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IFAST WP4 – Task 4.4:

Large scale Carbide-Carbon Materials for multipurpose applications

Open Steering Committee

16th November 2021

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With contributions from C. Accettura, J. Guardia, C. Gutierrez and S. Rivera

IFAST

Task 4.4 – Objectives and Participants

- Large scale Carbide-Carbon Materials for multipurpose applications (M1 – M48)
  - **Promote the use of carbide-carbon materials (CCM)** in future particle physics facilities and open up the market to commercial applications
  - Thermal conductivity 2-3 times higher than Cu! Stronger, low density

- How?

3x larger volume per sintering cycle

+

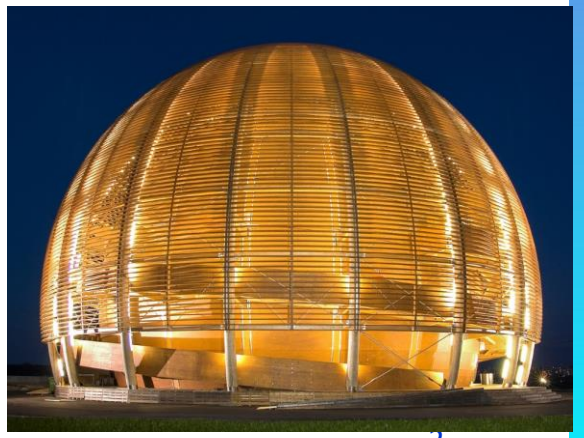
1.5x lower sintering temperature material

→ **2x Cost Reduction**

- Who?

nanoker
TAKING PROFIT FROM THE SMALL

CERN



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Task 4.4 – Deliverables and Budget

Milestone/Deliverable Number	Title	Lead beneficiary	Type	Dissemination level	Due Date (in months)
MS14	Evaluation of a CCM alternative to Molybdenum-Graphite	CERN	Report	Public	16
D4.4	Production of large-size CCM plates	CERN	Demonstrator	Public	24

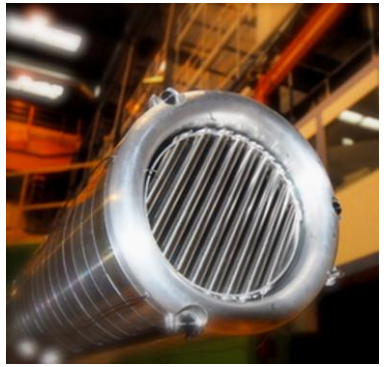
D4.4 description

- Produce two large CCM plates (cross section >400 cm^2) in a single sintering cycle

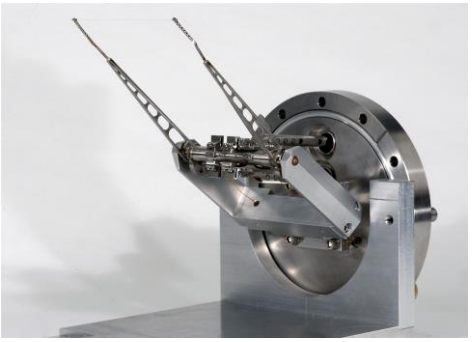
Beneficiary short name	Person-months	Monthly personnel cost	Personnel costs	Travel	Equipment and consumables	Other direct costs	Sub-contracting	Material direct costs	Total direct costs	Total indirect costs	Total costs (direct + indirect)	EC requested funding
CERN	3.0	8,000.00	24,000.00	16,000.00	20,000.00	10,000.00		46,000.00	70,000.00	17,500.00	87,500.00	35,000.00
Nanoker	10.0	3,500.00	35,000.00	3,000.00	95,000.00			98,000.00	133,000.00	33,250.00	166,250.00	85,000.00
Total	**13.0**		**59,000.00**	**19,000.00**	**115,000.00**	**10,000.00**	**0.00**	**144,000.00**	**203,000.00**	**50,750.00**	**253,750.00**	**120,000.00**

