Target production

1) Choose the wanted material

Preliminary diffusion, effusion and release calculations / In-depth knowledge of the material properties

Chemical composition:	material typology (UCx, ThCx, SiC, TiC, LaC2, ...), stechiometry, impurities,...
Structural composition:	crystalline grains sizes, crystalline grains distribution,...
Porosity:	amount, distribution, pores sizes, interconnessions,...
Thermal properties:	thermal conductivity, melting point, etc..
Mechanical properties:	thermal induced stress,...
Optical properties:	emissivity,..

2) How obtain the established material?

Strict controlled and reproducible processes

3) Verify if we have obtained the established material

In-depth (compositional, structural, thermal,…) characterization

4) Understand if the established material is really a good material

Testing measurements under beam

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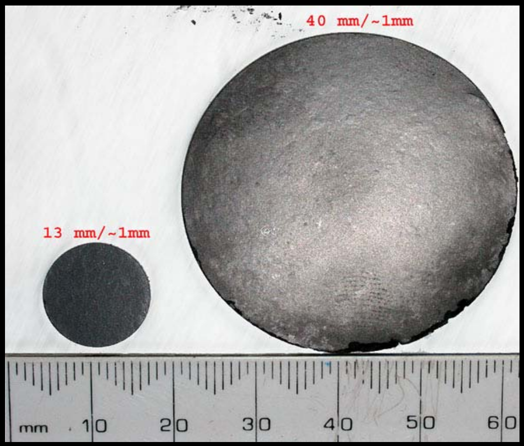
An example: LaC_2 pellets production

(Similar chemical & mechanical properties of UCx and ThCx)

1) Production of La_2O_3 in graphite matrix (starting material)



2) Thermal treatment (1800°C)

a) CARBURIZATION PROCESS $La_2O_3 + 11C \rightarrow 2LaC_2 + 4C + 3CO \uparrow$ (Theoretical mass loss: 18.5%)

b) SINTERING PROCESS

It is OF FUNDAMENTAL IMPORTANCE:

A) To establish a CONTROLLED AND REPRODUCIBLE PROCESS

Strict monitoring of the process

B) To obtain a DEEP KNOWLEDGE of the produced material (LaC_2 + C)

In depth characterization of the final material

Monitoring of the thermal process

($La_2O_3 + 11C \rightarrow 2LaC_2 + 4C + 3CO \uparrow$) (Theoretical mass loss: 18.5%)

1) Monitoring of THE PRESSURE in the chamber during the thermal treatment

(evaluate the reaction evolution monitoring the degasing of reaction products as H_2O, CO, CO_2, …)

2) Monitoring of THE RELEASED GASES during the thermal treatment (mass spectrometer)

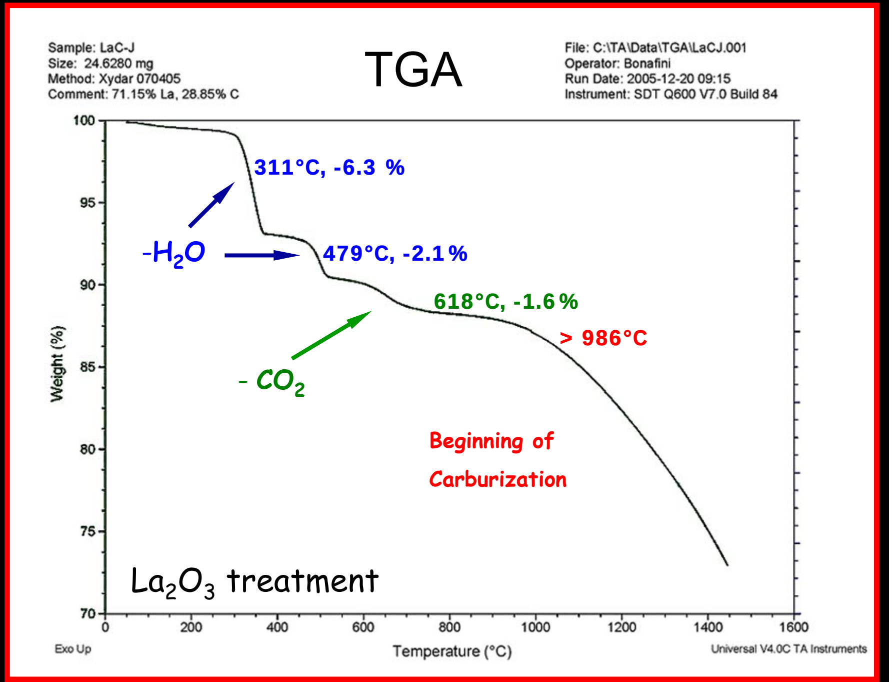
(allows to distinguish the reaction products → to have an increased control of the process)

