Seminar of Dr. Cláudia Lopes

Centre for Mechanical Technology and Automation at the University of Aveiro (TEMA), University of Aveiro, Portugal

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Nanostructured Ti-based thin films. A Versatile Platform for Biopotential Sensing and Neurorehabilitation

Four distinct Ti-based thin film systems, doped with different metals (Au, Ag, Cu, Al), have been prepared by magnetron sputtering, allowing precise control over their chemical composition and microstructure. The strategic incorporation of these metals induces significant variations in phase composition, grain morphology, crystallographic orientation, and surface topography, which directly impact the electrical conductivity, mechanical flexibility, and electrochemical stability. These tunable properties are crucial for optimising their performance in biomedical applications, particularly as functional interfaces for biopotential sensing. All the systems exhibit three distinct regimes based on their chemical composition. At low metal contents, Ti-based films establish α-Ti(metal) metastable solid solutions. For intermediate metal/Ti ratios, the precipitation of intermetallic phases leads to high structural disorder, giving rise to different microstructures depending on the metal type. At higher ratios, the systems display contrasting morphologies, from well-defined domains to amorphous structures. The mechanical properties vary accordingly: Ti-Au and Ti-Cu films demonstrate superior toughness ($H/E \approx 0.1$) and high elastic recovery, whereas Ti-Ag and Ti-Al, characterised by columnar and brittle intermetallic structures, exhibit lower plastic deformation resistance ($H/E < 0.04$). Electrical resistivity is also metal-dependent, with Ti-Au and Ti-Cu films maintaining nearly constant resistivity (~180 μΩ·cm) due to their Thin Film Metallic Glasses-like morphology, while Ag- and Al-rich films exhibit resistivity variations (130–270 μΩ·cm) linked to their crystalline structures. These Ti-based systems have been implemented as advanced dry biopotential electrodes, namely on the integration of novel neuro-rehabilitation systems combining electroencephalography (EEG), electrocardiography (ECG), electromyography (EMG), and functional electrical stimulation (FES). Ti-Au and Ti-Cu electrodes demonstrated superior electromechanical performance and in vivo signal acquisition, outperforming conventional Ag/AgCl electrodes. Their dense, disordered structures contribute to enhanced durability, while Ti-Cu electrodes exhibited prolonged reusability, maintaining high-fidelity signal recording for at least 24 hours. The integration of these biocompatible, flexible thin films onto polymeric substrates ensures mechanical adaptability and stable skin-electrode interaction, reinforcing their potential in bioelectronic and neurorehabilitation systems.

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Dr. Cláudia Lopes holds a PhD in Sciences (Physics) from the University of Minho (2018), Portugal. She is currently an Assistant Researcher at the Department of Mechanical Engineering, University of Aveiro, Portugal, under the FCT Tenure Programme. Her research focuses on nanostructured thin films and functional coatings for flexible, polymeric, and textile-based systems, with particular emphasis on biopotential sensing, electromagnetic compatibility, and self-powered wearable technologies. She has extensive experience in PVD-based thin-film deposition, including GLAD architectures, functionalization of elastomeric and textile substrates, and the development of dry thin-film electrodes for EEG, EMG and ECG monitoring, as well as triboelectric energy-harvesting platforms relevant for operation in demanding environments. She has authored 62 peer-reviewed journal articles, co-supervised a PhD theses and multiple MSc and undergraduate projects, and has participated in more than twenty national and international R&D projects, acting as Principal Investigator or Co-PI in several of them. In parallel with her academic activity, she co-founded a biomedical spin-off focused on the translation of nanomaterial-based sensing and wearable technologies into real-world applications

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