Task 4.4 – Motivation

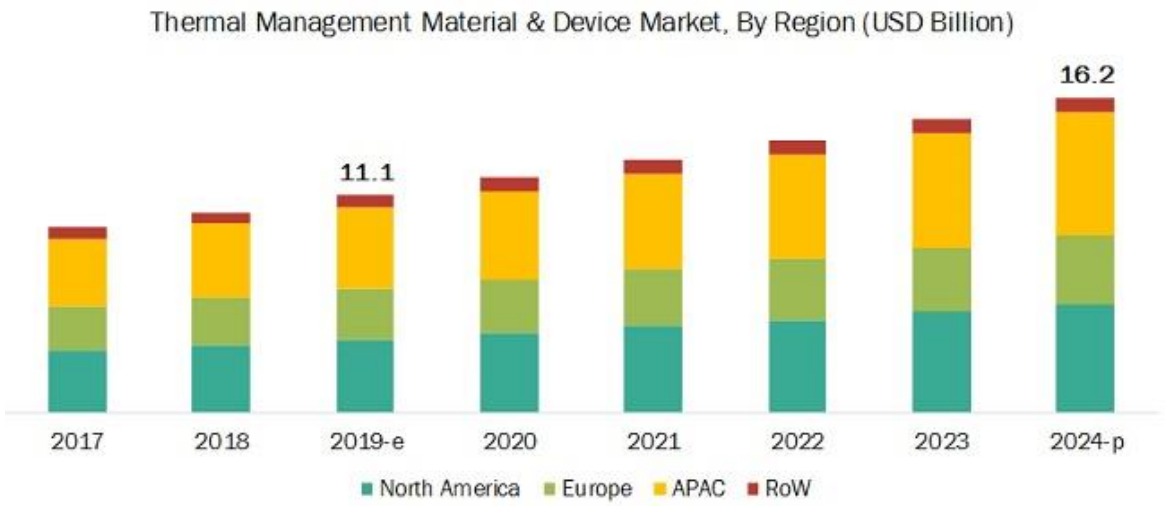
- **Increasing worldwide request for thermal management materials** (high thermal diffusivity and specific heat, low density)
- **Cost still high**: CCM are limited to high-end applications (nuclear energy, particle physics, aerospace, …)
- In particle physics: very interesting for **beam-intercepting devices and instrumentation**

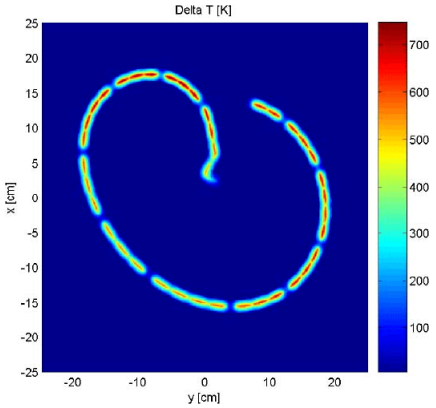


Targets

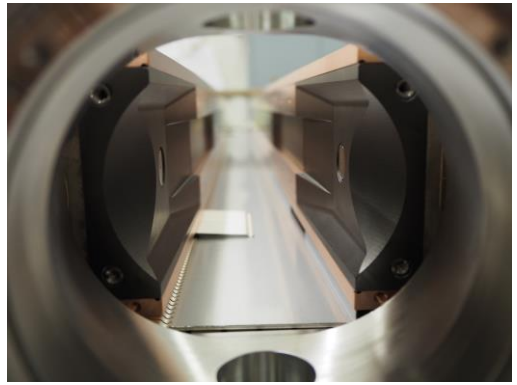


Beam wire scanners





Dumps



Collimators

Expected figures for the development of the thermal management market in the next years, source: *https://www.marketsandmarkets.com/Market-Reports/thermal-management-market-155049228.html*

Task 4.4 – CCM Production Cycle

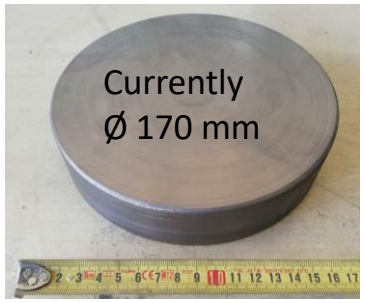
Selection and sieving of the powders

Preparation of the desired composition

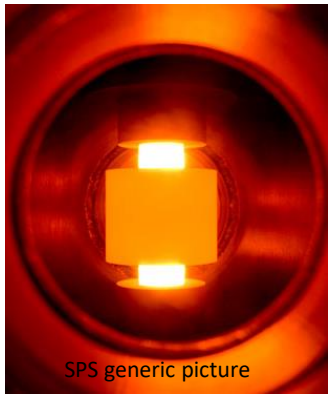
Powder	Vol. %
Graphite	93.9
Mo	5.5
Ti	0.6

