




UNIVERSITÀ
DEGLI STUDI
DI PADOVA A.D. 1222

Industrial CT Scanning Workshop
Munich, 23-25 October 2013

Industrial CT for manufacturing metrology at University of Padova

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Contents of presentation

- Short general presentation of University of Padova
- Precision manufacture engineering at UNIPD
- Geometrical and surface metrology activities
- CT metrology research activities
- Main collaborations and projects

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FOUNDED IN **1222** UniPadova at a glance

32 DEPARTMENTS	A BUDGET OF 607 MILLION EURO	64,000 STUDENTS	12,000 GRADUATES (2011 YEAR)
1 UNIVERSITY HOSPITAL	1 VETERINARY HOSPITAL	1 EXPERIMENTAL FARM	1 SCHOOL OF EXCELLENCE
2,214 PROFESSORS AND RESEARCHERS	2,265 TECHNICIANS AND ADMINISTRATIVE PERSONNEL	82 1 ST CYCLE DEGREE COURSES	81 2 ND CYCLE DEGREE COURSES
8 SINGLE CYCLE DEGREE COURSES	81 MILLION 748 THOUSAND EURO A YEAR FOR RESEARCH	65 1 ST AND 2 ND LEVEL SHORT SPECIALISATION DEGREE COURSES	65 SPECIALISATION SCHOOLS
72 RESEARCH AND SERVICE CENTRES	1,507 DOCTORATE CANDIDATES	14 HALLS OF RESIDENCES	




An historical University...



Oldest anatomic theater

Galileo Galilei

Elena Cornaro
First graduated woman in Italy (1678)

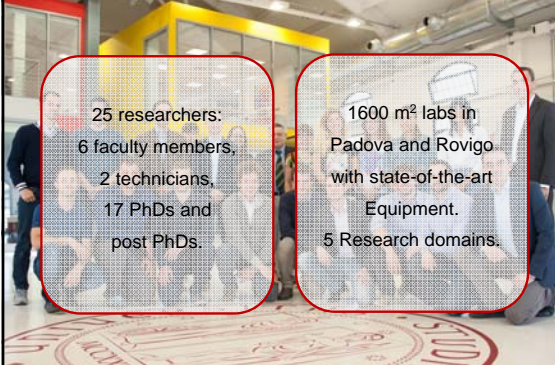


... in an historical and touristic City




2013 Ranking of Italian Universities:
No.1 Italian University for quality of research results

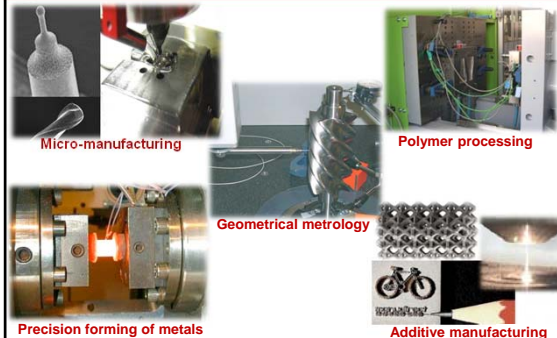
Precision Manufacture Engineering Group




25 researchers:
6 faculty members,
2 technicians,
17 PhDs and
post PhDs.


1600 m² labs in
Padova and Rovigo
with state-of-the-art
Equipment.
5 Research domains.

5 research domains






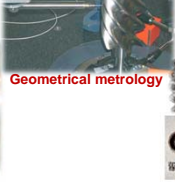
Micro-manufacturing




Polymer processing



Precision forming of metals



Geometrical metrology



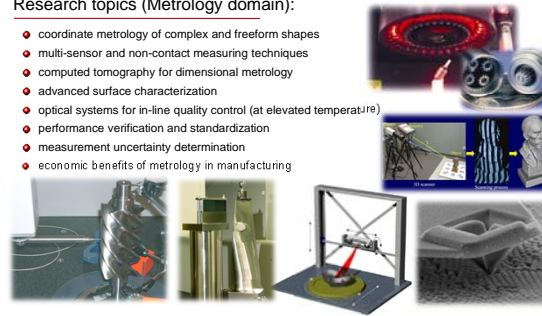
Additive manufacturing

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Geometrical metrology: Research topics

