“Ceramics and Energy: Intermediate temperature solid oxide fuel cells”

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Recent developments in renewable energy is likely to transform the current energy system into a new form. Solar and wind energy with a cost less than those produced by fossil fuels would be the dominant mode of energy production. Intermittent nature of these energy pose a number of problems that need to be solved in coming years. Intense research efforts are currently underway to develop low-cost batteries to be able to store these energies and release it when needed. The overall energy system involves not only electricity but also natural gas. These two grids need to be considered together in the coming era. To switch energy from one grid to the other is essential for the proper integration of these energy system. Currently it is possible to convert the energy of natural gas to electricity via thermal power plants. The reverse is also possible in theory, i.e. power to gas conversion, but currently there are a very few examples of it. This switch from conversion of power to gas is important not only for the proper integration of the energy system, but also because it is much easier to store gas than it is to store electricity.

Fuel cells as a energy conversion devices have been in the center of much research efforts over a number of decades. Solid oxide fuel cell(SOFC) with its versatile use of fuels has attracted much attention. This was also the case for SOEC, i.e. solid oxide electrolyser cell, which can convert electricity to gas. Although the operational SOFCs were developed in 1980’s in the temperature range of 850–1000 ^{0}C, they have not penetrated into the market because of the high operating temperatures. Although there are suitable materials that can function at these temperatures, it is very problematic to sustain the required durability and to afford high material cost. Thus, in order to decrease the material cost and to increase the life time of the cell, it is necessary to reduce the operating temperature of SOFC. Therefore, efforts concentrated towards the so-called intermediate temperature solid oxide fuel cells (IT-SOFC), i.e. cell that have acceptable performance at temperatures between 700-500 ^{0}C. Electrolyte and anode materials are already available that would function at these reduced temperature, but the main problem is sluggish ORR in the cathode materials. Therefore, efforts to develop IT-fuel-cells amounts to finding cathode materials that would have sufficiently fast ORR.

In this work, we report results from an extensive research program that we have undertaken at ENDAM, METU to develop LSC based cathode materials with an acceptable ORR kinetics [1,2]. The material under study was LSC113-LSC214 composites fabricated via sputter deposition in a wide range of compositions, i.e. 0.10:0.90< LSC113/LSC214<0.90:0.10 using combinatorial approach. The study has shown that the mid-compositions were particularly favorable yielding acceptable ORR kinetics at temperatures as low as 5750C. Cathodes at mid-compositions were either amorphous or nanocrystalline with a very stable performance over extended use.

[1] Z. Ç. Torunoğlu, D. Sarı, O. Demircan, Y. E. Kalay, T. Öztürk, Y. Kuru “One pot synthesis of (La,Sr)CoO3/(La,Sr)2CoO4 for IT-SOFCs cathodes” International Journal of Hydrogen Energy, 2018, DOI: 10.1016/j.ijhydene.2018.04.238

[2] D Sari, F. Piskin, Z. C. Torunoglu, B. Yasar, Y. E. Kalay, T. Öztürk “Combinatorial development of nanocrystalline/amorphous (La,Sr)CoO3-(La,Sr)2CoO4 composite cathodes for IT-SOFCs”, Solid State Ionics (in press)

[3] D. Sarı, B. Yasar, F. Piskin,Y. E. Kalay and T.Öztürk “Segregation resistant co-sputtered LSC-113/LSC-214 composite cathodes for It-SOFCs” (in preparation)