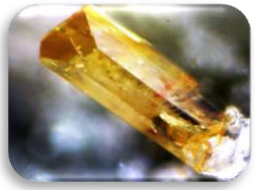
ERA-MIN 2

RESEARCH & INNOVATION PROGRAMME
ON RAW MATERIALS
TO FOSTER CIRCULAR ECONOMY



MONAMIX

New concepts for efficient extraction of mixed rare earths oxides from monazite concentrates and their potential use as dopant in high temperature coatings and sintered materials

Project coordinator: Radu-Robert Piticescu/National R&D Institute for Nonferrous and Rare Metals-IMNR/Romania

ERA-MIN 2 Final Conference and Final Seminar of Call 2017 projects
18-19th November 2021

Co-funded by the Horizon 2020 programme
of the European Union

Consortium

- Main call topic and subtopics addressed by the project:

2.1. Product design for increased raw material efficiency

- Project start 01.05.2018–end 31.10.2021/duration 42 Months
- Project consortium

National R&D Institute for Nonferrous and Rare Metals, Romania, funding authority UEFISCDI Romania

Italian National Agency for New Technologies, Energy and Sustainable Economic Development – ENEA Rome/funded by MIUR, **Italy**

MGM Star Construct SRL Bucharest, SME, **Romania/funded by UEFISCDI Romania**

Institute for Condensed Materials Chemistry – ICMCB Bordeaux/funded by ANR, **France**

- Start – end TRL: 2 - 5
- Project budget: **562,750 €**/requested funding **517,750 €** / % project execution: **100**

Co-funded by the Horizon 2020 programme of the European Union

Final Results

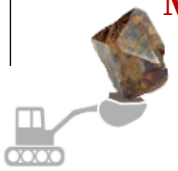
- Project **objectives and expect impacts** vs **final results and impact**

The objective of MONAMIX project was to demonstrate the potential use of mixed REOs obtained from monazite concentrates with natural occurring composition as dopant in the design of **high temperature oxide coatings** and **sintered zirconia-based oxide materials,** with high impact in reducing the actually reagents consumption and costs by eliminating the whole cycle of individual REO extraction and separation and decrease the production costs along the whole fabrication cycle from raw materials to product.

Co-funded by the Horizon 2020 programme of the European Union

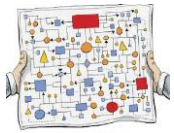
Final Results

MONAZITE (Ce, La, Nd, Th, Y, Dy, Sm)(PO_4)



Concentration and separation in individual REO:

- Complex process



large quantities of chemical reagents

waste gas, waste water

- High cost process

What happens if we use these mixed REO sites ?!

MONAMIX PROJECT

Mixed REO ✓

Individual REOs ✗

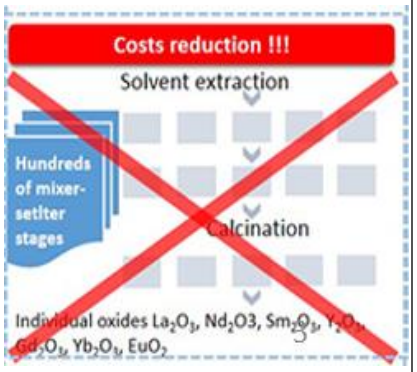
dopants agent

REO doped ZrO_2

ZrO_2

Used in TBC

Potential SOFC



transition

efficient economy

in terms of resource use

- ☑ To increase the lifetime of Ni / Cr alloys
- ☑ To obtain solid electrolytes for SOFCs

Co-funded by the Horizon 2020 programme of the European Union

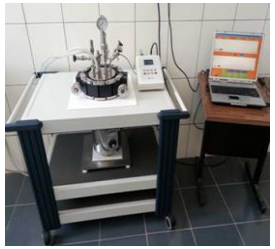
Final Results: Hydro-chemical technology

HYDROTHERMAL SYNTHESIS

$ZrCl_4$ solution

Hot mixing with stirring ← **Naturally mixed REOs**

Doped solution ← **NH_3**



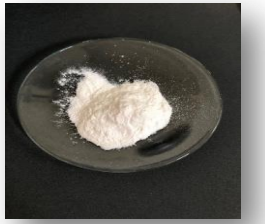
Hydrothermal treatment
Berghof autoclave
(T,P,t)

