Istituto di Tecnologie Industriali e Automazione
Consiglio Nazionale delle Ricerche

from research …. to market

Materiali avanzati per la Meccanica

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CNR – Confindustria Varese, 13/05/2014

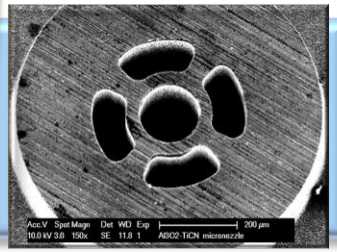
GRUPPI DI RICERCA ITIA

Macro Factory

ITIA-CNR Pilot system for footwear production,
Lab for Design &
Mass Customization, Vigevano

Micro Factory

ITIA-CNR Micro Manufacturing Chain,
Milano and Bari Laboratories



De Production Factory

ITIA-CNR Re/De Manufacturing Pilot Plant,
Milano (under construction)

Digital Factory

VFF - Virtual Factory Framework
EC FP7 Project,
Coordinator: ITIA-CNR

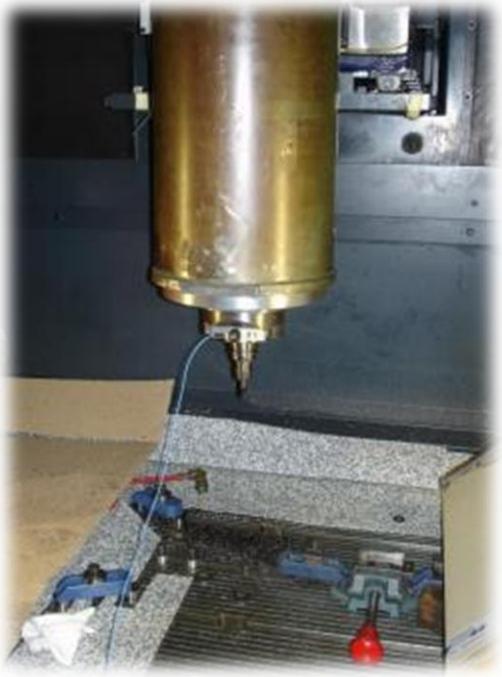
- *Manufacturing Business Models*
- *Products/Processes Design*
- *Life Cycle Assessment*
- *Enterprise Engineering and Virtual Applications*
- *Supply Chain and Integrated Logistics*
- *Machine and Manufacturing Energy Analysis and Optimization*
- *Machine and Manufacturing Control Systems*
- *Dynamic Analysis and Simulation of Machinery*
- *Manufacturing Technologies*
- *Robot Systems*
- *Micro Enabled Devices and Systems*
- *Innovative Mechanical Components*

MATERIALI AVANZATI: SFIDA E OPPORTUNITA’

Turbina in lega di Titanio

Lavorazioni produttive su materiali tenaci

Cannotto di fresatrice per stampi in schiuma metallica



Uso di materiali avanzati come componenti strutturali di macchinari

LAVORAZIONE DI MATERIALI TENACI

Negli ultimi 20 anni il settore aeronautico ha riportato in auge l'asportazione di truciolo con pezzi ricavati dal pieno in cui si arriva ad asportare il 90% del materiale. Spesso questo materiale è difficile da lavorare.

- *Titanio*
- *INCONEL*

→

- **Bassa conducibilità termica**
- **Non perdono tenacità alle alte temperature**
- **Alte forze di taglio**

→

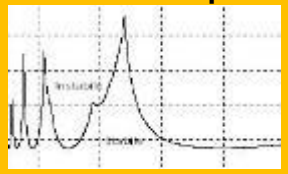
- **Bassa velocità di taglio**
- **Scarsa produttività**

LAVORAZIONE DI MATERIALI TENACI

Uno dei problemi che limita la produttività è l'insorgenza di vibrazioni durante le vibrazioni (CHATTER), che usurano l'utensile, danneggiano il mandrino e portano a scarsa finitura superficiale.

SOLUZIONI DI PROCESSO:

- Ottimizzazione dei parametri di taglio;



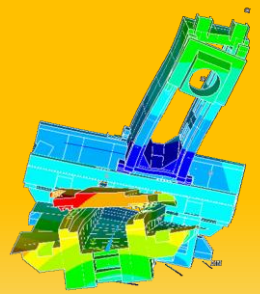
- Uso di utensili speciali (frese ad alto avanzamento, passo variabile, profili ondulati, ect…).