3) Monitoring of THE MASS of the sample during the thermal treatment

(thermal analysis)

(allows to increase the control of the process)

4) Other simple and powerfull monitoring techniques are welcome



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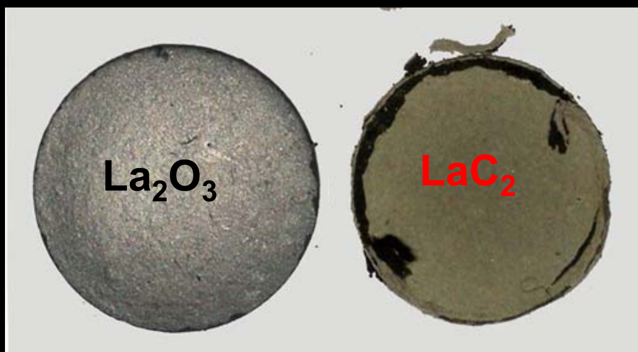
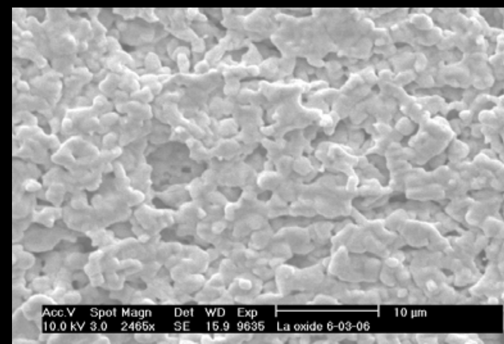
LaC_2 characterization

Commonly used techniques

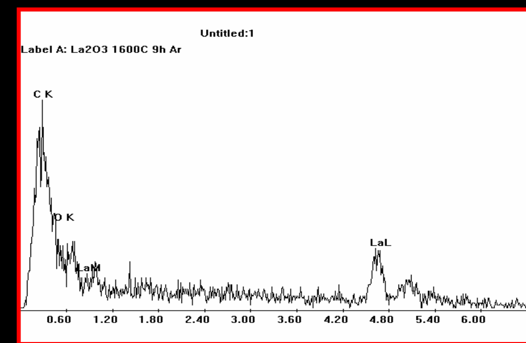
1) THE COLOUR



2) SEM PICTURES



3) EDAX ANALYSIS



Is the reaction occurred?
(very qualitative)

Sintering degree
(only on the surface)

Compositional information
(qualitative, especially for light elements (C,O,..))

OBTAINED INFORMATIONS

What kind of important INFORMATIONS HAVE NOT WE OBTAINED?

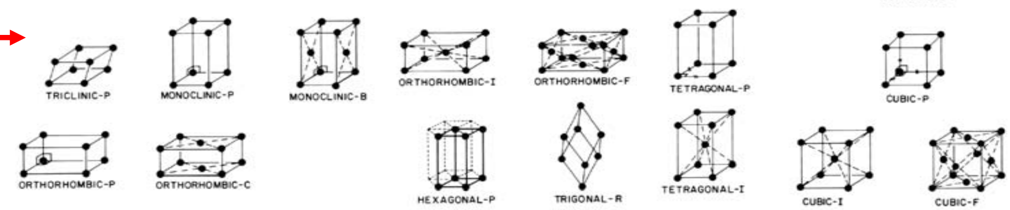
1) Impurities nature and amount (direct influence on melting point)

2) Grains sizes (direct influence on diffusion, effusion and release processes)

LaC_2 characterization

X Ray Diffraction (XRD) technique

Each crystalline solid has made of an unique unit cell (a Bravais lattice)



