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Current status and perspectives of CoMET laboratory

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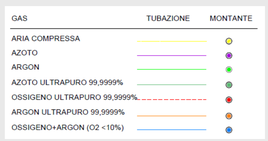
Scope

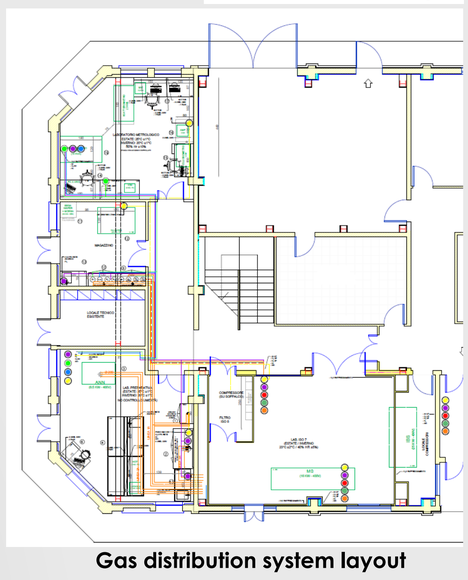
The COMET (Coating Materials for Einstein Telescope) laboratory of the University of Padua is growing in Rovigo within the ETIC project. This center will be dedicated to the production of GW-quality coating samples and the study of deposition processes crucial for high-quality mirror fabrication. The laboratory will focus on the R&D of innovative optical films characterized by properties such as extreme transparency and high mechanical quality factor. Among its main objectives is the identification and elimination of the physical causes of the optical absorption of coatings and sources of mechanical dissipation. Both of these parameters are critically influenced by complex factors such as the structural, mechanical, compositional, and surface properties of the materials.

Gas distribution system

During design of the facility, we have paid much attention to reaching a high level of control of the deposition processes and minimizing any impurity sources, which can compromise high-quality optical coatings.

The design and realization of gas distribution system has a huge impact on impurities level in PVD (physical vapor deposition) process. Chosen design of the gas system allows efficient UHP (ultra high purity) lines vacuuming/purging. We have to say that searching for understanding with Italian companies to produce the system according to our requirements we had to insist on "semiconductor industry" grade and keep under control a choice of the correct materials for UHP gas system components: electropolished stainless steel, full metal joints and sealings when possible, no zinc in sealings, tube orbital welding under Ar atmosphere.
The UHP system will guarantee 6.0 Ar, O_2, N_2 gases purity starting from the cylinders o equal purity grade.

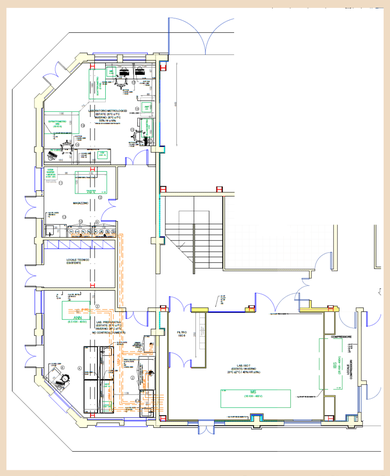




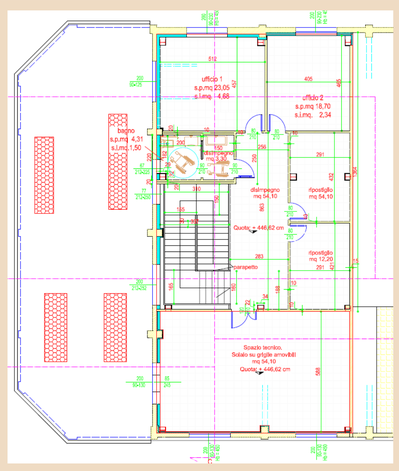
Gas distribution system layout

Besides that, gas distribution system provides compressed air and gas lines for PVD vacuum systems and other instruments for post-treatment of the mirrors (tubular furnace) and analysis instruments (XRD).

Construction



CoMET laboratory layout (ground floor)



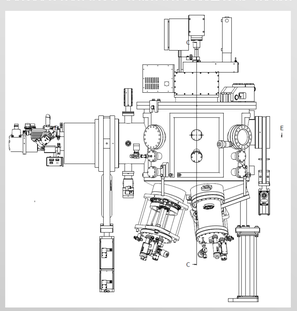
CoMET laboratory layout (floor 1)

Deposition machines

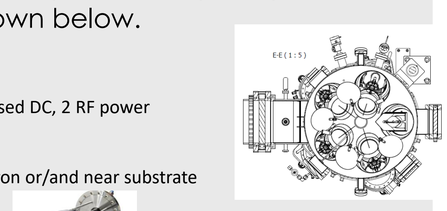
CoMET will be equipped with ad-hoc designed PVD machines: a Dual Ion Beam Sputtering system and an Ion Assisted Magnetron Sputtering system for the deposition under controlled conditions of multi-element coatings.