Filtration

Three stages washing

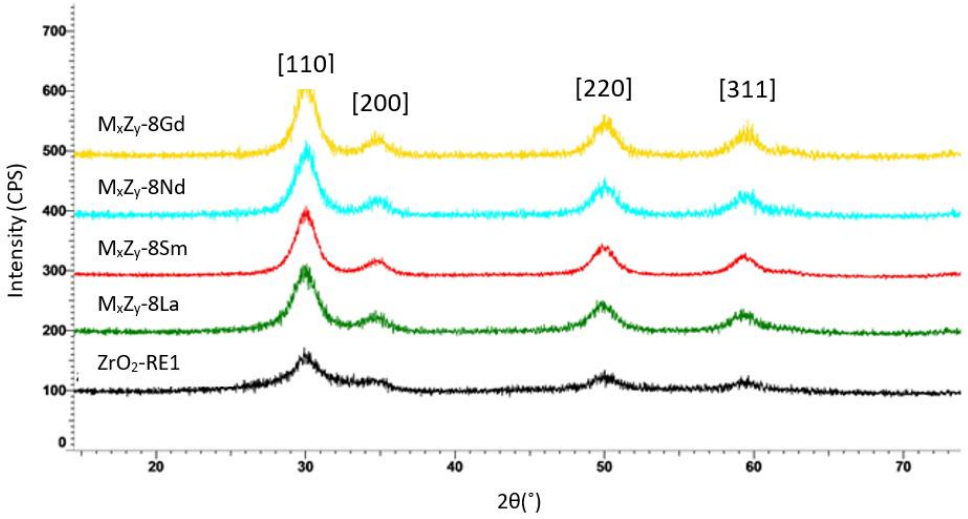
Drying

DRY CERAMIC POWDERS



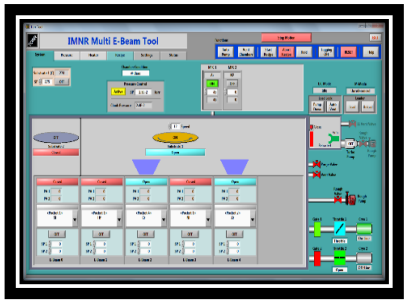
Sample		Chemical Analysis						
		La	Gd	Y	Yb	Sm	Nd	Zr
ZrO_2-RE1	wt.%	3.49	0.278	0.46	0.0032	0.409	2.33	52.19
MxZy8La	wt.%	8	-	5.50	-	<0.004	-	63.32
MxZy8Sm	wt.%	-	-	5.77	-	9.28		60.46
MxZy8Nd	wt.%	-	-	5.70	-	-	8.09	61.50
MxZy8Gd	wt.%	-	9.93	5.68	-	-	-	60.03

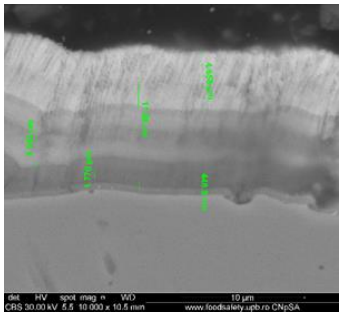
R.R. Piticescu, M.L.Grilli et al., Metals 2020, 10, 746; doi:10.3390/met10060746

