NOVEL CERAMICS AND COMPOSITES PROCESSING TECHNOLOGIES FOR ENERGY-INTENSIVE APPLICATIONS

27 SEPTEMBER, 2024

PISA, ITALY

WELCOME AND INTRODUCTION

Speaker: Prof. Andrea Lazzeri

CEM-WAVE

The CEM-WAVE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958170 The content of this document reflects only its authors' view and the European Commission is not responsible for any use that might be made of the information it contains.

Welcome to Pisa!

Pisa is world famous for its **Leaning Tower**, **the Cathedral**, the **oldest University Botanical Garden in the world** (founded in 1543) and many other historical monuments. It is in Tuscany, in the centre of the Italian peninsula, near the coast of the Mediterranean Sea.

In the city, the **University of Pisa** is a **public institution** with **twenty departments**, and high-level research centres in the agriculture, astrophysics, computer science, engineering, medicine and veterinary medicine sectors.

Nowadays the University of Pisa represents a prestigious modern centre for teaching and advanced research. Almost all its departments are located in the heart of the city in both the historical centre and the outer districts. Most facilities can be reached on foot within 20 minutes from the centre of Pisa.

Our research group is in **Department of Civil and Industrial Engineering (DICI)**

CEM-WAVE Coordination Team @ UNIPI

Our MISSION

Understanding and controlling, by careful processing, structure properties relations in polymers and composites with particular interests to mechanical properties, interphase adhesion, plasticity, creep, fatigue and fracture mechanics.

Our VISION

- Production of bio-based polymers and composites to solve the problems related to materials derived from oil.
- Improvement of mechanical and thermal properties of techno-polymers composites and ceramic composites.

Enjoy the final **CEM-WAVE Conference**! Please see a reminder of the agenda below

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PISA, ITALY

c/o Via Diotisalvi 2
Aula Magna Dini
Scuola di Ingegneria
Pisa

AGENDA

9:00 - 9:15	Welcome and Introduction	Prof. Andrea Lazzeri *University of Pisa*
9:15 - 9:45	From precursors to high performance fibers and ceramic matrix composites	Prof. Stefan Schafföner *Chair of Ceramic Materials Engineering* *University of Bayreuth*
9:45 - 10:15	Additive manufacturing of Ceramics from Preceramic Polymers	Prof. Paolo Colombo *University of Padova*
10:15 - 10:45	**COFFEE BREAK**	
10:45 - 11:15	Tailoring Adapted Ceramic Fibre Preforms by Wet Filament Winding Process	Dr. Alexander Konschak *Fraunhofer-Institute for Silicate Research ISC* *Center for High Temperature Materials and Design HTL*
11:15 - 11:45	MW-CVI production of large SiC-based CMCs for energy-intensive industries: a challenge won?	Dr. Roberto D'Ambrosio *Institute for Chemical-Physical Processes,* *National Research Council*
11:45 - 12:15	Why and how Micro-Wave Chemical Vapor Infiltration and other Thermal-Gradient Chemical Vapor Infiltration techniques can achieve optimal Ceramic-matrix Composites fabrication	Prof. Gerard Vignoles *University of Bordeaux, CNRS, CEA, Safran:* *Lab. for ThermoStructural Composites, LCTS*

12:15 - 12:45	Development of joining and surface engineering techniques for ceramics and composites under extreme environment	Prof. Valentina Casalegno *Department of applied science and technology* *Politecnico di Torino*
12:45 - 13:15	Research and Development of Braided CMC Technologies, SiC-CVI Joining and novel DLI-CVD EBCs at ATL for Demanding Combustion Environments	Dr. Michael Farnham *Archer Technicoat Ltd*
13:15 - 15:00	**LUNCH**	
15:00 - 15:30	Carbo ceramic materials for brake disc applications: 25 years of development Ceramic-matrix Composites fabrication	Dr. Marco Orlandi *Brembo SGL Carbon Ceramic Brakes Group*
15:30 - 16:00	Innovative technical ceramics processing routes and solutions for different demanding applications	Dr. Riccardo Rovai *Industrie Bitossi* *Colorobbia Group*
16:00 - 17:00	**COFFEE BREAK**	
	CLOSURE OF THE CONFERENCE	

