Stress-strain behaviour of MoRuB glassy metals

Stefano Tirelli
Undergraduate student
University of Pisa
Italy

ChenYang Wang
Graduate Student
Caltech
Now at University of Stanford

LIGO-G020441-00-R

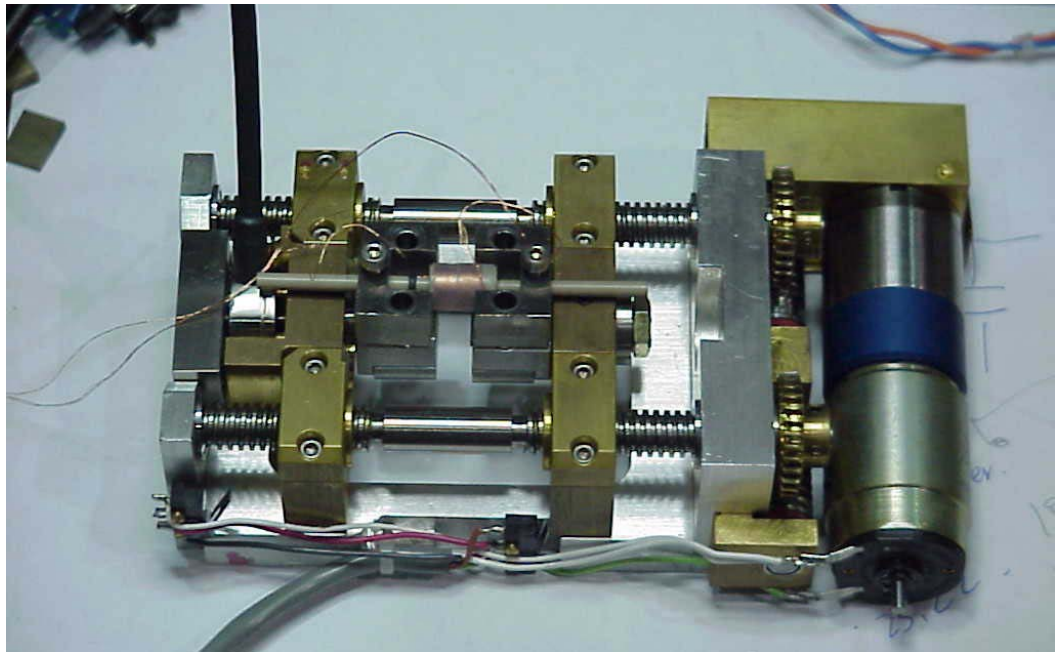
LIGO

Physical properties studied

- Young's Modulus
  - Mechanical hysteresis
- Yield Point
  - High yield point allows THINNER suspensions and less energy dissipation
- Structural modifications
  - Shear bands
  - Crack propagation (upcoming)

LIGO

How to study stress/strain of MoRuB?



Load frame, operational setup

Load frame and cell courtesy of Robert Rogan, Materials Science

LIGO

How to measure stress?

Micro Load Cell, maximum load 1000lbs (oversized!)