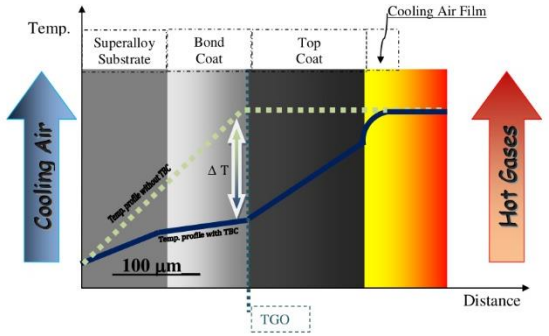


Co-funded by the Horizon 2020 programme of the European Union

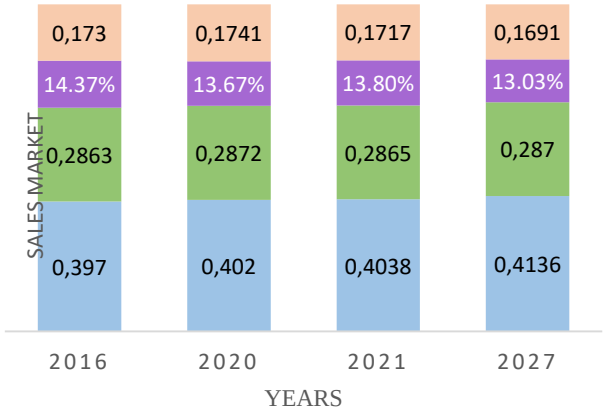
Final Results: EB-PVD REOs-ZrO_2 TBCs

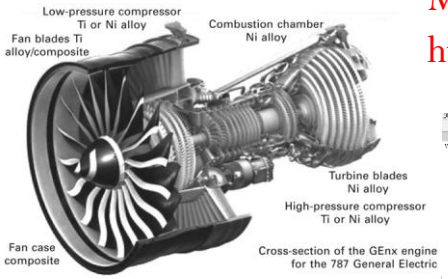




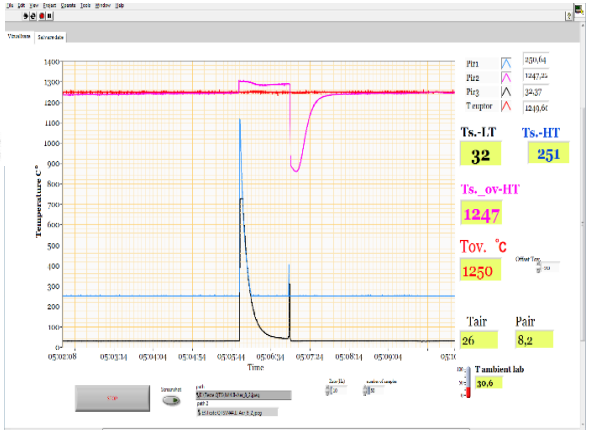


Combinatorial EB-PVD pilot 4 e-guns x 4 crucibles (IMNR)





M.L.Grilli et al,
Materials **2021**, 14, 1656.
https://doi.org/10.3390/ma14071656

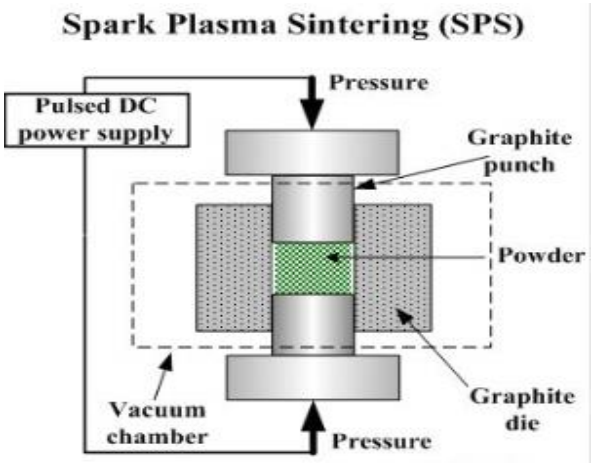


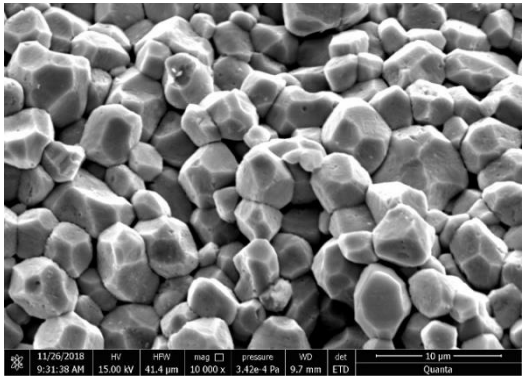
Total sales 697.07 M USD in 2016, 1990.43 M USD in 2021, expected 2827.82 M USD by 2027. CAGR 6.03% (2021 to 2027). For 5% of the estimated need at European level in 2027, respectively a coverage capacity of 2150 m.p./year the estimated price is **4260.33 EURO/ Kg**.