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The Ceramic Matrix Composites (CMC) Revolution

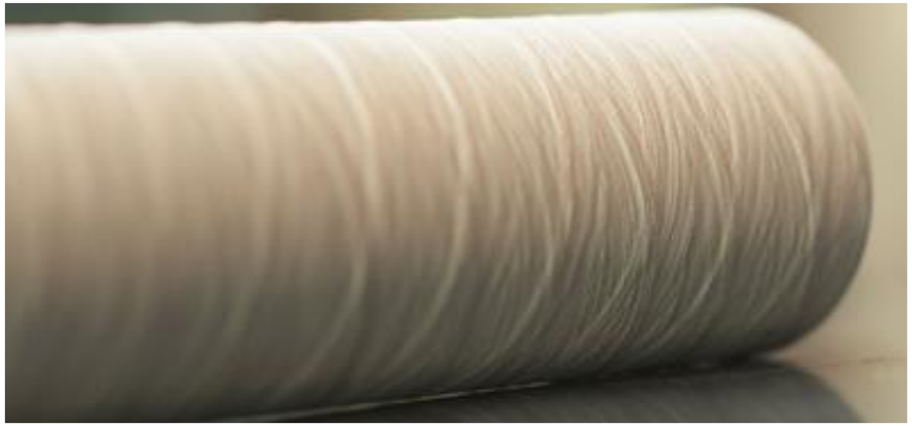
- To spearhead the shift to clean and renewable energies, heavy industry needs best-performing and energy efficient materials that can sustain harsh conditions, such as very high temperatures and corrosive environments. **The CEM-WAVE project proposes the use of Ceramic Matrix Composites in harsh-conditions manufacturing settings.**

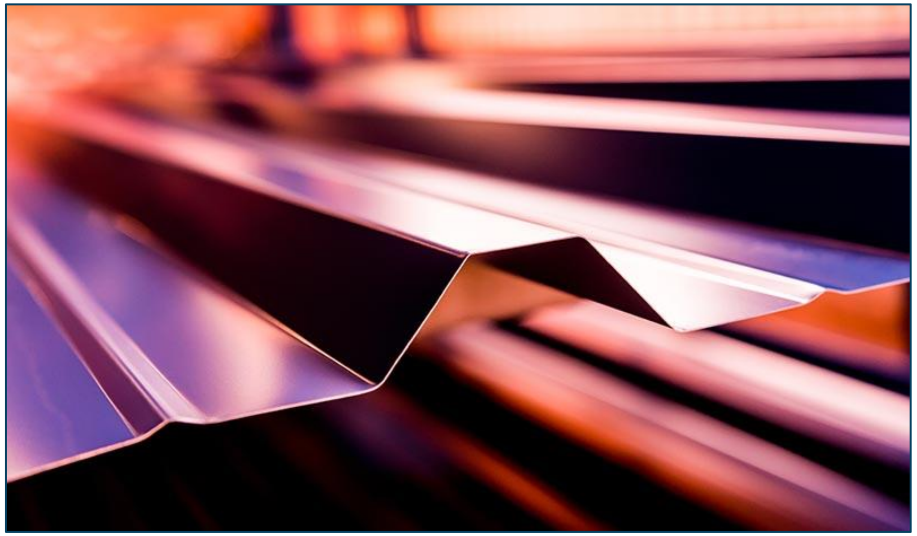
- Introducing an **innovative microwave-based production process** for Ceramic Matrix Composites (CMCs) the CEM-WAVE project has the potential to revolutionise those energy-intensive industries planning their full shift to renewable sources.