+

+

SOLUZIONI DI MACCHINA:

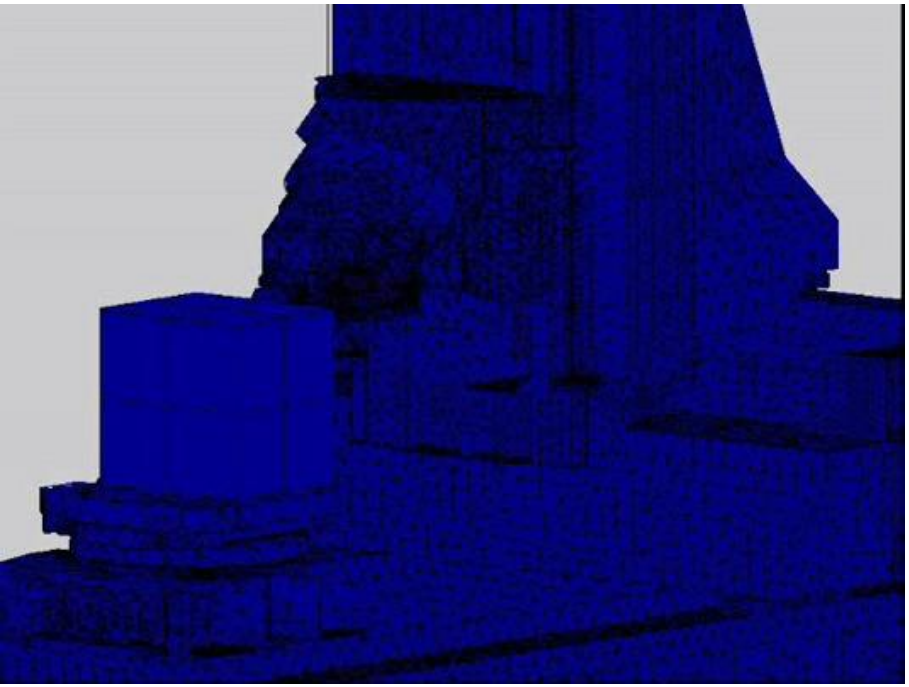
- Ottimizzazione delle caratteristiche strutturali;



- Nuovi algoritmi di monitoraggio e controllo.

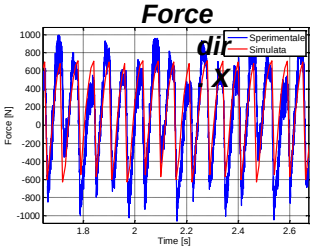
LAVORAZIONE DI MATERIALI TENACI

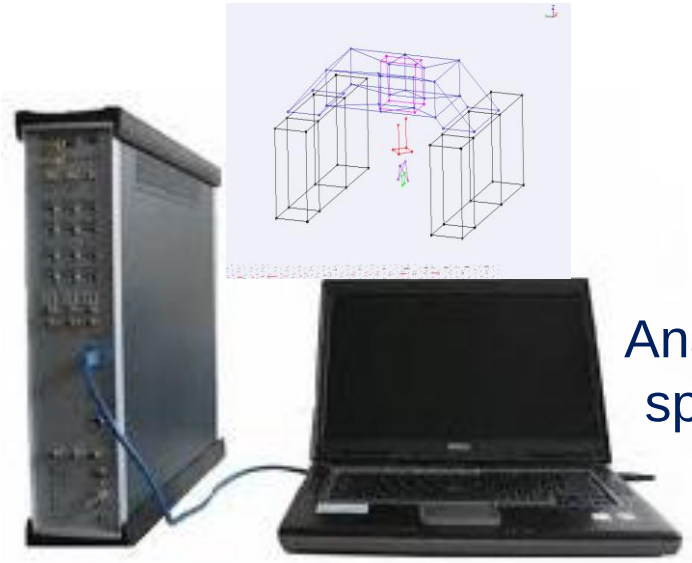
Attraverso lo sviluppo di modelli di simulazione avanzata e tecniche di indagine, CNR – ITIA supporta la progettazione congiunta macchina + processo nella lavorazione di materiali critici.