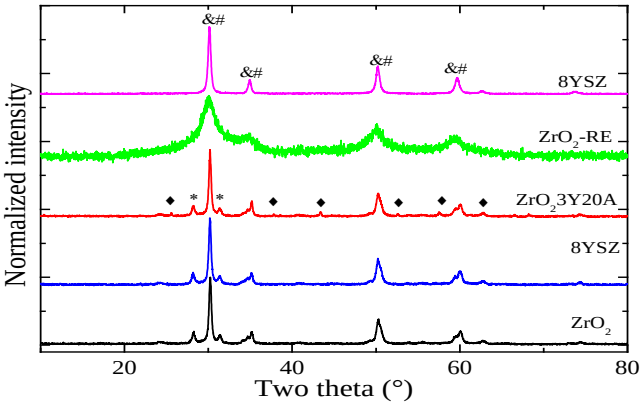
Thermal shock tests: 1200^{0}C limit achieved

Co-funded by the Horizon 2020 programme of the European Union

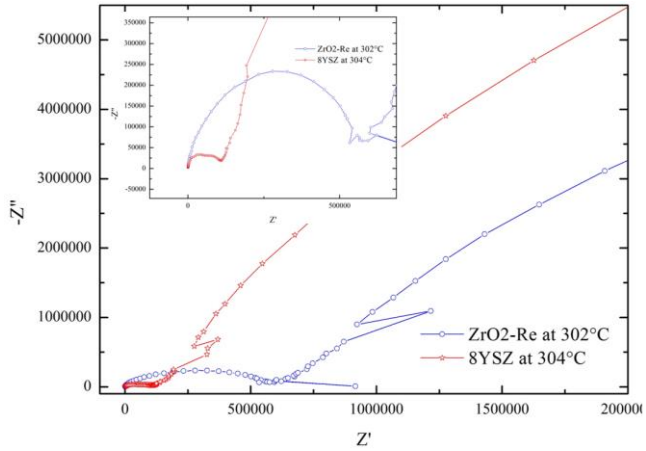
Final Results: sintered REOs-ZrO_2 ceramics







SEM and XRD of REOS doped-ZrO_2 pellets



Fully dense material (96% of theoretical).
Activation energy for ionic conductivity is **0.584 – 0.889 eV for REO doped ZrO_2, < 0.718 – 0.907 eV for 8YSZ.**
Preliminary studies demonstrated that ZrO_2-RE have a better ionic conductivity at moderated temperatures.

M. Prakasam et al, chapter book in Sintering Technology: Method and Application, ISBN 978-953-51-6802-7 INTECHOPEN

Co-funded by the Horizon 2020 programme of the European Union

Final Results

Outputs (publications, conferences, patents, awards, new or improved product/method/service):

6 publications in ISI and open access journals and book chapters

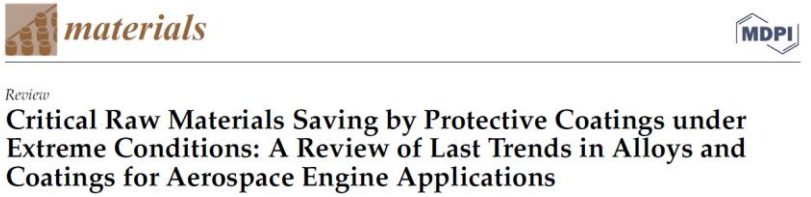
- Materials 2021, 14, 1656 https://doi.org/10.3390/ma14071656 (ENEA, IMNR)
- Metals 2020, 10, 746 https://doi.org/10.3390/ma13214797 (ENEA, IMNR, ICMCB)
- Sintering Technology, ISBN 978-953-51-6802-7 http://dx.doi.org/10.5772/intechopen.81323 (ALL)
- Nanomaterials: Functional Properties and Applications, vol. 28, 203-215 (IMNR, ICMCB)
- J. Nuclear Res. Development 2019, 18, pp. 18-23 (IMNR, ICMCB, ENEA)
- PSSA 2021, in press (ENEA), https://doi.org/10.1002/pssa.202100398

