Influence of annealing duration on the structure and magnetic properties of Co-Pt thin films

Pedan R.[1], Makushko P.[1,2], Dubikovskyi O.[1,3], Bodnaruk A.[1,4], Burmak A.[1], Makarov D.[2], Vladymyrskyi I.[1]

[1] *Igor Sikorsky Kyiv Polytechnic Institute, Prospect Peremogy 37, Kyiv 03056, Ukraine.*

[2] *Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany.*

[3] *V. Lashkaryov Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, Prospect Nauky 41, Kyiv 03680, Ukraine.*

[4] *Institute of Physics, National Academy of Sciences of Ukraine, Prospect Nauky 46, Kyiv 03028, Ukraine.*

E-mail: roman1pedan@gmail.com

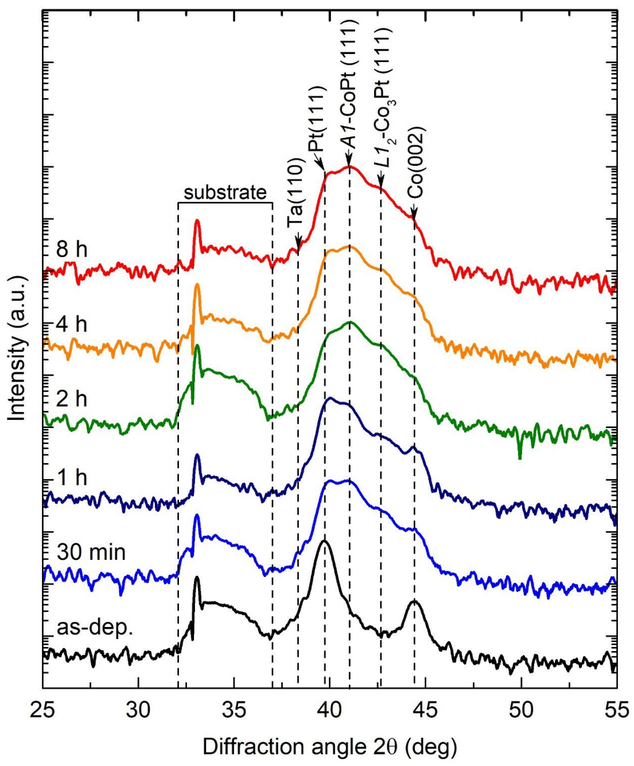
Introduction

CoPt-based magnetic thin films are attractive materials for different spintronic, permanent magnets applications and exchange coupled composites [1]. The formation of ordered magnetic phases in Co/Pt based thin films at low temperatures when bulk diffusion is frozen may require a longer annealing duration [2].

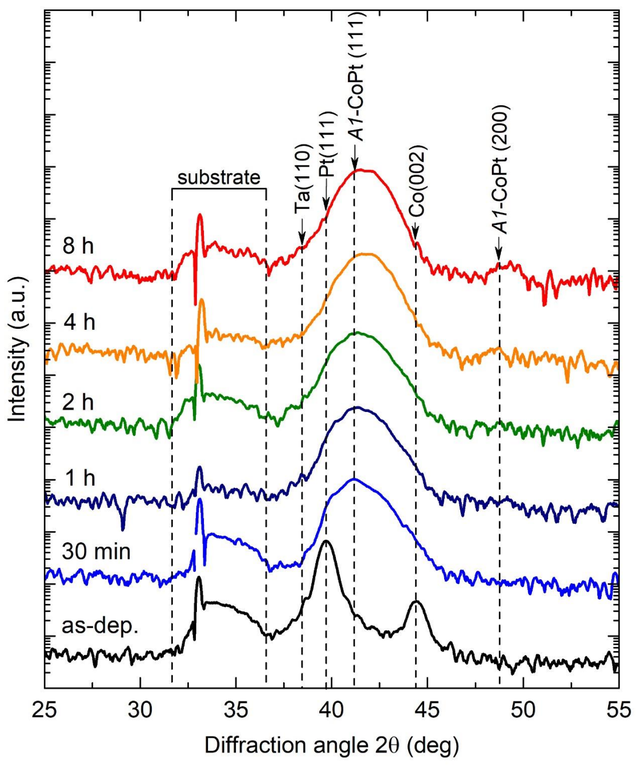
Experimental details

In present study, Pt(14 nm)/Co(13 nm)/Ta(3 nm) were sputter deposited on SiO2/Si substrate and annealed in high vacuum at the temperatures of 450 °C and 550 °C with annealing duration from 30 minutes to 8 hours. X-ray diffraction was used to analyze the effect of annealing duration on structure of the post-annealed stacks. Chemical composition and magnetic properties were determined by SIMS chemical depth profiling and VSM magnetometry.

