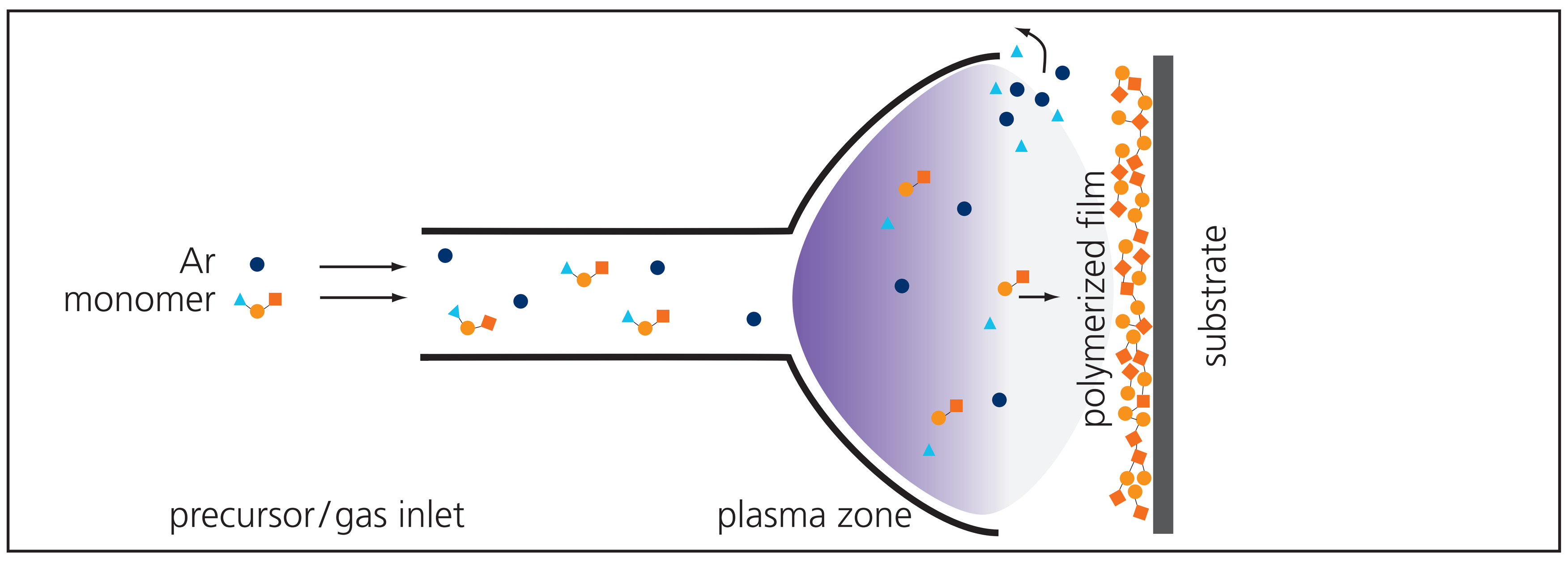
GPC UNIT FOR NANOPARTICLE GENERATION

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 condensate to form clusters and nanoparticles.



PECVD PROCESS FOR MATRIX MATERIAL DEPOSITION

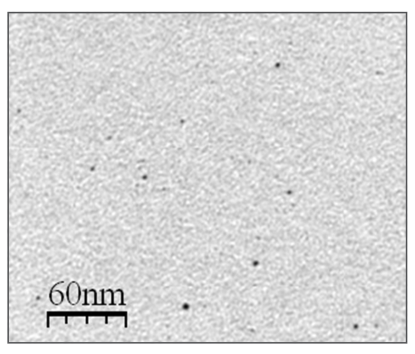
The PECVD Unit consists of a RF capacitively coupled discharge, fed by a 60 MHz generator. An inert gas is used to transport and distribute the gaseous monomer precursor within the source.
In the plasma region the monomer precursor is transformed into reactive species which polymerize as a thin film on the substrate.