Simulazione integrata macchina + process o + sistema di controllo

Prove di taglio





Analisi modale sperimentale

MATERIALI AVANZATI PER LE STRUTTURE

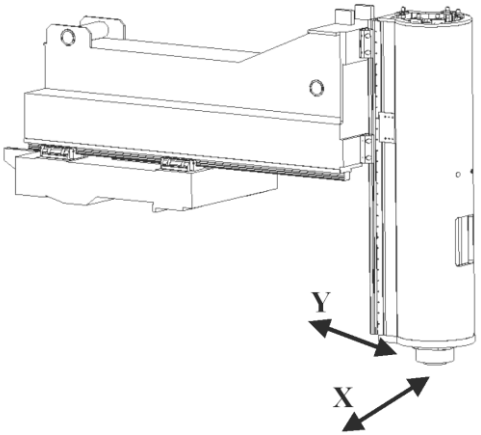
L'impiego dei materiali finora utilizzati nella produzione di macchinari, essenzialmente materiali metallici ferrosi (acciai e ghise), limita notevolmente l'incremento di prestazioni, a causa dell'elevata massa specifica, cui non corrispondono valori di rigidezza altrettanto elevati. Ciò penalizza anche le prestazioni di efficienza energetica.

NUOVE OPPORTUNITA' DA MATERIALI COMPOSITI

- Compositi metallici
- Compositi non metallici **(per es., matrice polimerica + fibra di carbonio)**
- Cemento polimerico (già molto diffuso, specialmente nei basamenti)
- Strutture laminate sandwich:
  - **Riempimento a schiuma metallica**
  - **Laminato corrugato**
  - Laminati lisci incollati

MATERIALI AVANZATI PER LE STRUTTURE

Confronto tra le prestazioni di rigidezza di un componente strutturale di una fresatrice in diversi materiali compositi.



Composito in fibra di carbonio

Laminato corrugato

Schiuma metallica

Progetto FP6 - NEXT (cortesia di CE.S.I.)

Risultati

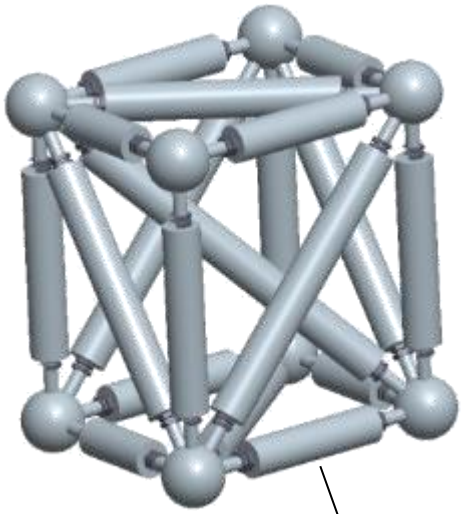
MASSA			
	Experimental mass [Kg]	Target value (steel Ram) [Kg]	Experimental vs Target
FIBRA DI CARBONIO	50	97	-48.5%
CORRUGATED	78	97	-19.6%
FOAM	100	97	3.1%

STIFFNESS X-Direction			
	Experimental Stiff. [Kg/micron]	Target value (steel Ram) [Kg]	Experimental vs Target
CFRP	2.1	2.2	-4.5%
CORRUGATED	1.75	2.2	-20.5%
FOAM	2.5	2.2	13.6%

STIFFNESS Y-Direction			
	Experimental Stiff. [Kg/micron]	Target value (steel Ram) [Kg]	Experimental vs Target
CFRP	5.5	3.4	61.8%
CORRUGATED	4.4	3.4	29.4%
FOAM	4.6	3.4	35.3%

Nuovi materiali, ma anche nuovi concetti su come utilizzarli…

Strutture basate su blocchi modulari ultraleggeri

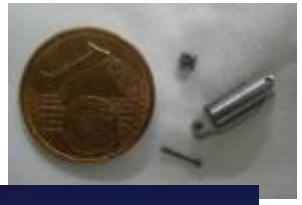


Tubi in fibra di carbonio

Sfere di acciaio

Progetto FP7 - DEMAT (cortesia di TECNALIA)

New materials for micro world



The research activities on MicroEngineering aim at developing methodologies and robotic tools for micro-manufacturing and assembly of hybrid (multi-materials: metals, plastics, silicon...) micro-products.

