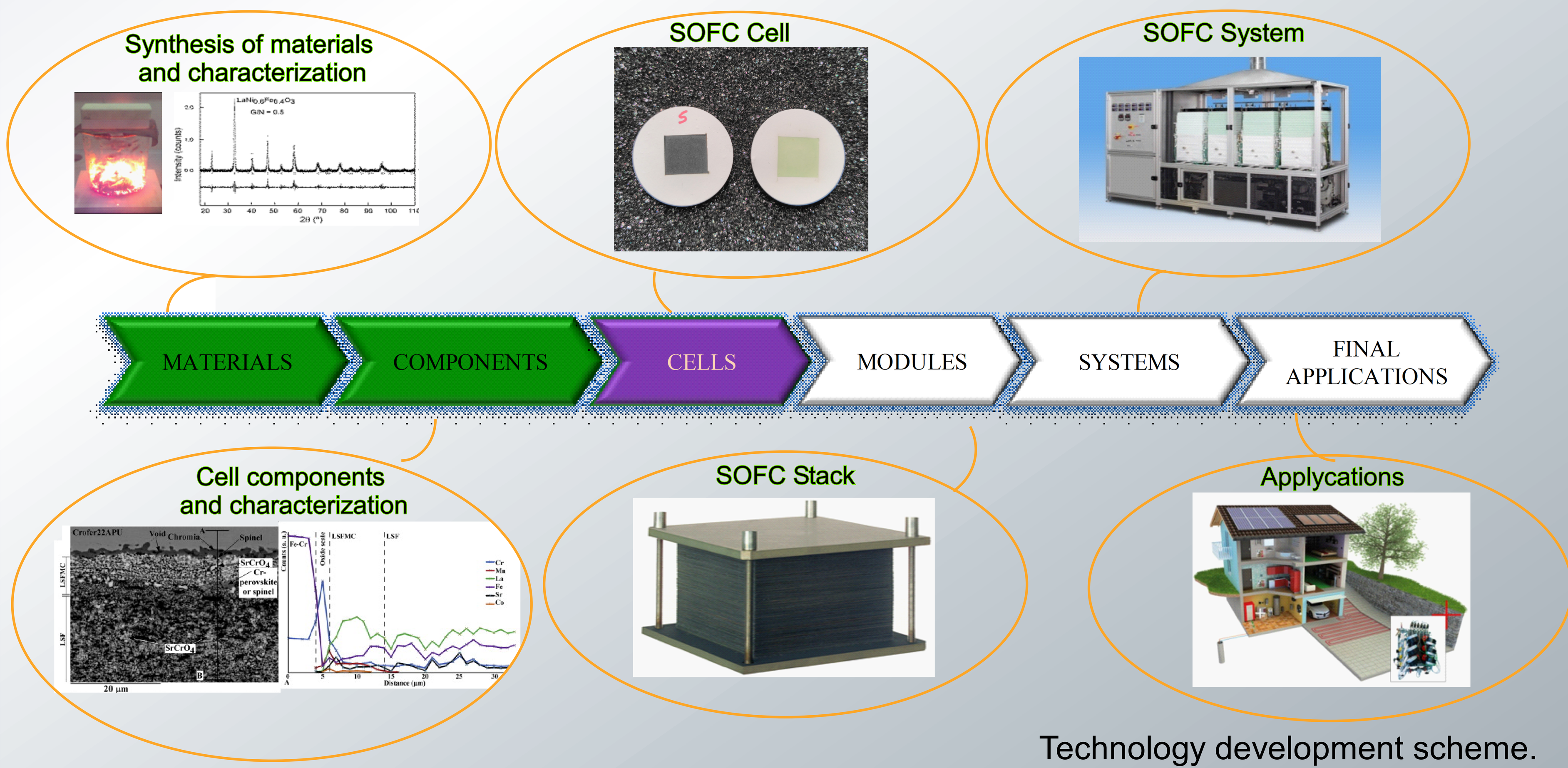
Introduction

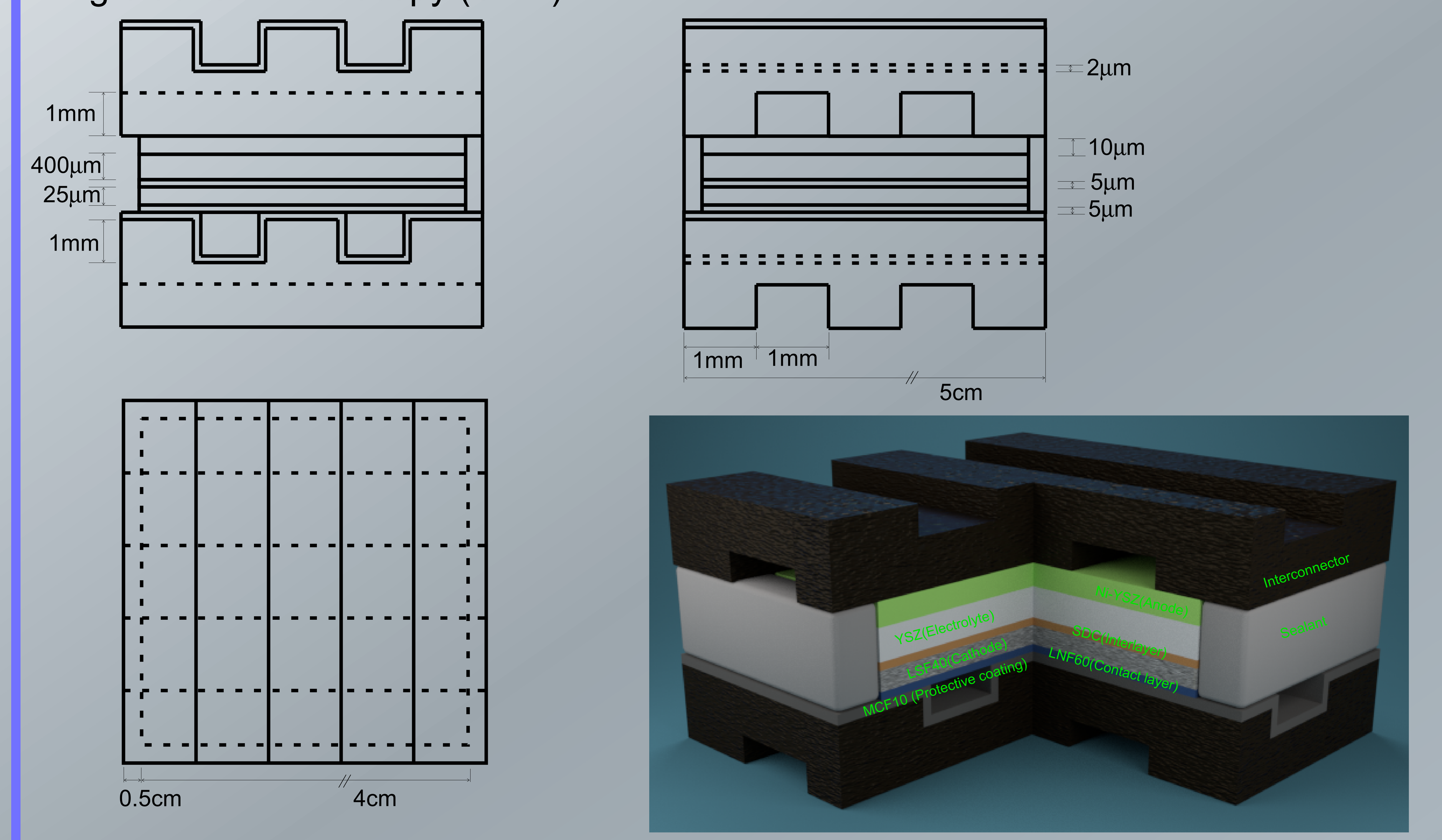
Solid Oxide Fuel Cells (SOFC) are one of the most promising technologies for the obtaining of clean energy with high efficiency for direct conversion of chemical energy into power [1]. For the implementation of these systems on the market and make them economically competitive, improving materials and manufacturing processes is constantly required. Therefore, industrial-scale production of SOFC materials is necessary, being combustion synthesis a simple and reproducible method to obtain various types of ceramic oxides used in these systems [2].