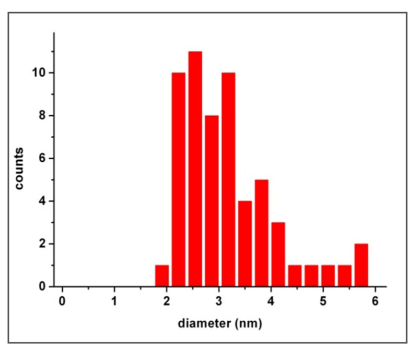


RESULTS

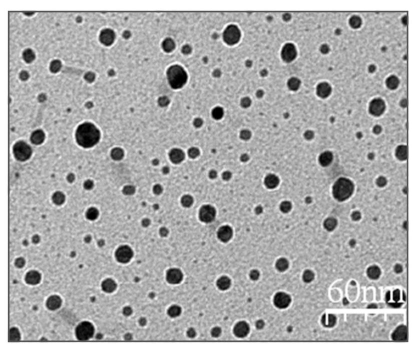
METAL NANOPARTICLES

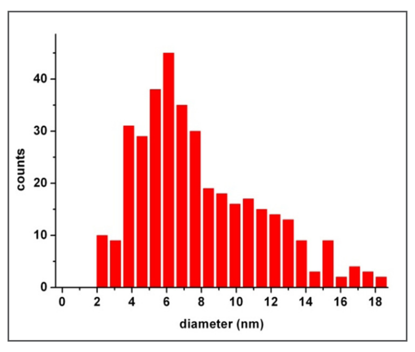
- discharge: P = 1.5 kW
- Ar flow: f = 1.0 slm
- diameter: d = 2 ... 4 nm
- metal: Ag





- discharge: P = 2.0 kW
- Ar flow: f = 3.0 slm
- diameter: d = 4 ... 15 nm
- metal: Ag

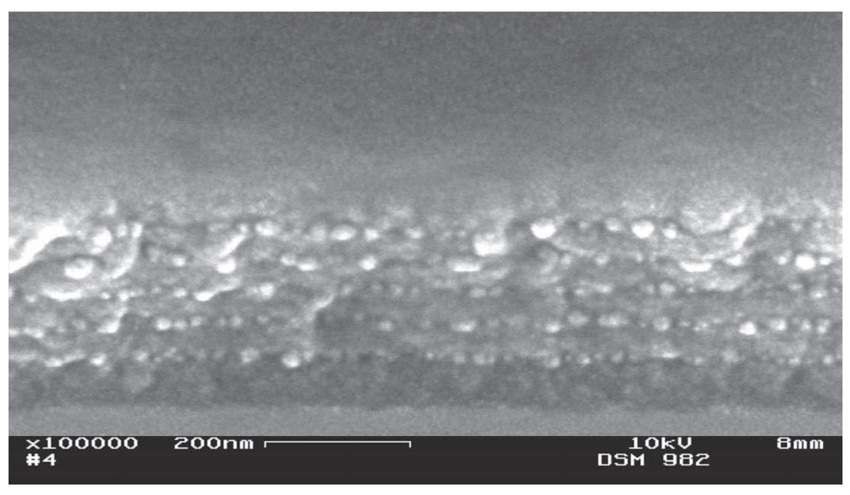




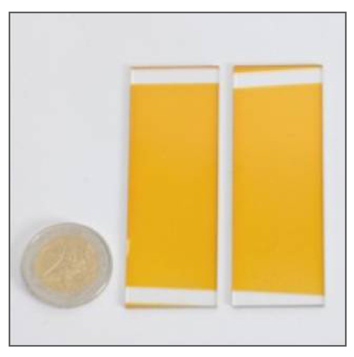
- the nanoparticle size can be adjusted by changing the pressure in the aggregation region or the length of the aggregation region.
- the nanoparticle size can be decreased by lowering the vapor density in the aggregation region, by decreasing the discharge power or pulsing the discharge

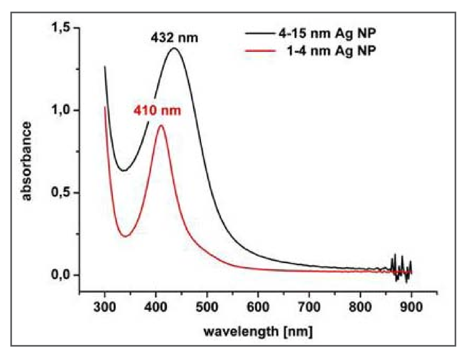
NANOCOMPOSITES

The SEM image shows a thin film consisting of Ag nanoparticles embedded in a carbon based plasma polymer matrix (Precursor: Isoprene; matrix consisting of 200 single layers). The deposition was conducted in rotational mode at 3.5 rpm.



UV/VIS measurements show an absorption maximum depending on the particle size: 432 nm or 410 nm for particle size 4 ... 15 nm or 1 ... 4 nm, respectively. These are typical maxima for the plasmonic absorption of Ag nanoparticles. The particles are embedded in a transparent silicon based plasmapolymer matrix (Precusor: Hexamethydisiloxane).





CONCLUSIONS

A new nanoparticle source for thin film deposition using an inert gas phase condensation process was successfully established. The nanoparticles can be embedded in a matrix material by sequential deposition using sputtering and plasma polymerisation processes. The nanoparticle size and the matrix properties can be independently adjusted.

The thickness of each layer can by varied by rotation speed of the sample holder. Ag nanoparticles with adjustable size were successfully deposited by the new nanoparticle source. Thin film plasmonic absorbers were obtained by embedding the nanoparticles in a transparent matrix using the PECVD source.

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