Founded in 1965
68 Employees
30 PhD students and Visitors
5 MI $ Annual Budget for Research
3.5 MI $ External source of Finance
1.5 MI $ Public Funds

ISTEC-CNR
Director Dr. A. Tampieri

Founded in 1923
113 Research Institutes
8,000 Employees

Earth Sciences and Technologies for Environment
Bio-agroFood Sciences
Biomedical Sciences
Chemical Sciences and Materials Technology
Physics and Technology of Matter
Engineering and ICT for Energy and Transport
Human and Social sciences, Cultural Heritage

Emilia-Romagna Region
Mission: to perform research

✓ to promote innovation and competitiveness of the industrial system,
✓ to promote the internationalization,
✓ to provide technological solutions for emerging public and private needs,
✓ to advice Government and other public bodies, and
✓ to contribute to the qualification of human resources.
Basic & applied Research:

- High Tech & Environment
- Health & Nanotechnology
- Energy & Mechatronics
- Cultural Heritage & Building
- **Ultrarefractory flaw tolerant ceramics:** sintered borides (ZrB$_2$, HfB$_2$) and carbides (ZrC, HfC) ceramic matrices reinforced with short or continuous C/SiC fibers.

- **Wear, corrosion resistant and textured hard ceramics:** sintered oxide and Non-oxide ceramics (SiC, HfC, ZrB$_2$) with textured surfaces via chemical / physical etching.

- **Transparent Ceramics:** sintered polycrystalline optically isotropic transparent oxides like YAG (Y$_3$Al$_5$O$_{12}$) and spinel (MgAl$_2$O$_4$) and Sc$_2$O$_3$, Lu$_2$O$_3$; pure or doped with rare earth ions in tailored architectures and controlled dopant distribution.

- **Dual Composites:** sintered ceramic bulk composites with multi-scale architectures for multiple uses in extreme environments.

- **Bioactive Ceramic phases:** multisubstituted apatitic phases MgCHA, SrHA, FeHA, TiHA, FeTiHA.

- **Hybrid nano-composites:** nano Ag and nanocrystalline ceramic phases nucleated and grown on natural and synthetic polymeric templates.

- **Polymeric hydrogels and conducting polymers:** natural, synthetic and biohybrid materials tunable by means of cross-linking reactions.

- **Geopolymers and geopolymer based composites:** syntetic alkali-aluminosilicates and chemically bonded phosphate ceramics.
Nano-particles and Micro-beads: magnetic, electro-conductive, catalytic and bioactive phases.

Superhydrophobic and superhydrophilic materials: ceramics, glasses, metals and alloys.

Oleophobic, Amphiphobic (superhydrophobic + oleophobic) materials

Nanolubricants: metallic- and oxide-based nanoparticles incorporated in commercial oils.

Ceramized textile: keratin nanofibers or textiles functionalized, respectively, through co-electrospinning or sol-gel deposition of dispersed ceramic nanophases (Ag and TiO₂ based composition).

Engineered colloidal phases: nano metal, nanometal oxide, core-shell structures, nano-pigments, ceramic inks.

Multiferroic composites: particulate and laminate.

Hydraulic mortars based on lime (CL or NHL) and metakaolin, with different physical-mechanical properties, for restoration interventions and green building.
Non-conventional and wet synthesis: sol-gel synthesis, hydrothermal synthesis, geo-polymerization, MW assisted, microemulsion, co-precipitation.

Sintering: pressureless sintering under high vacuum, hot pressing.

Biomineralization processes: heterogeneous nucleation of inorganic nanophases on self-assembling natural and synthetic polymers.

Cross-linking processes: chemical treatment, Michael click enzymatic reaction, thermal process.

Colloidal processing: heterocoagulation, surface powder functionalization.

Biomorphic transformation: ceramization processes (multi-step process that enables the natural structures to be transformed into hierarchically organized ceramics); PIP (polymer infiltration and pyrolysis); flash pyrolysis (ultrafast pyrolysis of thin layers of ceramic precursors).