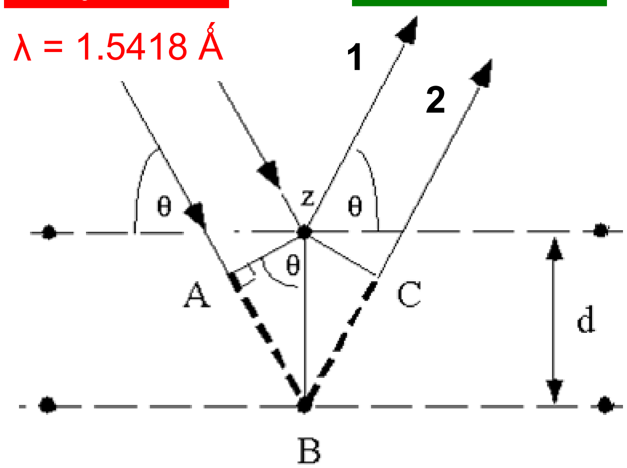
The 14 Bravais lattices

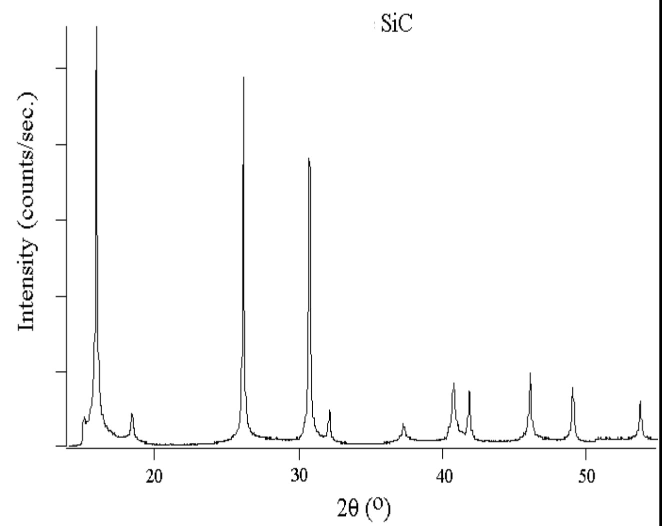
It is possible to investigate what kind of Bravais lattice by means of XRD technique

X ray source

X ray detector

λ = 1.5418 Å





The Bragg law

AB + BC = n λ

AB = BC = d sin θ

n λ = 2 d sin θ

XRD PATTERNS (peak positions, height and width) DEPEND ON:

1) THE SHAPE OF THE UNIT CELL
2) THE SIZE OF THE UNIT CELL
3) THE TYPE OF ATOMS PRESENT IN THE UNIT CELL
4) THE ARRANGMENT OF THE ATOMS IN THE UNIT CELL

EACH CRYSTALLINE SUBSTANCE HAS A UNIQUE XRD PATTERN (LIKE A FINGERPRINT !!!)

