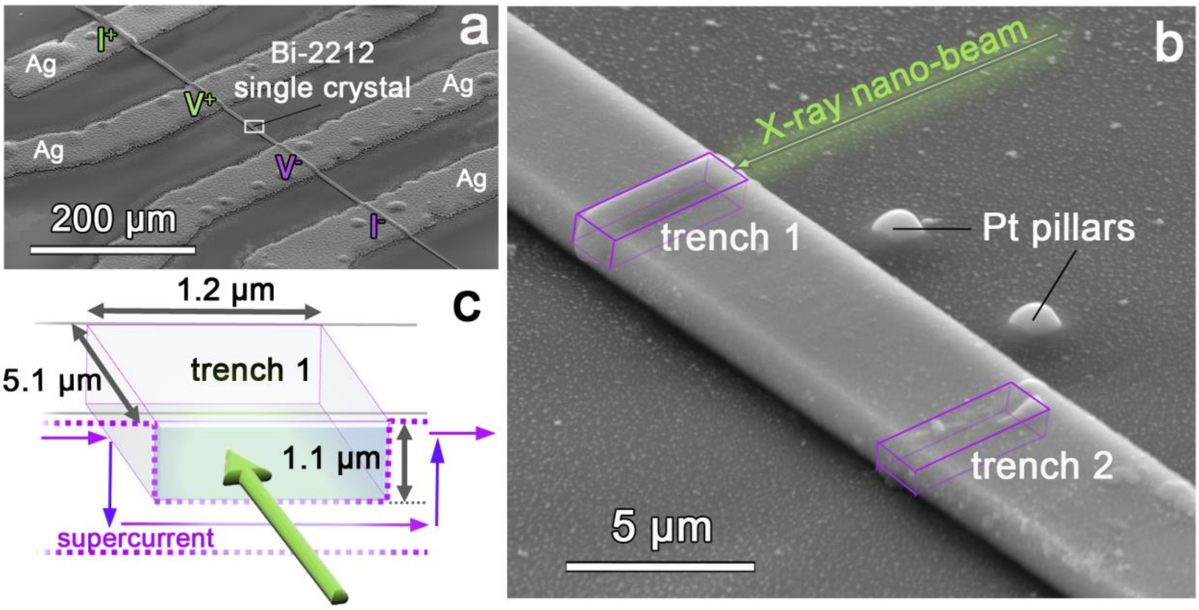
Current research topics and funding

X-ray nanopatterning for oxides



Experimental setup for X-rays nanopatterning experiments. a) Bi-2212 single crystal on a sapphire substrate, with 4 Ag electrodes for electrical measurements, b) example of irradiated regions acting like « trenches » for the current path, and c) sketch of the modifications induced by X-rays irradiation in the current path around a « trench ». Pt pillars are just markers for alignment purposes.

Nowadays, very high power densities can be achieved at 3rd generation synchrotron sources, where hard X-rays fluxes as intense as about 10^{11} ph/s can be focused over typical areas of 50 × 50 nm^2. Our group has recently shown that so intense beams, with peak power of the order of 10^{14} W/m^2, can affect the properties of superconducting oxides like $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212), probably because of their ability to selectively remove O atoms from this material. We have already shown that this ability can be exploited to pattern superconducting devices without disrupting the crystal structure, which is very different from what is obtained by using the conventional procedure based on photoresist impression and subsequent crystal etching. This idea opens new possibilities about oxides patterning, which could be of considerable interest in oxide-based electronics.

Present hot topics are:

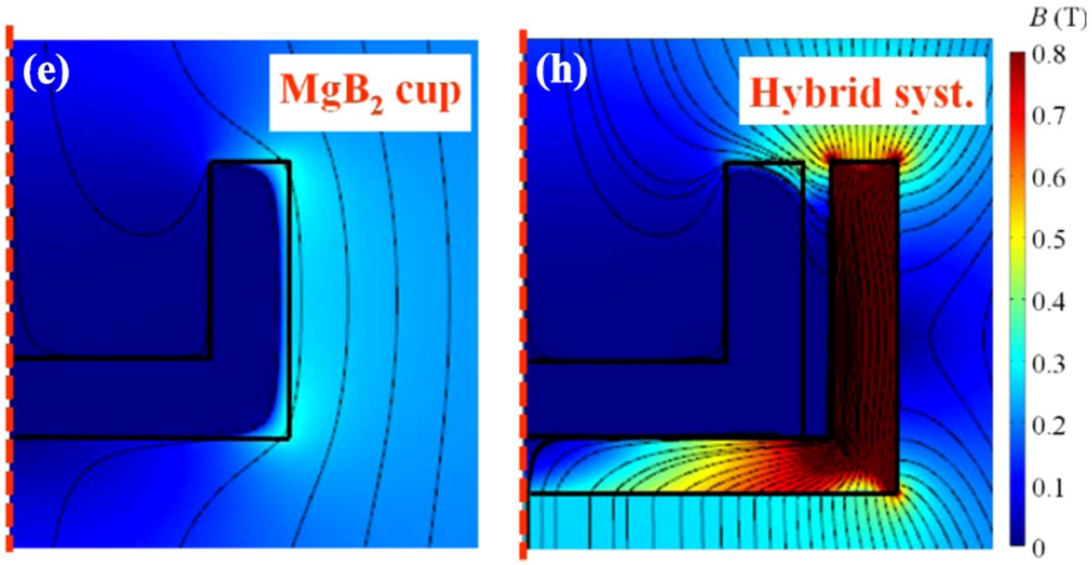
- Microscopic mechanisms responsible for modifications of material.

- Numerical assessments of thermal load induced by synchrotron nanobeams .
- Extension of direct-writing nano-patterning to different superconducting and transition-metal oxides.

Related project:

Joint project University of Torino-Compagnia di San Paolo, “X-ray nano-patterning for oxides”

Superconducting magnetic shielding



Magnetic field distribution in the case of applied magnetic field $\mu_0 H = 0.2T$ in the case of purely superconducting (e) and of hybrid superconducting/ferromagnetic (f) cylindrical coaxial cups.

Shielding of magnetic fields has become an important issue in many different fields like nuclear magnetic resonance (NMR) imaging and electromagnetic compatibility (EMC) for electronic devices. Superconducting materials offer a large potential in this respect because of their property of expelling the magnetic field (Meissner effect), but their practical use is hindered by the requirement of low temperatures. However, the appearance of high-temperature superconductors and of electromechanical cryocoolers able to provide the necessary low temperatures has opened new perspectives. Specifically, materials like MgB_2 and $YBa_2Cu_3O_{7-\delta}$ have shown to be able to shield magnetic fields of the order of 1 T and are considered for practical applications, especially in space missions.

Present hot topics are:

- Numerical assessment of shielding properties for both purely superconducting and hybrid superconducting/ferromagnetic materials.
- Fabrication of MgB_2 shields and of hybrid MgB_2/μ-metal shields, and their experimental assessment.
- Improvement of MgB_2 shielding properties via different doping methods suitable to increase both its critical current density and its workability.

Related project:

Project "SR2S-RD", i.e. Space Radiation Superconducting Shields-Research and Development, by Italian National Institute for Nuclear Physics (INFN).

Selected Publications:

M. Truccato, et al. ,
Direct-write X-ray nano-patterning: a proof of concept Josephson device on $Bi_2Sr_2CaCu_2O_{8+\delta}$ superconducting oxide
Nano Letters, 16 (3), 1669-1674, (2016)
DOI: 10.1021/acs.nanolett.5b04568

L. Gozzelino, R. Gerbaldo, G.Ghigo, F. Laviano,M. Truccato, A. Agostino,
Superconducting and hybrid systems for magnetic field shielding
Superconductor Science and Technology, 29 (3), 034004, (2016)
DOI: 10.1088/0953-2048/29/3/034004

O. Kizilaslan, M. Truccato, et al.
Interlayer tunneling spectroscopy of mixed-phase BSCCO superconducting whiskers
Superconductor Science and Technology, 29 (6), 065013, (2016)

DOI: 10.1088/0953-2048/29/6/065013

A. Pagliero, L. Mino, E. Borfecchia, M. Truccato, et al.
Doping change in the Bi-2212 superconductor directly induced by a hard X-ray nano-beam
Nano Letters, 14 (3), 1583-1589, (2014)
DOI: 10.1021/nl404834u

S. Cagliero, E. Borfecchia, L. Mino, L. Calore, F. Bertolotti, G. Martinez-Criado, L. Operti, A. Agostino, M. Truccato, P. Badica, C. Lamberti
Insight into non-linearly shaped superconducting whiskers via a synchrotron nanoprobe
Superconductor Science and Technology, 25 (12), 125002, (2012)
DOI: 10.1088/0953-2048/25/12/125002