Technology development scheme.

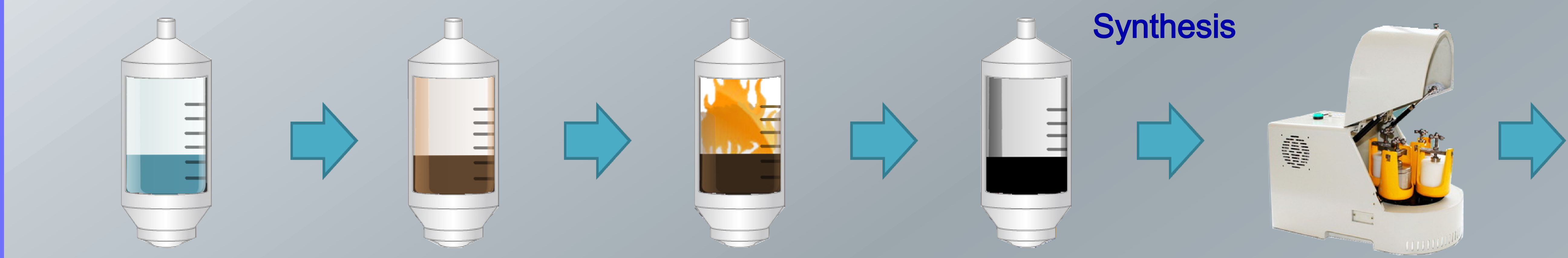
Objectives

We describe the adaptation of an existing lab-scale cell components production method to an industrially ready and easily scalable method using glycine-nitrate combustion synthesis. For this, batches up to 12 g of sample have been synthesized, were the synthesized components were: interconnect protective coatings (MCF10), contact layers (LNF60), cathodes (LSF40), interlayers (SDC), electrolytes (YSZ) and anodes (Ni-YSZ). The constituent phases were identified compositionally by inductively coupled plasma atomic emission spectroscopy (ICP-AES) and X-ray fluorescence (XRF), structurally by X-ray diffraction (XRD), while the microstructure was characterized by scanning electron microscopy (SEM).



Technical sketch of a fuel cell stack.

Synthesis



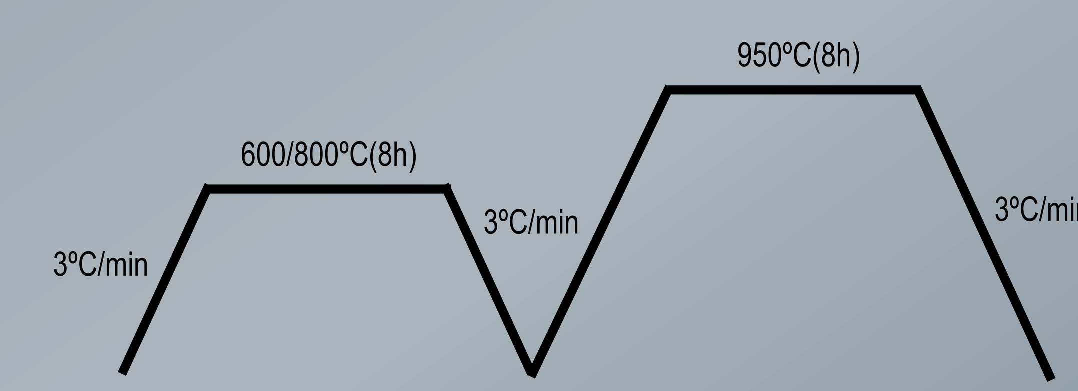
Stoichiometric amounts of the corresponding metal nitrates were dissolved in deionized water

The dissolution was homogenized while stirring and glycine was added maintaining glycine to nitrate molar ratio in a unit.

