Effect of the magnetic field on formation of Cu nanoparticles during the magnetron sputtering in a gas aggregation source

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In this study, the impact of the adjustable magnetic field on the formation of Cu nanoparticles (NPs) in the Gas Aggregation Source (GAS) of nanoparticles was investigated. It was found that the deposition rate of NPs passed through a maximum when decreasing the magnetic field from 83 mT down to 30 mT. The change in the deposition rate was furthermore accompanied by alteration of the size distribution and the shape of produced NPs. Spherical NPs with the size of 26±1 nm as well as cubic NPs with the size of up to 150 nm were successfully prepared.

1. Introduction

Over the last few decades, there was an increasing interest in efficient and wet chemical-free preparation of metal NPs by means of gas aggregation sources. Gas pressure and flow as well as magnetron current were recognized to be crucial parameters for tuning the structure, size distribution and yield of produced NPs. An impressive number of metallic nanoparticles (Ag, Cu, Ti etc.) were studied in terms of the influence of these parameters. Nevertheless, energetic conditions of the plasma can be also affected by the intensity of the magnetic field above the magnetron target, a parameter which has been given much less attention. Vernieres and co-authors studied the impact of the magnetic field (adjusted by thickness of the magnetron target) on the efficiency of the deposition of Fe NPs [1]. In their research, the intensity changed together with the shape of the magnetic field. In our work, we demonstrate an approach that conserves the shape of the magnetic field and thus allows studying the formation of Cu NPs solely by changing the field intensity.

2. Experimental

Cu NPs were deposited by means of a Haberland type GAS. The GAS was equipped with a specially constructed 81 mm planar magnetron that enabled the adjustment of the magnetic induction above the target from 30 mT to 83 mT. Variation of the field was performed manualy by changing the distance between the magnetic circuit and the target surface. A special circuit of permanent magnets was designed to provide the invariable shape of the magnetic field with different intesity.

3. Results

It was found that the deposition rate of Cu NPs, their size and shape can be indeed tailored by the intensity of the magnetic field. This is demonstrated for two selected values of magnetic field in Fig. 1, where are presented 3D maps of the deposition rate in dependence on pressure and magnetron power for a given magnetic field together with SEM images of produced NPs. As can be seen either spherical or bigger cubic NPs may be produced depending on the magnetic field.

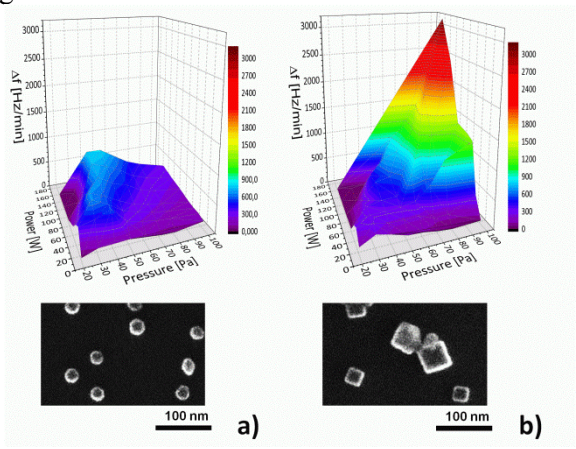

Fig. 1. Dependence of the deposition rate of Cu NPs on pressure and power with magnetic field of: a) 83 mT; b) 53 mT and examples of SEM images of produced NPs.

Acknowledgements

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4. References

[1] J. Vernieres, S. Steinhauer, J. Zhao and A. Chapelle et al., Adv. Funct. Mater. (2017) 1605328