This dissertation thesis revolves around hydrogen economy and energy-storage electrochemical systems. More specifically, it investigates the possibility of using magnetron sputtering for deposition of efficient thin-film anode catalysts with low noble metal content for proton exchange membrane water electrolyzers (PEM-WEs) and unitized regenerative fuel cells (PEM-URFCs). The motivation for this research derives from the urgent need of minimizing the price of mentioned electrochemical devices should they enter mass production.

Numerous experiments were carried out, correlating the actual in-cell performance with the varying position of thin-film catalyst within the membrane electrode assembly, with the composition of high-surface support sublayer and with the chemical structure of the catalyst itself. The wide arsenal of analytical methods ranging from electrochemical impedance spectroscopy through scanning electron microscopy to photoelectron spectroscopy allowed us to describe complex phenomena behind different obtained efficiencies.

Consequent systematic optimizations led to the design of novel PEM-WE anode thin-film iridium catalyst with thickness of just 50 nm, supported on optimized TiC-based sublayer which performed similarly to standard counterparts despite using just a fraction of their noble metal content. Moreover, the novel anode thin-film bifunctional Pt/TiC/Ir sandwich-like PEM-URFC catalyst yielded 41.86 % round-trip efficiency in comparison to 48.60 % given by a combination of dedicated high loading devices.