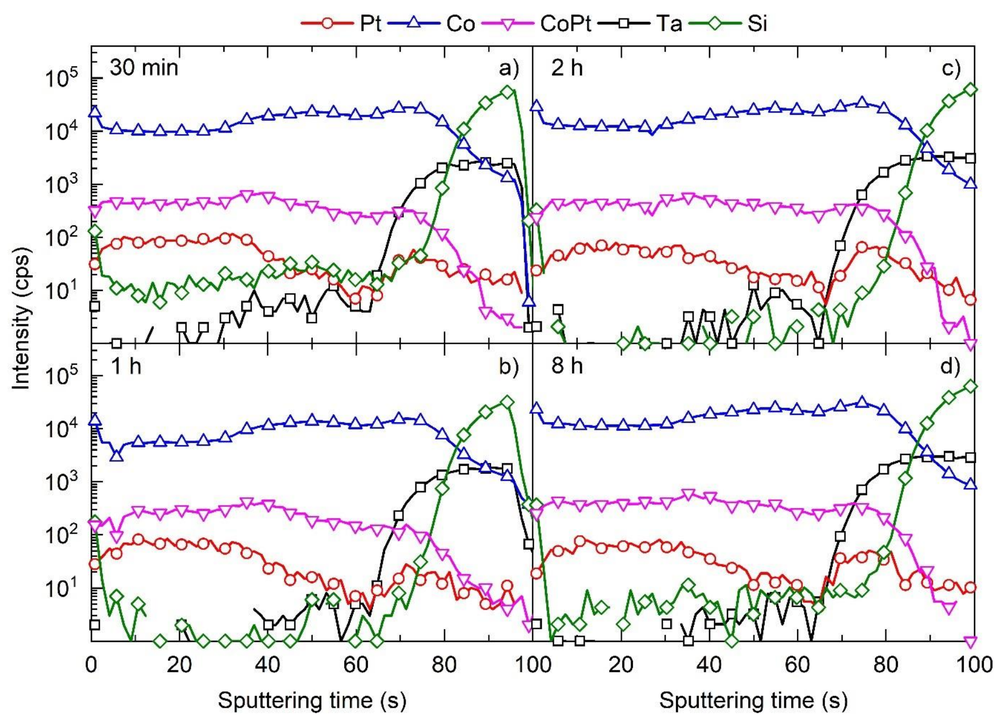
Results



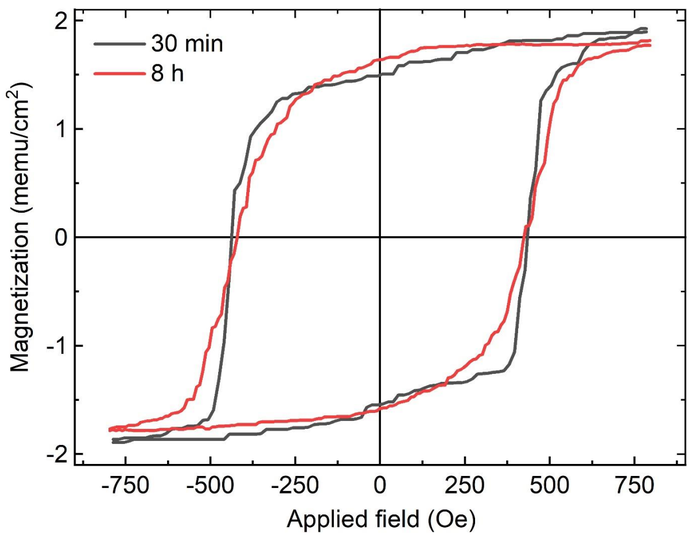
XRD patterns of Pt(14 nm)/Co(13 nm)/Ta(3 nm)/substrate stack after deposition and annealing at 450°C with different annealing duration.



XRD patterns of Pt(14 nm)/Co(13 nm)/Ta(3 nm)/substrate stack after deposition and annealing at 550°C with different annealing duration.



SIMS chemical depth profiles of Pt(14 nm)/Co(13 nm)/Ta(3 nm)/substrate stack after annealing at 450 °C with different duration.



Magnetic hysteresis loops of Pt(14 nm)/Co(13 nm)/Ta(3 nm)/substrate stacks after annealing at 550 °C with different duration.

Conclusions

Despite the fact that the disordered A1-CoPt remains the main phase in the stack composition, a long heat treatment time leads to complete homogenization of the stack structure and an increase in the coercive field.

References

1. A. Hafarov, O. Prokopenko, S. Sidorenko, D. Makarov, I. Vladymyrskyi L10 ordered thin films for spintronic and permanent magnet applications // Modern Magnetic and Spintronic Materials. NATO Sci. Peace Secur. B: Phys. Biophys.-2020.-P. 73-84.

2. Beke D.L., Kaganovskii Y., Katona G.L. Interdiffusion along grain boundaries – diffusion induced grain boundary migration, low temperature homogenization and reactions in nanostructured thin films // Prog. Mater. Sci. -2018.-98.-P. 625-674.

Acknowledgements

We thank Bernd Scheumann (HZDR) for his support with the preparation of thin films and Romy Aniol (HZDR) for the preparation of TEM specimens. Support by the Structural Characterization Facilities Rossendorf at the Ion Beam Center (IBC) at the HZDR is greatly appreciated. This work was financed in part via the German Research Foundation (DFG) grants MA 5144/13-1, MA5144/22-1, MA5144/24-1, MA 5144/28-1 and Helmholtz Association of German Research Centres in the frame of the Helmholtz Innovation Lab “FlexiSens”. Furthermore, the funding of TEM Talos by the German Federal Ministry of Education and Research (BMBF), Grant No. 03SF0451, in the framework of HEMCP is acknowledged. The work was also supported by the Ministry of Education and Science of Ukraine (Project 0119U001483).