Engineering of Lanthanum Perovskite Thin Films for Magnetic Sensors Applications

N. Žurauskienė [1,2]*, V. Stankevič [1,2], S. Keršulis [1], V. Plaušinaitinė [1,3], R. Lukošė [1,4], S. Balevičius [1], S. Tamulevičius [5]

[1] Department of Functional Materials and Electronics, Center for Physical Sciences and Technology, Vilnius, Lithuania
[2] Faculty of Electronics, Vilnius Gediminas Technical University, Vilnius, Lithuania
[3] Faculty of Chemistry and Geosciences, Vilnius University, Vilnius, Lithuania
[4] IHP – Leibniz-Institut für innovative Mikroelektronik, Frankfurt (Oder), Germany
[5] Institute of Materials Science, Kaunas University of Technology, Kaunas, Lithuania
** Corresponding author: nerija.zurauskiene@ftmc.lt*

Increasing demand for magnetic field sensors with high sensitivity in a wide range of magnetic fields and operating temperatures has resulted in numerous investigations of physical phenomena in advanced materials and fabrication techniques of novel magnetoresistive devices. The commercially available magnetoresistive (MR) sensors are based on so-called xMR effects (anisotropic AMR, giant GMR, and tunneling TMR) [1]. Magnetoresistive magnetic sensors are becoming one of the most important components in information technologies, automotive and internet-of-things applications, medical and consumer electronics. Recently it was demonstrated that the colossal magnetoresistance (CMR) effect [2] also can be employed for the development of magnetic field sensors, which can measure high magnetic fields up to megagauss [3]. These sensors are based on nanostructured (polycrystalline with nanosized grains) lanthanum manganite films and are capable to measure the magnetic field magnitude, when field direction is not known in advance (CMR-B-scalar sensors) [4]. Such sensors were used to measure the magnetic field dynamics in railguns [5], non-destructive pulsed-field magnets [3], for monitoring of magnetic pulse welding quality [6], etc. Each application has specific requirements for the sensor fabrication, its specifications, magnetic field and temperature ranges of operation, and sensor accuracy. Therefore, the possibility to tailor magnetoresistive properties of advanced magnetic oxides and their nanostructures for the development of magnetoresistive sensors with increased field and temperature ranges of operation is of great importance.

In this study, the main physical properties of nanostructured lanthanum manganite-cobaltite films grown by pulsed injection MOCVD technique, and examples of their applications for the development of magnetic sensors will be presented. It will be demonstrated that CMR behaviour in such films significantly depends on the chemical composition, structure, and morphology of the films, especially on the properties of nanometer size crystalline grains and intergrain boundary material. The obtained magnetoresistance values, magnetoresistance anisotropy, and relaxation processes will be analyzed to have possibilities to tune the main properties of nanostructured films for the development of magnetic field sensors operating in a wide magnetic field range at the room as well as cryogenic temperatures. Finally, the hybrid manganite-graphene magnetic field sensor which operation is based on negative CMR effect in manganite and Lorentz force induced positive magnetoresistance effect in graphene will be presented. Such hybrid sensor exhibits higher sensitivity to the magnetic field in comparison to individual manganite or graphene sensors.

References:
[1] C. Zheng, Ke Zhu, S. Cardoso de Freitas, *et al*., *IEEE Trans. Magn*. 55, 1 (2019).
[2] D. Pla, C. Jimenez and M. Burriel, *Adv. Mater. Interfaces* 4, 1600974 (2017).
[3] S. Balevicius N. Zurauskiene, V. Stankevic *et al*., *Appl. Phys. Lett*. 101, 092407 (2012).
[4] T. Stankevič, L. Medišauskas, V. Stankevič, *et al*., *Rev. Sci. Instrum*. 85, 044704 (2014).
[5] T.L. Haran, R.B. Hoffman and S.E. Lane, *IEEE Trans. Plasma Sci*. 41, 1526, 2013.
[6] V. Stankevic, J. Lueg-Althoff, M. Hahn, *et al*., *Sensors* 20, 5925, 2020.