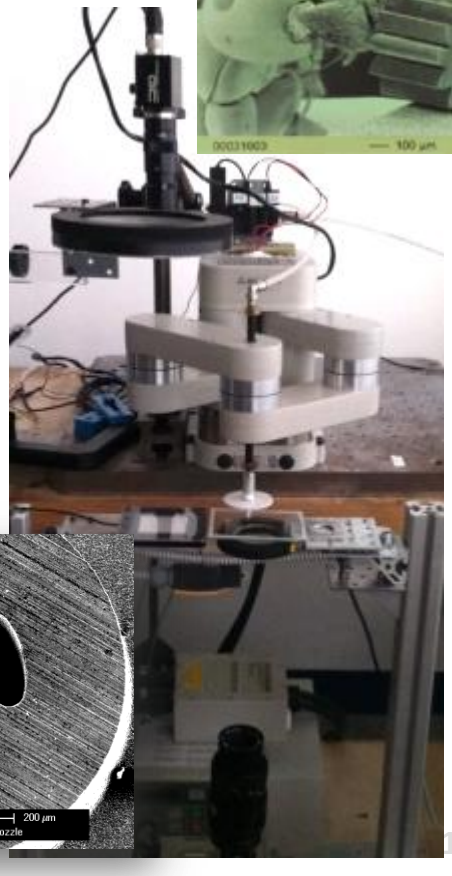
Specific topics:

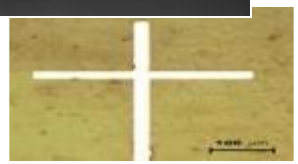
- Micro-assembly automation & robotics: control techniques for precision assembly, design of micro-PKMs;
  Micro-manipulation: grippers, micro-positioners

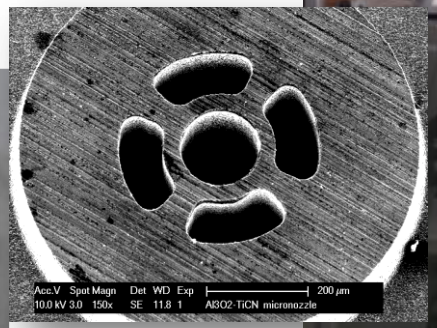
- Micromanufacturing:

  - Enhanced materials: nanofilled polymeric compounds, micro-extrusion and micro-injection

  - Micro-EDM

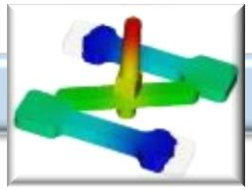


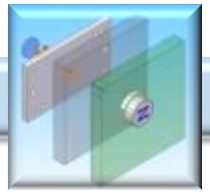




New materials for micro world

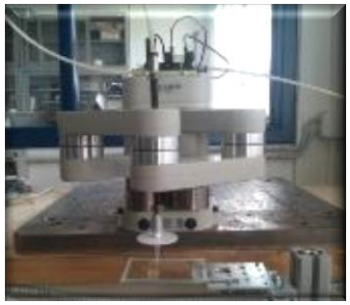
Product/Process Design





Raw Material Design

Micro EDM Process



Micro Assembly

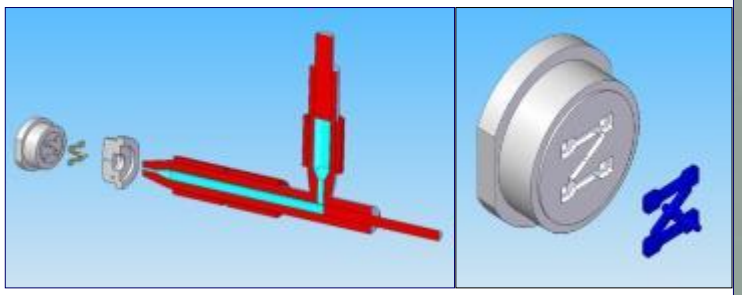
Micro Extrusion Process

Micro Injection Process

Characterization

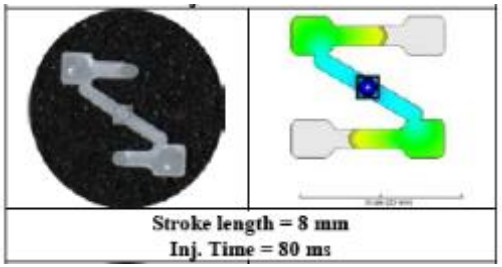
PLASTICS COMPOUNDING AND PROCESSING

Materials: POM, HDPE, PMMA, PPS, PC, PP, PP
Fillers: talc, nanoclay, glass beads/fibers, MWCNT