Casting processes: freeze-granulation, emulsion processes, tape-casting, 3D printing, infiltration & vacuum bagging, gel casting, ink jet printing, foaming process, freeze-casting (porosity graded structures, isotropic/anisotropic porosity).
Research – 2  *Processes*

- **Powder engineering:** core-shell synthesis, matrix encapsulation, spray-drying and spray-freeze drying technologies, powder granulation, cold isostatic pressing, pelletizing.

- **Digital control and additive manufacturing:** 3D printing, 3 axis dispensing system, decoration, glazing, smart surfaces.

- **Thick film deposition:** screen printing, tape casting.

- **Thin film deposition:** spray coating, spin coating, dip coating, electrophoretic deposition, ink jet, physical vapor deposition.

- **Composite’s architecture engineering:** particulate, laminated, functionally graded materials etc.

- **Surfaces functionalization:** linking of organic molecules, coating with inorganic nanoparticles (dip coating, plasma deposition, electrophoretic deposition).

- **Archaeometry and diagnostic investigations for Cultural Heritage:** studies of provenance, reconstruction of working-production methodologies, identification of deterioration forms and mechanisms for ceramic, stone and mosaic materials.
Regenerative medicine

Hybrid biomimetic nano-composites for osteochondral regeneration

Hybrid biomimetic nano-composites for periodontal regeneration

Customized porous ceramic scaffolds for cranial defects

Biomimetic bone cements for vertebral regeneration

Hierarchically organized scaffold for long bone regeneration

Smart applications
Nanomedicine

Ceramic and hybrid superparamagnetic μ- n-particles as drug delivery systems

Magnetized cells for faster scaffold colonization

Biocompatible superparamagnetic nanoparticles for Theranostic

Stable injectable suspension of superparamagnetic nanoparticles

Imaging

Cancer therapy by hyperthermia

Genetic therapy Magnetofection

Early diagnosis in tumor (μ-RNA recruitments)

Colonized scaffold

Smart applications
Cosmetic

Bioactive multi-substituted hydroxyapatite:
- for skin rejuvenation
- to increase the skin permeability
- as physical filter in sunscreen lotion

Health disposable

Ceramic and polymeric smart filters for gases and liquids

- HME filter for tracheostomized patient (Medical field)
- Filter for nanoparticles capture (Mask for military)
- Water remediation

EU PROJECTS:
- **BIO-INSPIRE**: PITN-GA-2013-607051 (2013-17) *Bio inspired bone regeneration*
- **SMILEY**: NMP-2012-SMALL-6-310637 (2012-15) *Smart nano-structured devices hierarchically assembled by bio-mineralization processes.* Coord. ISTEC
- **NANoREG**: contract n. 310584 (2012-15) *A common European approach to the regulatory testing of Manufactured Nanomaterials*
- **OPHIS**: NMP-FP2466373-2 (2010-14) *Composite Phenotypic Triggers For Bone and Cartilage Repair.* Coord. ISTEC
- **MAGISTER**: NMP3-LA-2008-214685 (2008-13) *Magnetic Scaffolds For In Vivo Tissue Engineering*
- **TEM-PLANT**: NMP4-CT-2006-033277 (2008-11) *New bio-ceramization processes applied to vegetable hierarchical structures.* Coord. ISTEC
Materials and Technology for Environment Protection

Ceramic Textile (self cleaning, anti-odour and flame retardant)

Green Matrix Encapsulating Structures for the Controlled Release of Antimicrobials

INORGANIC ACTIVE PHASES INTEGRATED

SELF CLEANING

ANTI-ODOUR

FLAME RESISTANT COATINGS

DIP-PADDING CURING

Spray-coating

Supported Nano-Catalysts for the Photo Degradation of Air and Water Pollutants

Nano-fluids for Catalytic or Energy Application

Safer by Design Nano-Products for the Control of their Potentially Adverse Effects