- Via a systemic and multidisciplinary approach, the **CEM-WAVE project tests and demonstrates possibilities to reduce the production costs of ceramic matrix composites** and establish new supply and value chains in the composite materials and manufacturing economy.

- The key benefits of Ceramic Matrix Composites (CMCs) over other materials includes **high thermal resistance, hardness, corrosion resistance** and non-magnetic in nature.

- The industrial demand for high temperature-resistant equipment is the primary factor driving the expansion of the global ceramic matrix composites market.





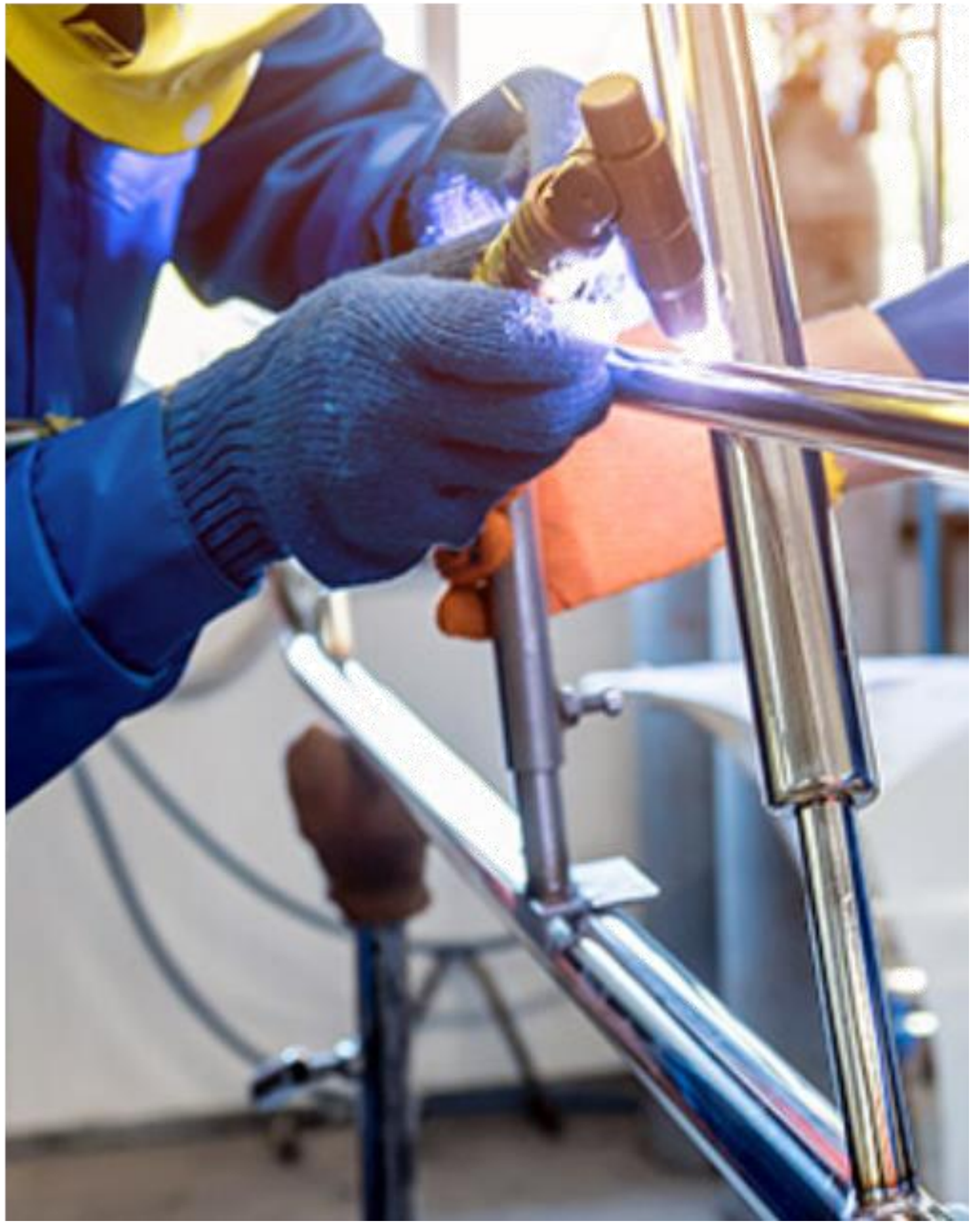
CEM-WAVE objectives

Optimise the Microwave-assisted Chemical Vapour Infiltration (MW-CVI) technology to produce non-oxide and oxide-based CMCs, including coating and joining