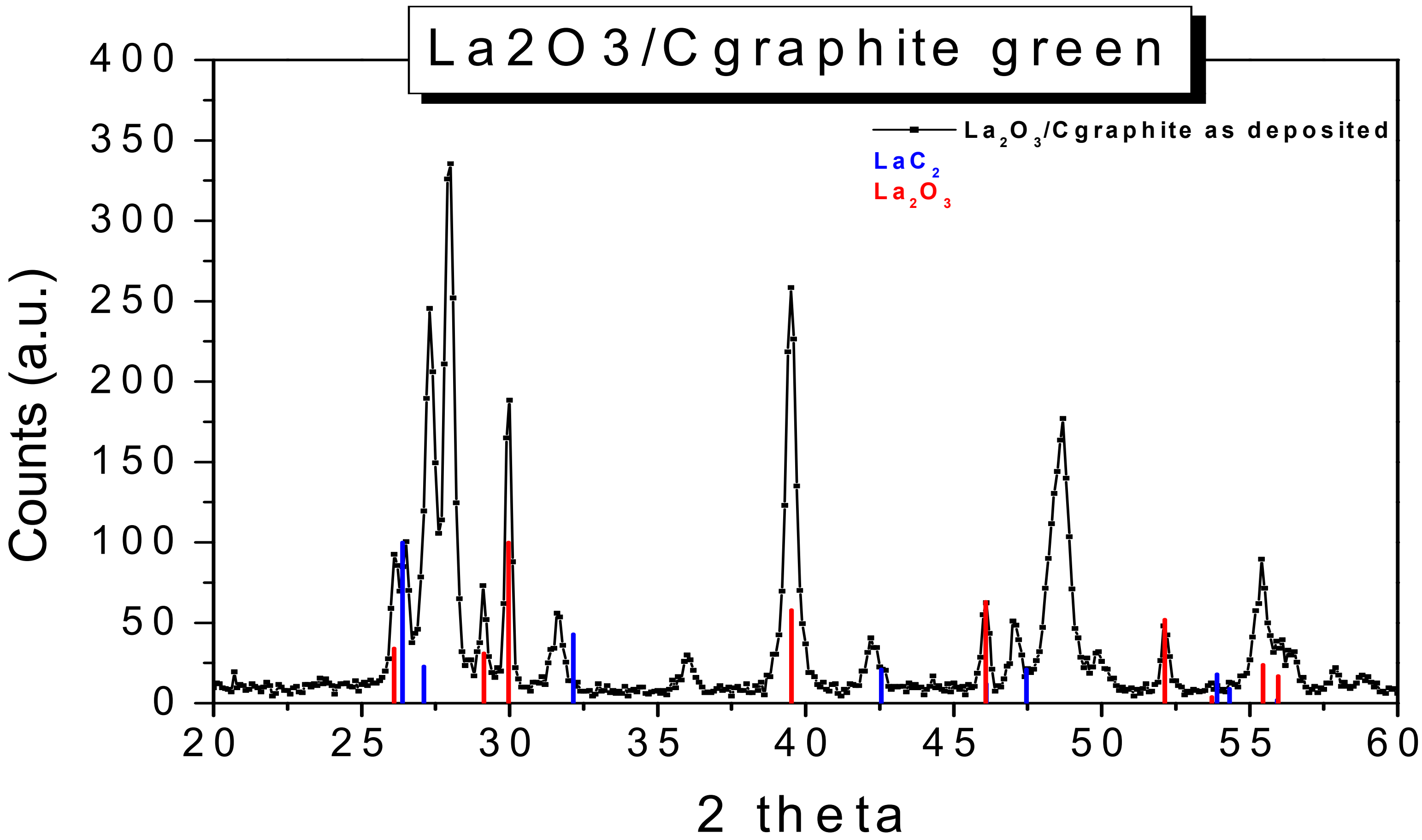
XRD PATTERNS ALLOWS TO OBTAIN INFORMATIONS ON

1) **THE NATURE OF THE CRYSTALLINE SUBSTANCE** (CORRELATED WITH THE POSITION AND INTENSITY OF THE PEAKS)

2) **THE AVERAGE DIMENSION OF CRYSTALLINE GRAINS** (MORE HIGH THE HEIGHT / WIDTH PEAK RATIO→ MORE LARGE THE AVERAGE SIZES OF THE GRAINS)

3) **THE PRESENCE AND THE NATURE OF IMPURITIES** (PRESENCE OF EXTRANEOUS PEAKS)

XRD characterization: GREEN MATERIAL



PRESENCE OF LA_2O_3 (THERE ARE SEVERAL LANTHANUM OXIDE PEAKS)

NO PRESENCE OF LAC_2 (THERE NOT ARE ANY LANTHANUM CARBIDE PEAK)

PRESENCE OF IMPURITIES LIKE GRAPHITE, BINDER (PRESENCE OF EXTRANEOUS PEAKS)