Experimentation

Simulation

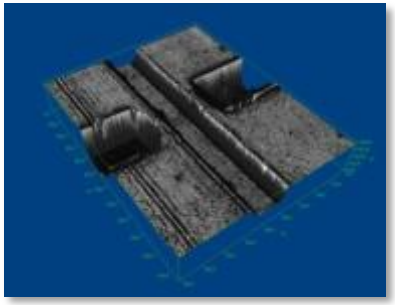


Monitoring

Materials, process study and optimization for high-performance micro-manufactured products

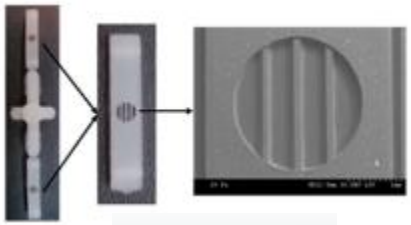
Micro-extrusion and injection moulding

Micro channel (fluidic application)

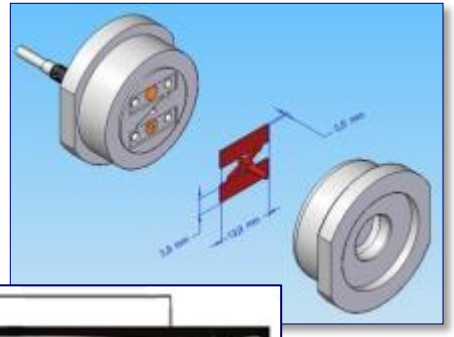


Micro rib (filter application)

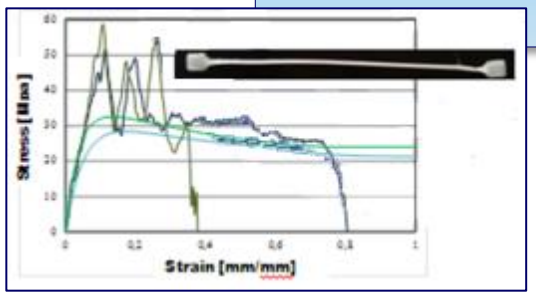
Mould with insert



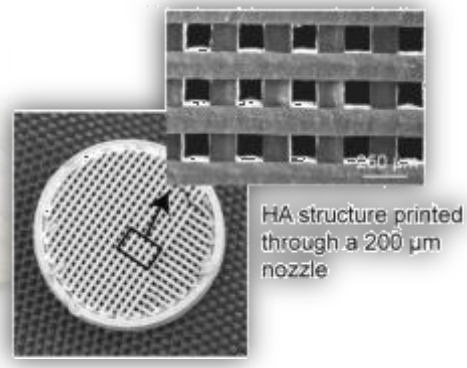
The University of Nottingham



Testing

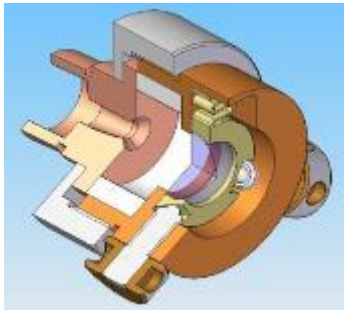


MICRO-EDM



Mini-fixation devices: Si_3N_4-TiN, ZrO_2

Optic Collimator



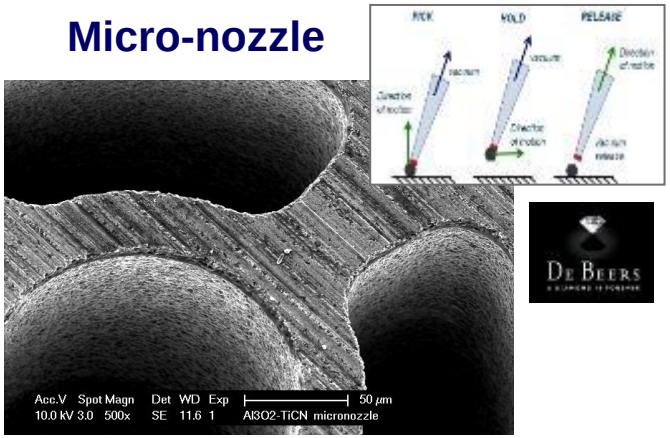
Turbine Fan

Trust Insert Air Bearing

Devices used by Biomedical, Power generation, Optics or telecommunications field require new materials and freeform micro-features

Middle Ear Prosthesis (Ti)

Micro-nozzle



Jaws of aneurysm clip

Extrusion Head

GRAZIE PER L'ATTENZIONE!

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(MICRO)