The resulting viscous liquid was autoignited by heating up to approximately to 455 ºC (violent explosion).

Powders with very fine grains and very voluminous have been obtained.

The resulting powders were ball milled.



Powders were calcined between 600 and 800°C for 5 h to remove carbon residues and in the case of MCF10, LNF60 and LSF40, were pelletized and calcined in air at 950 °C for 8 h to obtain pure samples.

Characterization

ICP+XRF

Table 1: Summary ICP results for LSF40 (La, Sr, Fe), LNF60 (La, Ni, Fe) and MCF10 (Mn, Co, Fe).

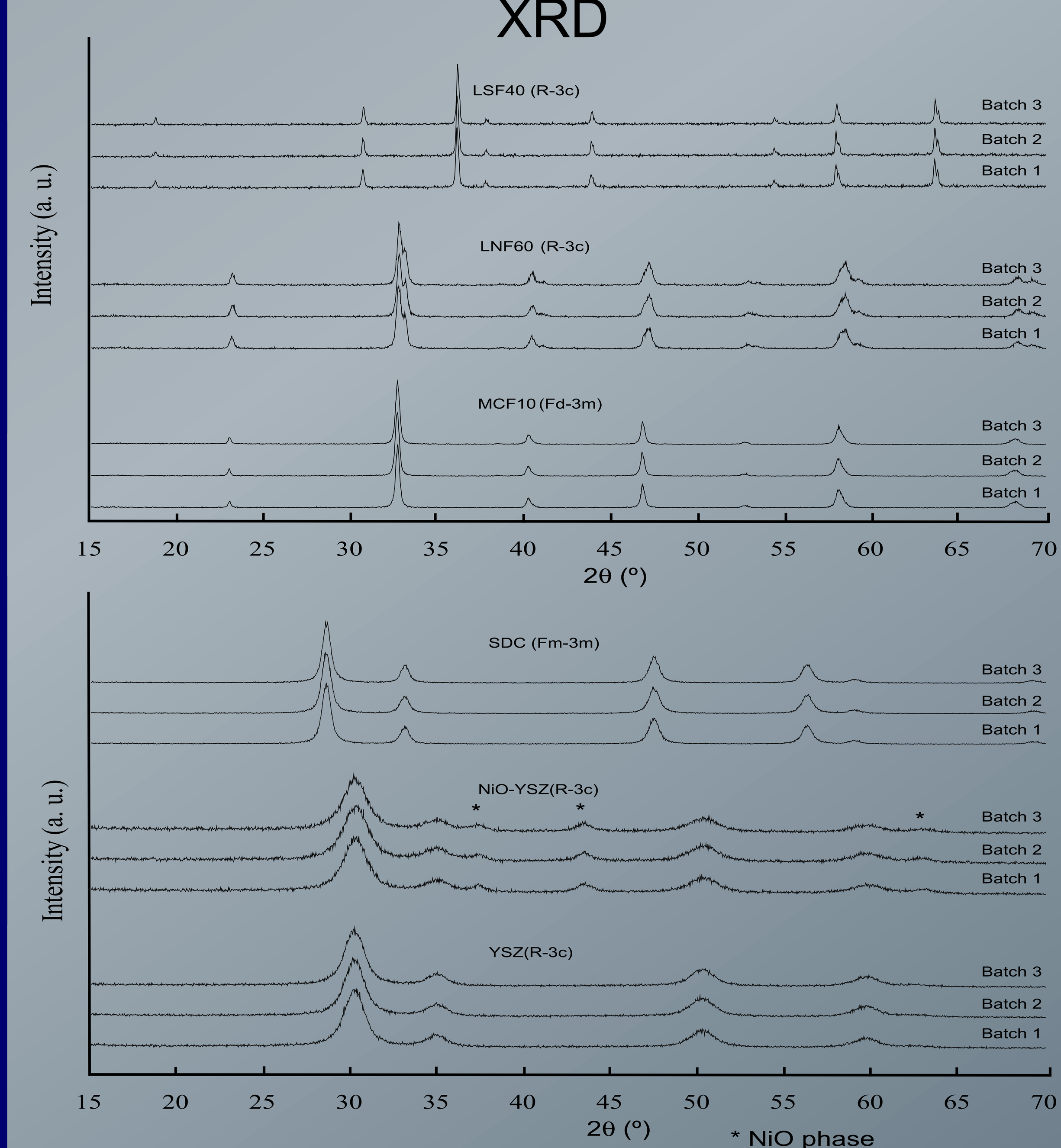
	Sr	La	Fe	Ni	Mn	Co
LSF40	0.41(1)	0.58(2)	1.02(3)	---	---	---
LSF40	0.40(1)	0.58(2)	1.01(3)	---	---	---
LSF40	0.41(1)	0.58(2)	1.02(3)	---	---	---
LNF60 (Batch 1)	---	0.98(9)	0.41(6)	0.61(8)	---	---
LNF60 (Batch 2)	---	0.97(9)	0.41(6)	0.60(8)	---	---
LNF60 (Batch 3)	---	1.02(9)	0.45(6)	0.65(8)	---	---
MCF10	---	---	0.10(1)	---	0.99(4)	1.86(5)
MCF10	---	---	0.10(1)	---	1.02(4)	1.90(5)
MCF10	---	---	0.10(1)	---	0.98(4)	1.93(5)