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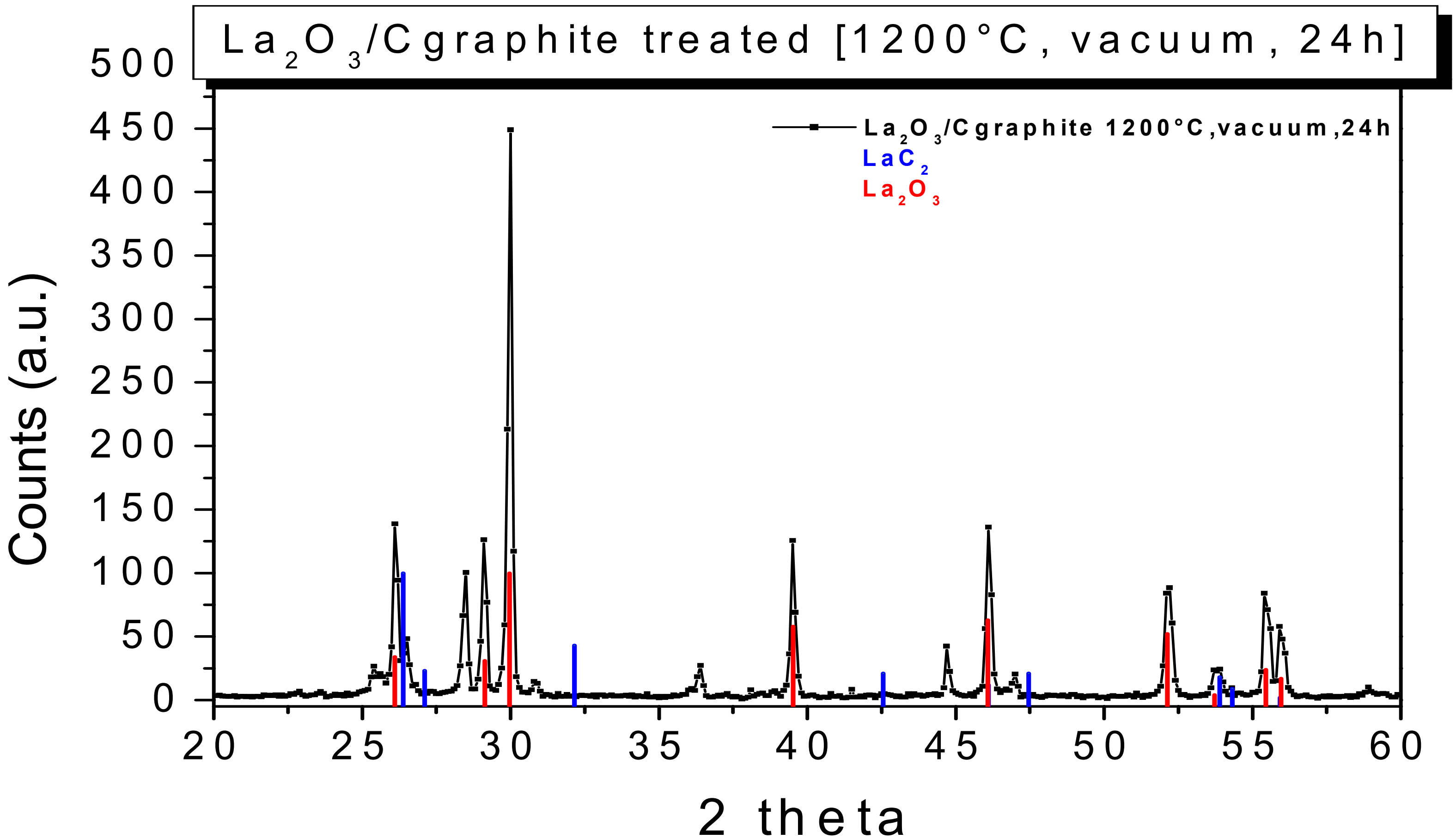
TREATED MATERIAL [1200 °C, vacuum, 24h]