11 participations in Scientific Conferences (9 oral, 2 posters)

1 Romanian Patent Request (a 2019 00876/09.12.2019)

2 awards in Int. Fairs (Bronze medal-Euroinvent 2019; Gold Medal -Traian Vuia 2021)

3 Technologies and 2 new products


materials MDPI

Review

Critical Raw Materials Saving by Protective Coatings under Extreme Conditions: A Review of Last Trends in Alloys and Coatings for Aerospace Engine Applications

Maria Luisa Grilli [1,*], Daniele Valerini [2], Anca Elena Slobozeanu [3,*], Bogdan O. Postolnyi [4,5], Sebastian Balos [6], Antonella Rizzo [2] and Radu Robert Piticescu [3]

Co-funded by the Horizon 2020 programme of the European Union

Final Results

- Communication and dissemination activities (tools/audiences/stakeholders/end-users/public in general)

Active participation in COST Action 15102 "CRM Extreme" (2016-2020) and COST Innovation Grant CIG 15102 ITHACA (2020-2021):

-Over 500 participants from all EU countries

-Contacts with agencies, big companies, end-users:

Romanian Space Agency ROSA,

EASN- European Aeronautics Science Network,

Apulia Aerospace Technological District (DTA),

D4S Group Durante Space Tech

Co-funded by the Horizon 2020 programme of the European Union

Impact

- Lessons learnt (i.e. impact of COVID-19): Digitalization is the winner
- Have you cooperated with policymakers during the lifetime of the project? ERMA
- Have the results been implemented by the industry to some extent? Pre-feasibility study completed by SME partner MGM Star Construct srl
- Have the results contributed to white papers, regulations or standards? NO
- How have the results contributed to the priorities of the ERA-MIN Research Agenda and the Strategic Implementation Plan of the EIP on Raw Materials?: IMNR is active member in ERMA
- What's the biggest impact that the project has produced in the regions/countries of consortium partners? We have developed an integrated technology for REOs-doped Zirconia materials and coatings testes at TRL5

Co-funded by the Horizon 2020 programme of the European Union

Follow-up

- How will the research results of the project be utilised?

- We intend to valorize the know-how in new Horizon Europe Projects related to Cluster 4 and Cluster 5.

- Will the cooperation continue after the end of this project?

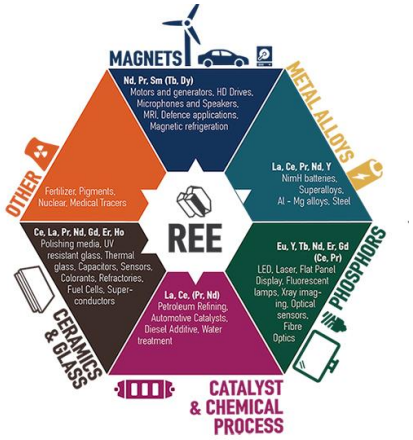
Yes, we will participate together in new Horizon Europe Proposals

Co-funded by the Horizon 2020 programme of the European Union

ERA·MIN 2

Follow-up

Thank you for your attention



Consortium

Coordinator: National R&D Institute for Nonferrous and Rare Metals-IMNR, **Romania**
Project Director: Dr. Radu-Robert Piticescu

Italian National Agency for New Technologies, Energy and Sustainable Economic Development – ENEA, **Italy**
Project Responsible: Dr. Maria Luisa Grilli

Institute for Condensed Materials Chemistry – ICMCB Bordeaux, **France**
Project Responsible: Dr. Mythili Prakasam

MGM Star Construct SRL Bucharest, **Romania**
Project Responsible: Arcadie Sobetkii, Scientific Director

Co-funded by the Horizon 2020 programme of the European Union