Table 2: Summary XRF results for SDC (Sm, Ce), NiO-YSZ (Ni, Y, Zr) and YSZ (Y, Zr).

	Zr	Y	Ni	Sm	Ce
SDC (Batch 1)	---	---	---	0.7(5)	0.2(4)
SDC (Batch 2)	---	---	---	0.7(5)	0.2(4)
SDC (Batch 3)	---	---	---	0.7(5)	0.2(4)
NiO-YSZ (Batch 1)	0.9(3)	0.2(2)	0.3(4)	---	---
NiO-YSZ (Batch 2)	0.9(3)	0.2(2)	0.3(4)	---	---
NiO-YSZ (Batch 3)	0.9(3)	0.2(2)	0.3(4)	---	---
YSZ (Batch 1)	0.8(6)	0.2(2)	---	---	---
YSZ (Batch 2)	0.8(6)	0.2(2)	---	---	---
YSZ (Batch 3)	0.8(6)	0.2(2)	---	---	---

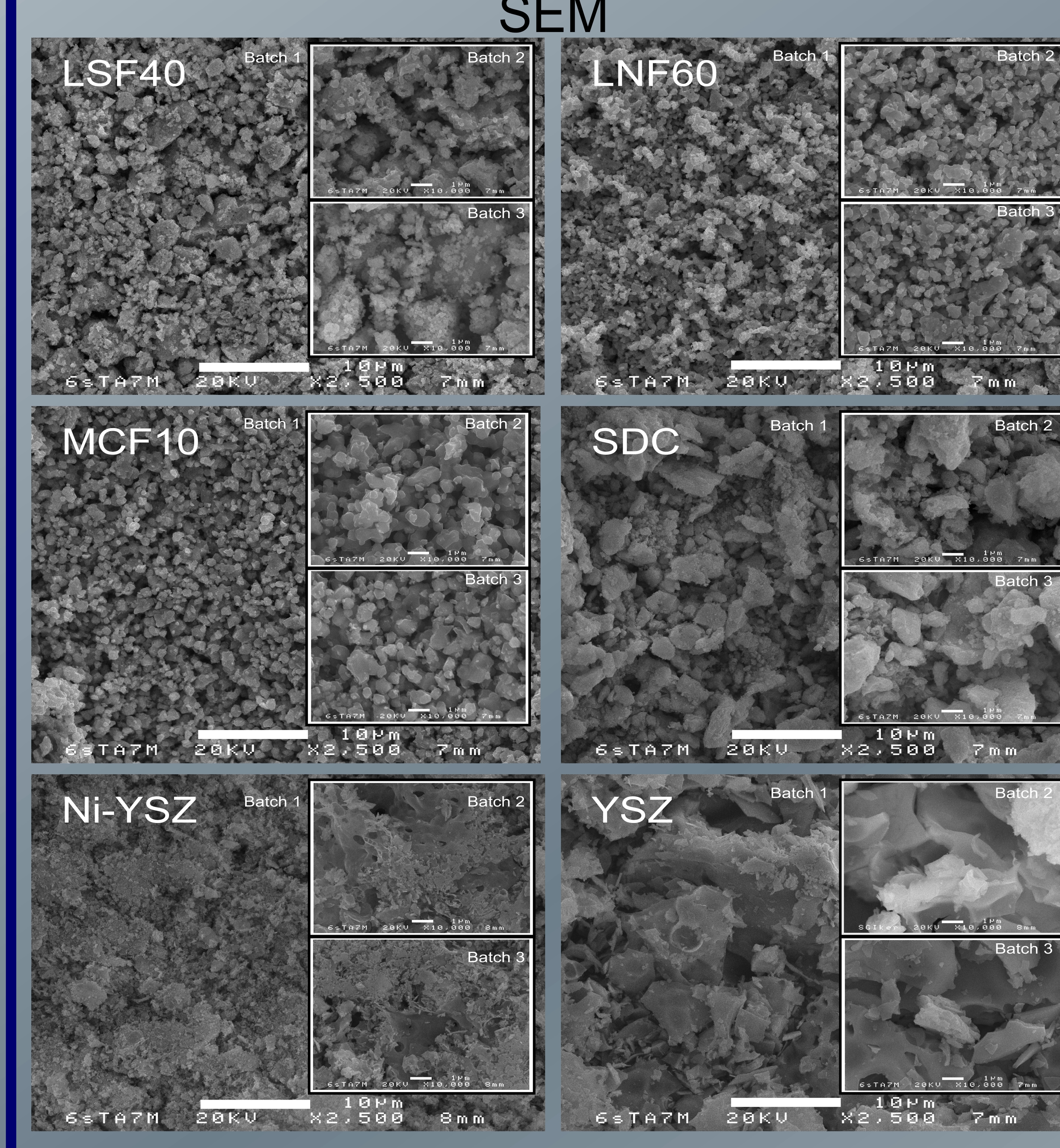
Within the experimental errors for all the samples, the experimental compositional values match the nominal composition. In all the cases, the difference between the relative amounts of the elements in different batches was not significant. Thus, the synthesis procedure shows an adequate chemical reproducibility.

XRD



The purity of the samples were studied by X-ray diffraction. All the materials present the desired final phases. For the LNF60 compound, the appearance of extra shoulders in the experimental profile indicates a possible phase segregation to give two perovskite phase with different Ni/Fe ratio.

SEM



In all the cases, the agglomerates formed during the combustion reaction are usually soft and easy to break due to the higher escaping gases for these samples [3]. In addition, comparing the same compound between different batches, it can be shown that the particle sizes and shapes are homogeneous.

Conclusions

- Six fuel cell different compounds have been easily synthesized in big amounts by glycine-nitrate method with stoichiometric fuel/oxidizer ratio.
- The synthesis has demonstrated to be compositionally and morphologically reproducible in different batches. Therefore, it can be concluded that the glycine-nitrate process, with an optimal G/N ratio of 1.0, is an appropriate technique for preparing big quantities of different compounds for SOFC fabrication.

Acknowledgements

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References

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