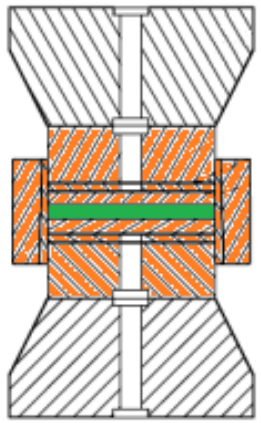
Mixing

Green body preparation



Spark Plasma Sintering (SPS) >25 MPa, >2600 °C

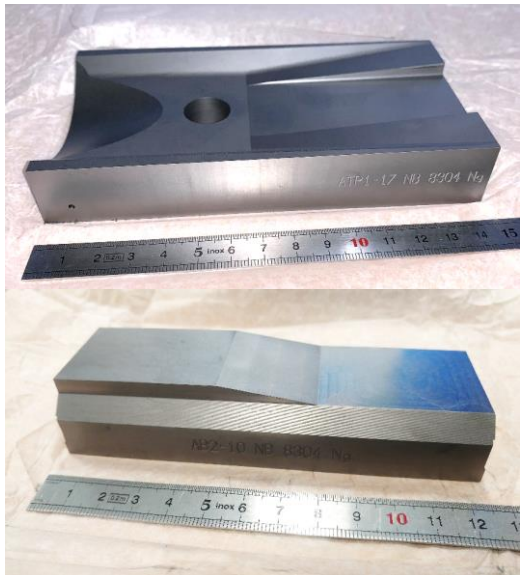




Sintered CCM
Single-use mould elements (graphite)

Stress relieving thermal treatment 0 MPa, >2400 °C

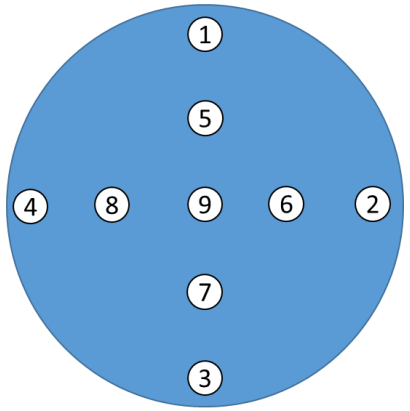
Machining of the pieces



Task 4.4 – Ongoing activities

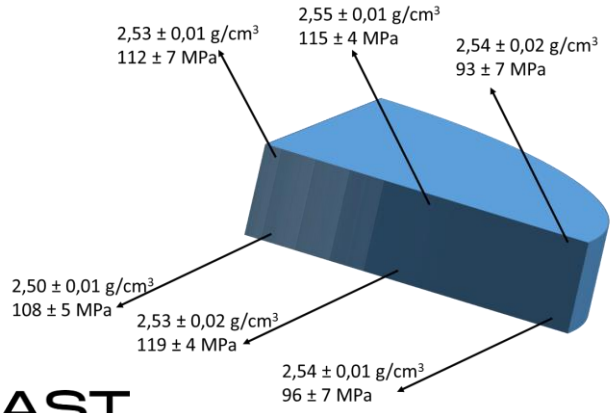
- **Molybdenum-Graphite** (sintered at 2640°C)

2 plates produced with 230 mm Diameter (2x bigger section than before IFAST)



Disk (230 mm diameter)	Density (g/cm³)	Electrical Conductivity (Mean values on each side) (MS/m)
Plate #1 (p=26 MPa)	**2,53**	**0,6 – 0,63**
Plate #2 (p=40 MPa)	**2,60**	**0,65 – 0,68**
Specification	**2,3 ÷2,6**	**>0,8**

Lower electrical conductivity values than in the 174 mm diameter disks



Pre-compaction of the green powder:

Maximum Applied Force Uniaxial Hydraulic Press ~ 900 kN

- 170 mm Ø → 40 MPa → 2,00 g/cm³
- 230 mm Ø → 21 MPa → 1,65 g/cm³

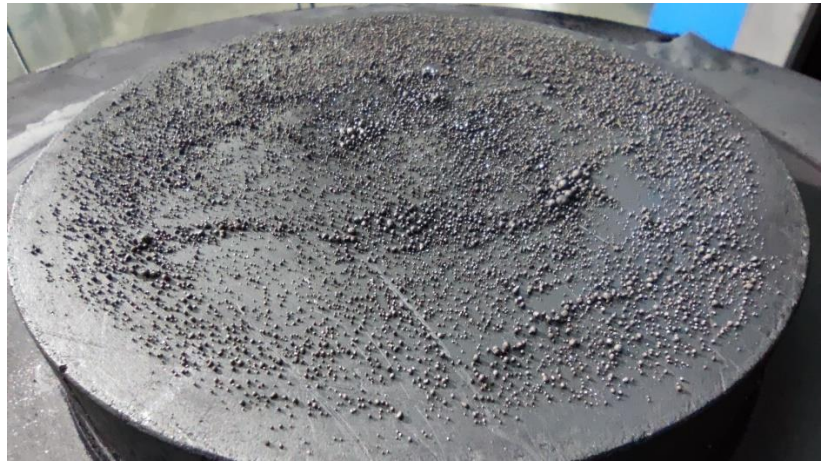
Next: increase the metal content, together with the higher pressure

Task 4.4 – Ongoing activities

- **Chromium-Graphite** (sintered at 2000°C – 1.3x lower T)

1 plate produced with 170 mm Diameter

Disk (170 mm diameter)	Density (g/cm^3)	Electrical Conductivity (MS/m)
Plate #1	**2,30**	**1,00 – 1,07**
Specification	**2,3 ÷2,6**	**>0,8**

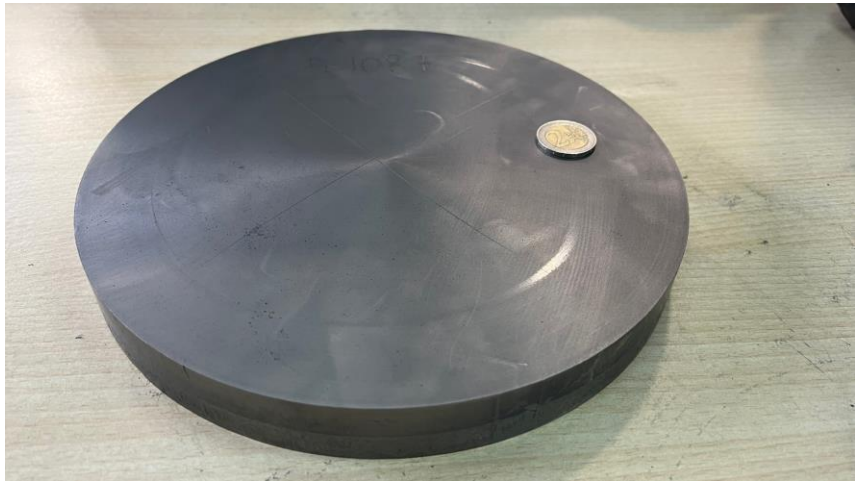


Reusable Mold and Parts → Important Cost Reduction

Next steps:

- Thermomechanical characterization at CERN
- Production of 170 mm diameter, 2 disks per cycle
- Upscale to 230 mm diameter, 1 disk per cycle
- Upscale to 230 mm diameter, 2 disk in one cycle

Task 4.4 – Ongoing activities



Task 4.4 – Conclusions and Next Steps

- Carbide-Carbon Materials are of great interest because of their **exceptional thermal transport properties**
- WP4.4 aims at reducing the production costs and increasing the available component size, in order to **promote their use in industry and research**
- CERN and Nanoker working at an **upscaling of the blank size and at a reduction of the production temperature**
- **Positive results** have already been obtained in both directions in the first 6 months of the project
- More tests are foreseen in the coming weeks to optimize the thermophysical properties of the material

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Thank you for your attention!

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