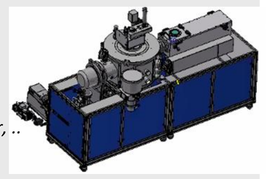
The machines will also feature several in-situ characterization tools to study the deposition process and the material characteristics while the process is carried out. The purchase and design of the deposition systems have already been completed; they are planned to be installed within September 2025. Specific details are shown below.

Kenosistec customized cluster MS system.

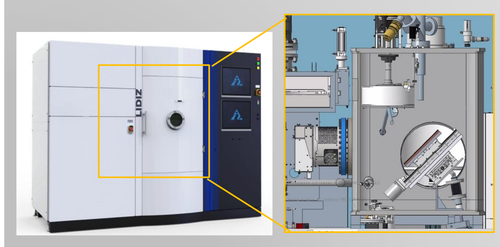


- 4 4'' **magnetron sources** for co-deposition (for now 1 pulsed DC, 2 RF power supplies)
- **High vacuum** ($< 6 \times 10^{-8}$ mbar)
- 5 **gas lines** (Ar, O2, N2, ..) each can be used near magnetron or/and near substrate
- **Assistance ion source** Kaufmanne H200HC
- **Uniformity** better than 1% on 100 mm diameter
- **Substrates** up to 125 mm diameter, up to 20 mm thickness
- Rotated **substrate holder**, heating up to 700°C
- Predisposition for RF susbtrate **bias**
- Predisposition for several **in-situ diagnostics**: RGA, ellipsometry, *energy-mass spectrometry, stress/curvature measurement, optical(photon) emission monitor, ..*

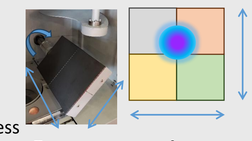




I-Photonics LIDIZ customized IBS system



- Multimaterial deposition with compositional control up to 4 different **targets** (each can be multicomposition).
- **Primary ion source** 400 mA 2000 eV,
- **Assistance ion source** 2A, 450eV
- High **vacuum** ($< 1 \times 10^{-7}$ mbar)
- High purity **gas lines** for each source and neutralizer
- **Substrates** up to 125mm in diameter, several mm thickness
- **Uniformity** better than 0.5% on 100 mm diameter substrates
- Rotating **sample holder**, heated up to 700°C, 10cm ΔZ position
- Predisposition for several **in-situ diagnostics**: ellipsometer, RGA, *mass-energy spectrometer, optical(photon) emission monitor,* optical thickness monitor, ..

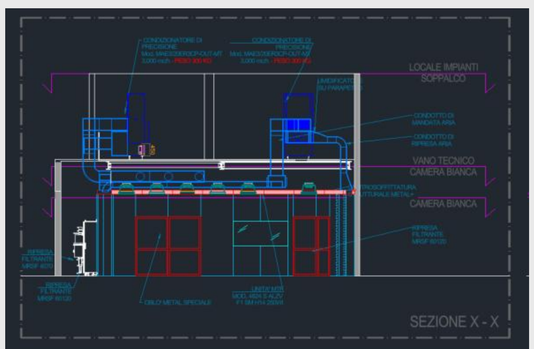


Target movements for composition and angle control

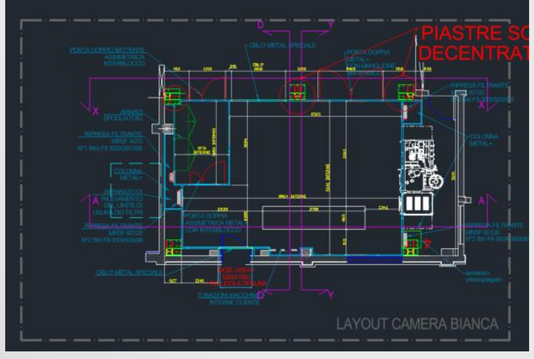
Cleanroom

The clean-room is the heart of the coating's deposition laboratory. The MS deposition system if fully located in ISO 7 clean room of 50 m^2. Instead, being much bigger in size IBS deposition system is positioned in a way to have access from the clean–room to the front panel and load-lock and deposition chamber and the vacuum system with auxiliary equipment is located in a technical zone. To keep cleanliness level the clean-room has ISO 8 pre-camera. The clean-room is climatized to guarantee 22°C±2°C, 50±10% humidity.

The clean-room is equipped with 2 air treatment units (floor 1 over the clean-room) and a set of filters mounted in the ceiling. The air is passing the filers to arrive to a clean-room area and collected through 3 colons incorporated into the opposite walls. The floor is not elevated. This scheme allows to have a mixed air flow near-laminar of the top of the room and turbulent near the collection points, which is sufficient to guarantee ISO 7 specification.



Clean-room air treatment units



Clean-room scheme

Photos of the clean-room construction. May 2025

Timeline for the laboratory completion

June 2025 - Cleanroom installation completed

Mid. July 2025- building renovation completed, lab. support installations: gas lines, cooling system, electrical system cleanroom

September 2025 - IBS system installation, testing, training

July or October 2025 – MS system installation, testing, training

End of September 2025 - Ellipsometers installation, testing and training