Harness CMCs' dielectric properties to optimise their use as sensors, both to determine the optimal MW-CVI processing conditions and to monitor their use in radial tube furnaces, in combination with infra-red imaging and electrical analysis

Build and validate a small-scale version of a CMC tube to display improved properties compared to current alternatives

Bring the solution to market, making it a long-term sustainable method and leading the application of circular economy principles in energy-intensive industries



Potential applications

- **Ceramic Matrix Composites** have been widely used in the transport sector for components such as **aircraft engine parts, turbine blades, exhaust systems, valve trains and car brake discs**.

- In the energy sector, they are employed in high-temperature applications like silicon foundry furnaces, energy reactors, gas burners, and high-pressure heat exchangers due to their refractory properties.

- Using Microwave-assisted Chemical Vapour Infiltration (MW-CVI) technology, the **CEM-WAVE project will develop a CMC-based component to build a small-scale innovative sensor-embedded tube, for use in radiant tube furnaces in the steelmaking industry**. Beyond validating the microwave-assisted technology, the sensor-embedded CMC-based tube will provide a viable substitute to currently used Inconel/Stainless steel alloys.

- Given the increased efficiency and lifetime of CMCs compared to currently employed metallic alloys in radiant tube furnaces, new possibilities will open within the **steelmaking industry**, such as chances to use higher annealing temperatures and new processing chemistries.

Impacts and KPI contribution

CEM-WAVE-produced Ceramic Matrix Composites have the potential to **improve energy efficiencies in future steelmaking production of up to 30%**, with a reduction in costs ranging between 7 and 13%

Improved Energy Efficiencies -30%

If steelmaking transitions to using CMCs produced by Microwave-assisted Chemical Vapour Infiltration (MW-CVI) in radiant tube furnaces, **the sector's CO_2 emissions could be reduced up to 20%**

Reduction In CO_2 Emissions -20%

Using CEM-WAVE-produced CMCs is expected to **enlarge the lifetime of radiant tube furnaces of up to 20%** compared to the current average, which is between 4 and 8 years

Product Lifetime Extension 20%

Contribution to EU policies

- **Contribution in relation to the "Strengthening EU's open strategic autonomy" EU policy**: Improving the production processes for the development of advanced materials as CMCs would contribute to reduce the dependence on foreign suppliers for critical materials or components.

- **Contribution in relation to the "Circular Economy Action Plan" EU policy:** It is expected that the use of CMCs allows to extend the service life of radiant tube furnace components in steelmaking plants, which would reduce the need of frequent replacements, lowering the environmental impact associated with production, transport and disposal of materials.

- **2050 long-term strategy for climate neutrality:** CMCs used on the radiant tube furnaces in the steelmaking industry, due to their properties can enhance the energy efficiency of these furnaces, reducing losses and minimizing the energy required to maintain high temperatures. Improving the efficiency of the steelmaking processes, CMCs can help reducing carbon emissions, contributing to the EU decarbonization efforts.

- **Contribution to "Renewable Energy Directive" and "REPower EU" EU policies:** Greener fuels containing hydrogen/ biogas mixtures, that will be used to replace current fuels, can cause harmful phenomena such as hydrogen embrittlement for metals and hydrothermal attack for ceramics, which suppose a burden for several production processes, as in the steelmaking industry. The use of CMCs components on the steelmaking industry plants would contribute to accelerate the adoption of hydrogen as a fuel.

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