SURFACE COATING

NANO IN MICRO

SPRAY-GRANULATION

IMMOBILIZATION

GEL COATING, IMPREGNATION ON POROUS INORGANIC STRUCTURE

INORGANIC

ORGANIC
Smart surfaces

Superhydrophobic, Oleophobic, Amphiphobic materials

Water (g = 72.8 mN/m)  
$CA = 178^\circ$

Diiodomethane (g = 50.8 mN/m)  
$CA = 165^\circ$

Hexadecane (g = 27.5 mN/m)  
$CA = 150^\circ$

De-icing materials for aeronautic, energy and communication systems

New materials with intrinsic de-icing properties to reduce the need for currently used (mechanical, thermal, chemical) anti-icing procedures

Low friction components for oleodynamic systems

Bare Al  
Coated Al

Amphiphobic surfaces with antifouling properties

Low friction coatings on metal alloys  
$CuZn_{40}Al_{2}$

CA with lubricant = 16°  
CA with lubricant = 140°
Technological Transfer activities:
Creation of new enterprises through know how transfer and licensing of patents

CNR-ISTEC IP Portfolio:
- n. 22 Patents;
- n. 1 Utility model;
- Extensive Know-how on ceramic and advanced materials and processing.

Main Technology Transfer modes*:
- Scientific Publications
- Research Programs
- Patent licensing
- Know-how transfer to industry
* National Science Academy
Technological Transfer: CNR-ISTEC Portfolio

Main field of application

• Materials for medicine and health
• Materials for aerospace and severe environments
• Advanced smart materials for industrial applications
• Materials for energy and electronics

Main tools

✓ Non-Disclosure Agreement
✓ Secrecy Agreements
✓ Confidentiality Agreements
✓ Licence Agreement
✓ Research and Development Agreement
✓ Know-How transfer Agreement
Technological Transfer: our case studies of success

Creation of new enterprises through know-how transfer and licensing of patents

Finceramica S.p.A.
www.finceramica.it/

Finceramica was founded in 1992; the company is world leader in cranial reconstruction and one of the outstanding European producer for bone and cartilage substitutes.

GREENBONE Ortho S.r.l.
www.greenbone.it/

Greenbone was founded in 2014, to develop highly innovative wood-derived bone implants: the unique regenerative solution for the cure of large comminuted or non-union fractures and other nasty skeleton damages.
Training & Education: ISTEC CNR is involved in higher education initiatives at all levels, Masters degree, post graduate courses, Ph.D. collaborations, European union initiatives to promote excellent Scientists

MASTER Degree in «Chemistry and Technologies for the Environment and Materials»
Curriculum: Traditional and Innovative Materials, Faenza, University of Bologna

Master Doctoral Multinational Course in Medical Biotechnology supported by ERASMUS + European Program

Ph.D. in «Science and Technologies of Materials» jointly with University of Parma.
Ph.D. in «Chemistry» - course “Processes and applications of ceramic materials” University of Bologna.

«Initial Training Network», BioInspire project - Bio-inspired bone regeneration Marie Curie Action European Program

Ph.D. collaborations:
Universidad Federal de Santa Catarina (Brazil); University of Ferrara (IT); University of Bologna (IT); University of Parma (IT); University of Trieste (IT); University of Chemistry and Technology of Prague (Czech Republic); Polytechnic of Turin (IT); University of IASI (Romania); University of Tor Vergata Roma (IT); University of Trento (IT); ISIA-Institute for artistic industry (IT); University of Palermo (IT)
ISTEC Collaborations: USA, ASIA, AFRICA, AUSTRALIA
Main facilities: Technological Laboratories

- Rheology Laboratory
- Forming Laboratory
- Sintering Laboratory
- X-ray Diffraction Laboratory
- Thermal Analyses Laboratory
- Mechanical properties Laboratory
- Microscopy Laboratory
- Electric & Magnetic Laboratory
- Cell/biomaterial interactions Laboratory
Thank you for your attention!