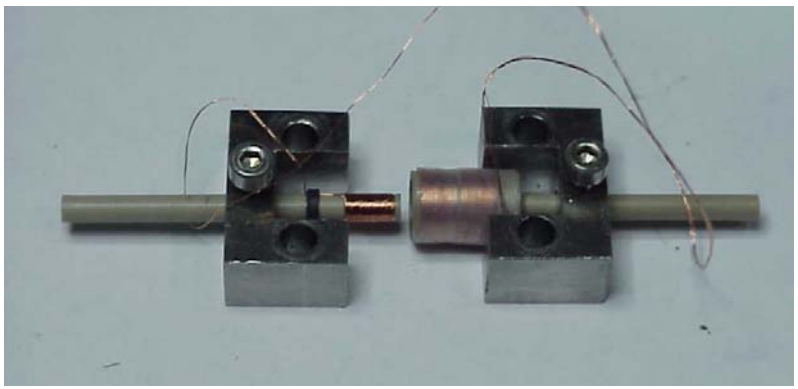
Wheatstone-bridge based

Present resolution ~ 50 grams

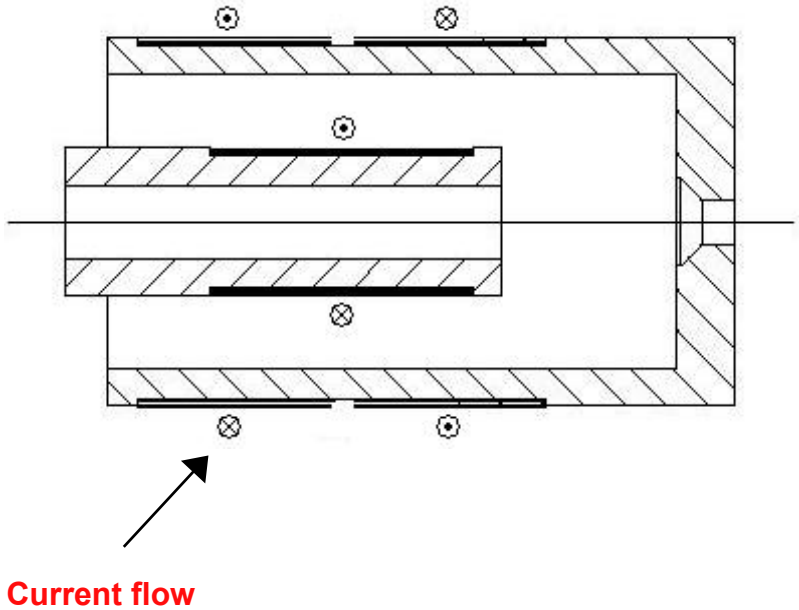
LIGO

How to measure strain?