Research topics (Metrology domain):

- coordinate metrology of complex and freeform shapes
- multi-sensor and non-contact measuring techniques
- computed tomography for dimensional metrology
- advanced surface characterization
- optical systems for in-line quality control (at elevated temperature)
- performance verification and standardization
- measurement uncertainty determination
- economic benefits of metrology in manufacturing




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Geometrical metrology: Lab equipment

Main equipment (Metrology domain):

- Metrological CT system Nikon Metrology MCT225
- Multisensor measuring machine WERTH Video Check IP 400
- Coordinate measuring machine ZEISS Prismo VAST 7
- 3D laser triangulation scanner 3Shape D-250
- Digital roughness tester ZEISS-TSK Surfcom 1400A
- Atomic force microscope (AFM) DME Dualscope 95-200
- Strain measurement system GOM ARAMIS
- WLI/confocal microscope SENSOFAR Plu Neox
- Scanning electron microscope FEI Quanta 450



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Collaboration with Elettra, Italian Synchrotron




Elettra Synchrotron Trieste, Italy

SYRMEP beamline:
Monochromatic beam
Monochromatic and laminar-section X-ray beam with a maximum area of 120x4 mm².
CT, phase contrast imaging, diffraction enhanced imaging.




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Research on CT metrology at UNIPD started in 2004



Reference CMM measurements



CT measured data

[Carmignato S., et Al.; IMEKO Int. Symp.; 2004]

First research activity:

- Uncertainty determination through substitution method [ISO/TS 15530-3:2004]
- Preliminary study on comparability between CMM and CT
- Comparison of both data-sets with freeform CAD surfaces based on CT data

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Development of calibration objects and procedures

10 mm

CT Tetrahedron Pan Flute Gauge Hourglass standard

Increasing structure resolution

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The Fiber Gauge

(a) Detail SEM image of the reference standard, showing two rows of fibers with different heights (fibers have a diameter of 125 μm; holes have a lattice of 250 μm);
(b) Volume rendering obtained from a microtomographic scan.

Marinello F., Carmignato S., et AL. 2008. Calibration Artefact for the Micro Scale with High Aspect Ratio: the Fiber Gauge, Annals of CIRP, 57/1, 497-500.

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'CT Audit' Project

'CT Audit' was the first international intercomparison of CT systems for dimensional metrology.

Final CT Audit Workshop - Padova, Italy, October 2011.

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Example of intercomparison's results

Deviation from ref. value [μm]

Participant Number

Inner Diameters
Outer Diameters

- Most participants obtain **sub-voxel accuracy**; size measurement errors within 1/10 of voxel size
- Measurements of **form** are more problematic than size measurements (influence of CT data **noise**)
- Traceability** of CT dimensional measurements is still a major **challenge**, even for expert users.

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CT for manufacturing processes

Example: CT for Additive Manufacturing (AM)

- Reverse engineering for rapid prototyping: Object → CT → AM
- Process optimization: AM → CT
- Quality control and dimensional metrology: AM → CT → Report

AM example: Titanium micropump component

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Examples of Industrial collaborations

The Research Group is active in numerous industrial collaborations

- Quality control and dimensional metrology
- Process optimization
- Bulk and sheet metal forming
- Additive manufacturing
- Micro manufacturing
- Injection moulding
- Composite manufacturing
- Biomedical industry
- Automobile industry
- ...

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Fiber orientation analysis of composite materials

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Volume measurement of microcavities

- Drug-eluting stent

500 μm

[Carmignato S., CIRP Annals 2011]

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Wear volume evaluation

- Wear evaluation of femoral head prosthesis

Femoral head

[mm] -0.50
-0.25
0
+0.05
+0.10

[Carmignato S., CIRP Annals 2011]

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Thank You