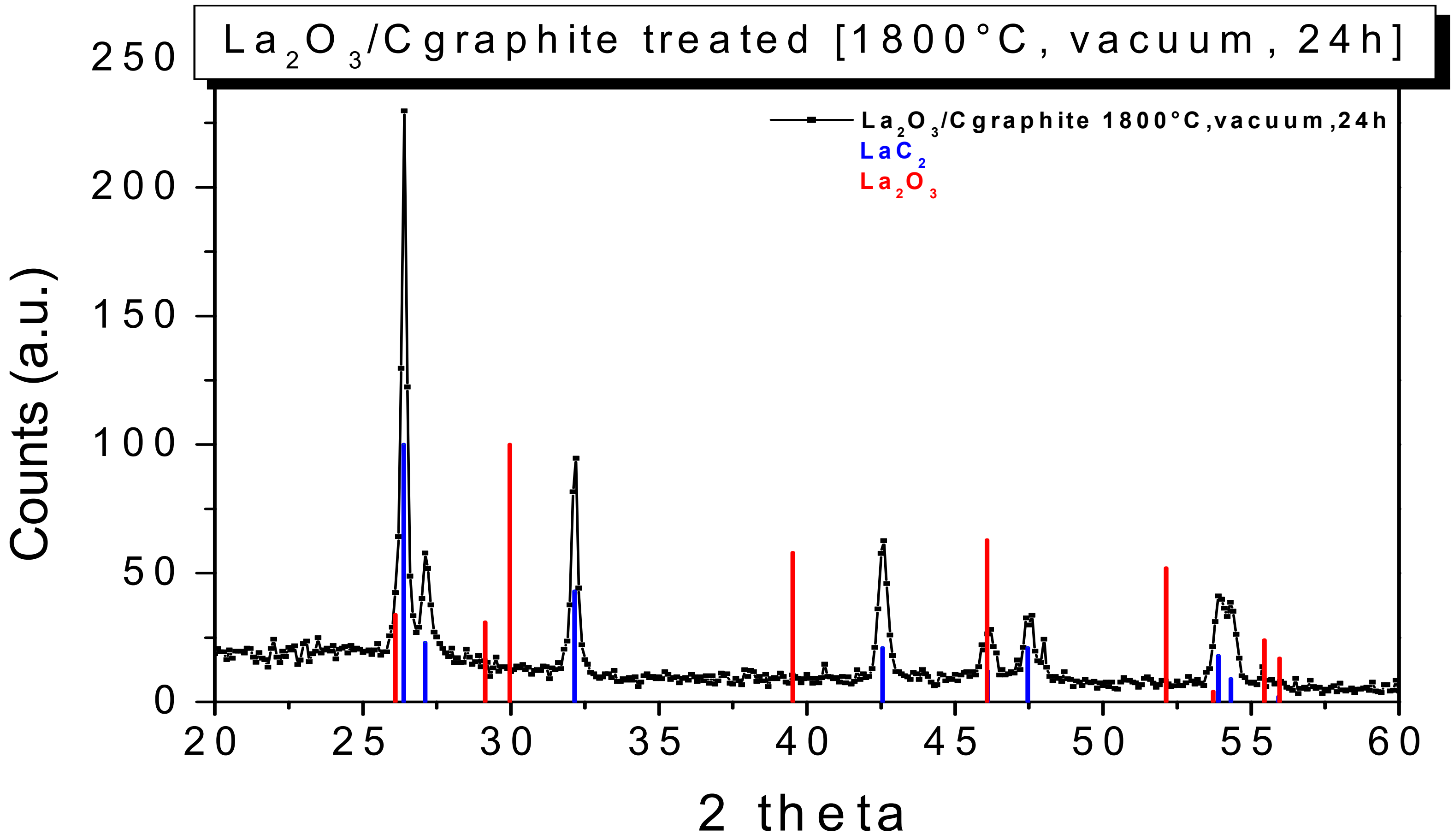


1) SAMPLE MADE UP BY LANTHANUM OXIDE (HEXANOGAL STRUCTURES)
   La2O3 PEAKS ARE NARROW AND HIGH → LARGE CRYSTALLINE GRAINS

2) NO PRESENCE OF CARBIDES

3) DECREASE OF IMPURITIES AMOUNTS (DECREASE OF EXTRANEOUS PEAKS)

TREATED MATERIAL [1800 °C, vacuum, 24h]



1) NO PRESENCE OF LANTHANUM OXIDES

2) SAMPLE MADE UP BY LaC_2 CARBIDE (LARGE GRAINS, VERY NARROW AND HIGH PEAKS)

3) NO PRESENCE OF IMPURITIES (NO PRESENCE OF EXTRANEOUS PEAKS)

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In "conclusion"…

Target production needs:

1) Strict control of production process with:
   - use of the existent monitoring techniques;
   - development of further monitoring techniques.

2) Deep characterization analyses on the produced targets:
   - establishment of a whole of simple and powerfull characterization techniques

To get a real knowledge of the parameters that play important roles in diffusion effusion and release processes ⟷ To obtain real diffusion and effusion data so to have more significative models

3) Testing measurements under beams in order to understand the effects of the different target features on the target performances

What do you think?