LVDT: Linear Variable Differential Transformer

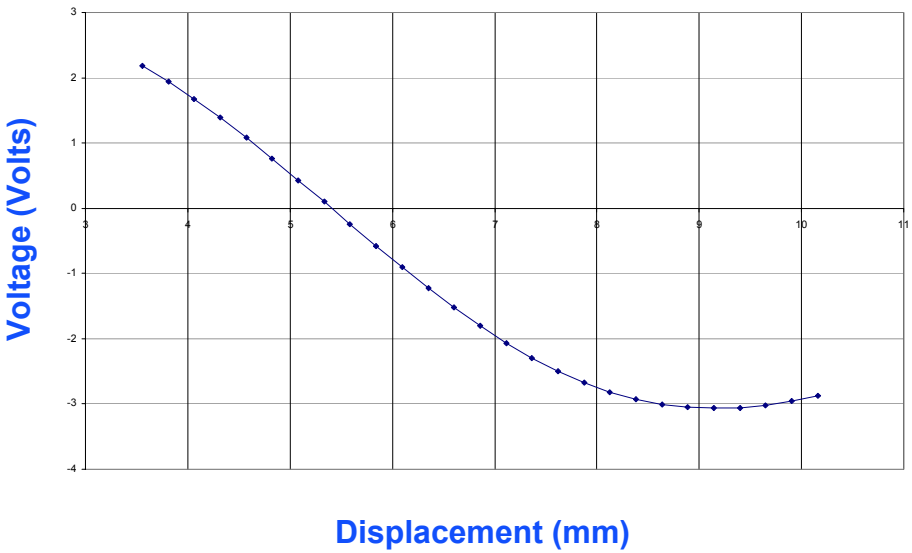


Custom designed micro-LVDT and holders

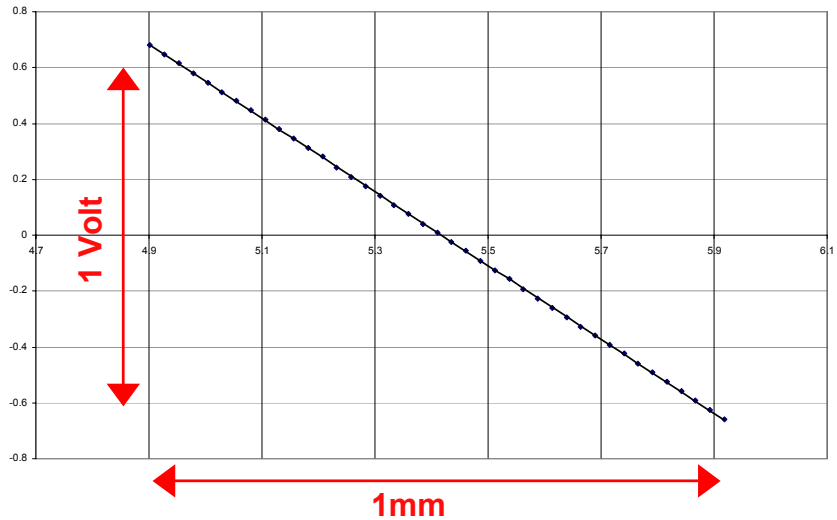


Differential measurement = high resolution, rejection of noise

Linear response:



Linear regime:

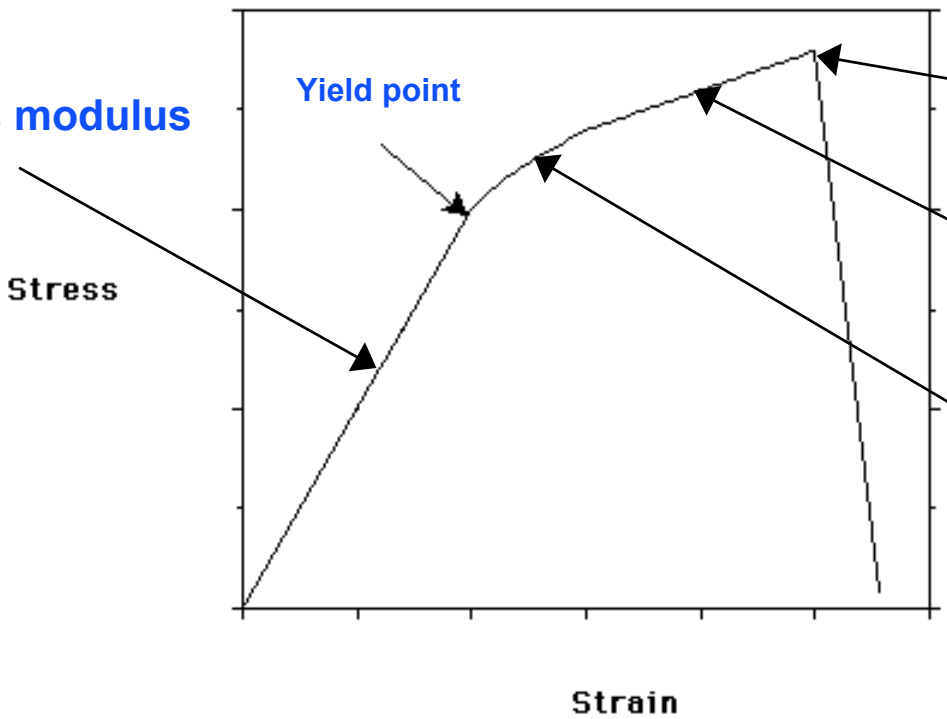


Present resolution: 15nm

LIGO

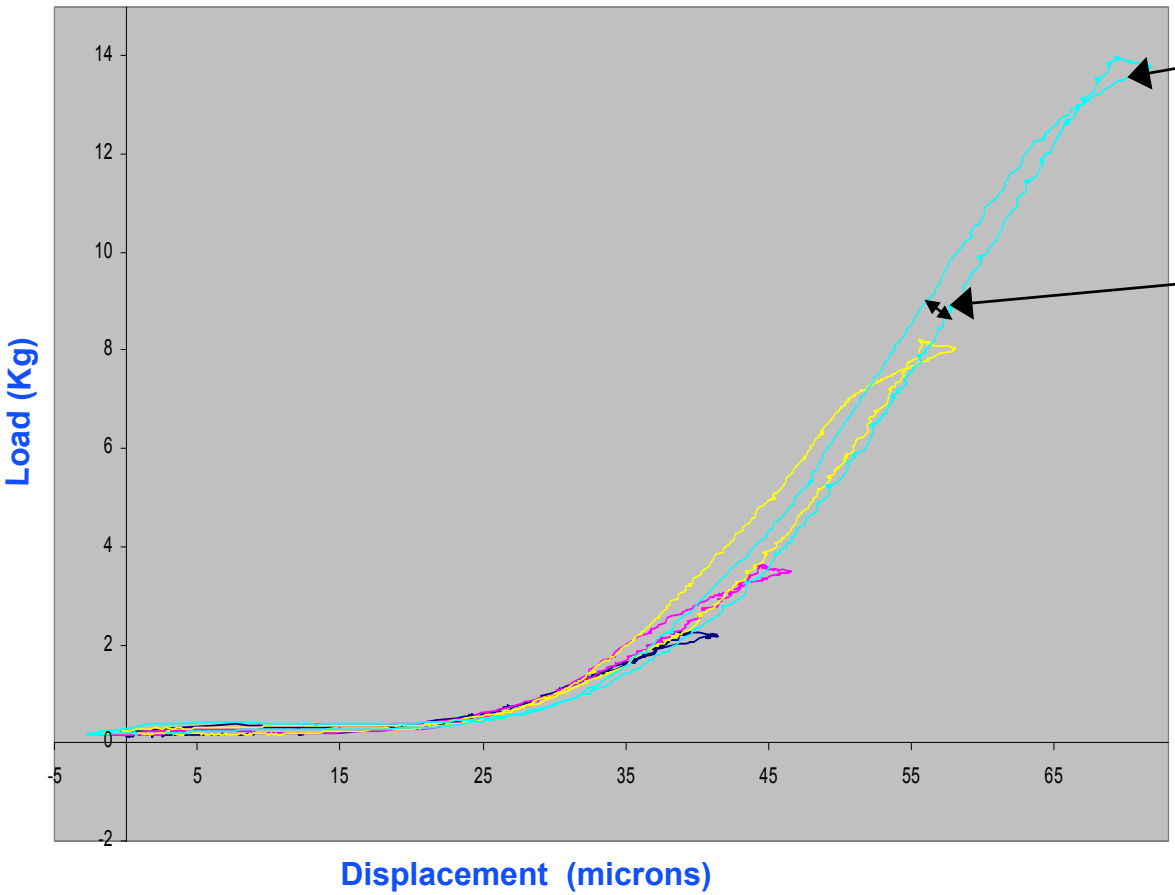
The stress/strain chart

The stress\strain chart give us a clear picture of many properties of the material:



Stress/strain chart for MoRuB

First cycles: low load



Non-rigidity of the system

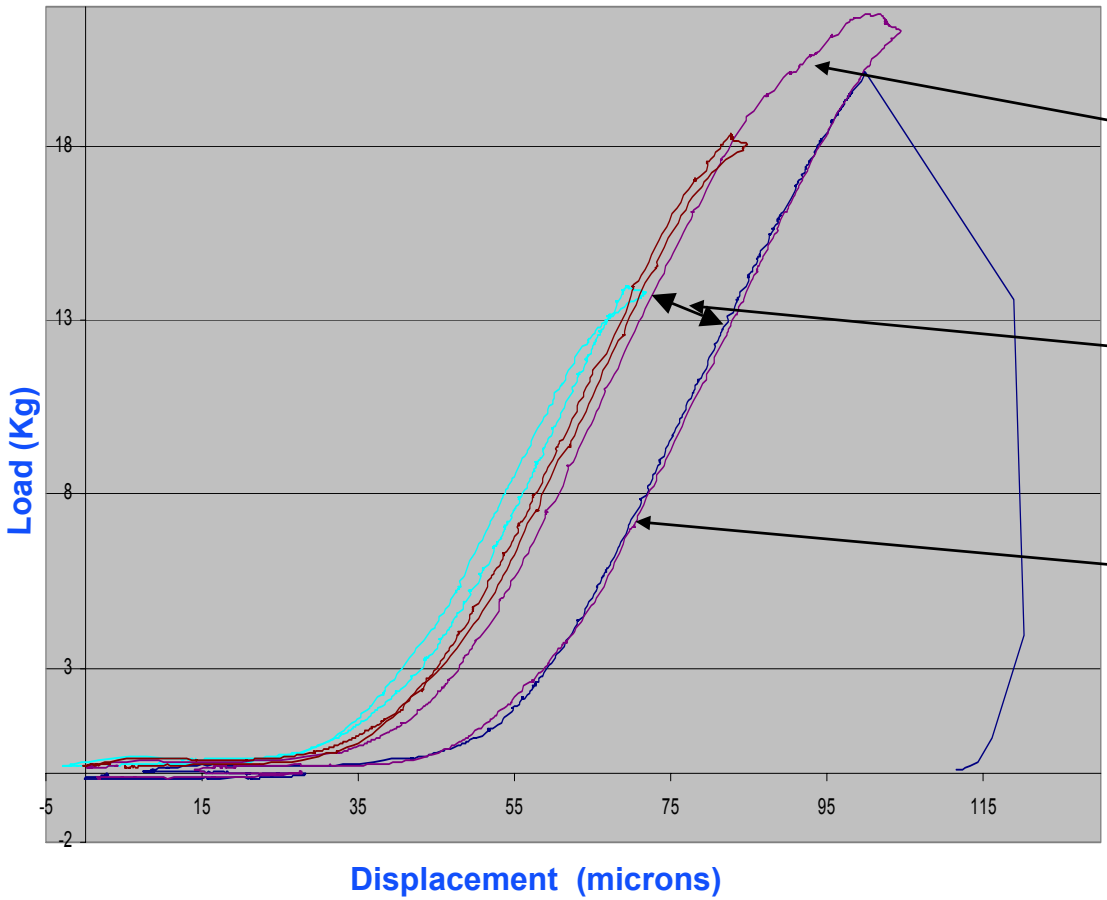
Hysteresis NOT due to sample

Sample tested:
$Mo_{50.4}Ru_{33.6}B_{16}$

Cross section:
3.3mm x 50um

Stress = load * g * 1/cross-section

Stress/strain curves for MoRuB



Crack formation

Material hysteresis

Permanent deformation
No breakdown failure as in crystals!

Why low values for yield point?

Young's modulus:

Boron 16: 174 GPa

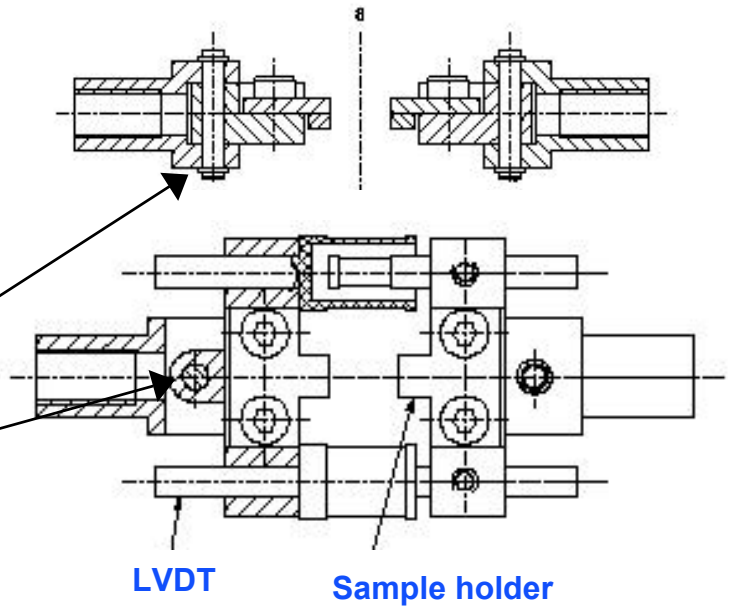
Error: ~15% mainly due to poor thickness Measurement. Solution: precision-micrometer Upcoming.

Yield point (lower limit!):

Boron 16: 1.34 Gpa

(upper limit: 5.2GPa)

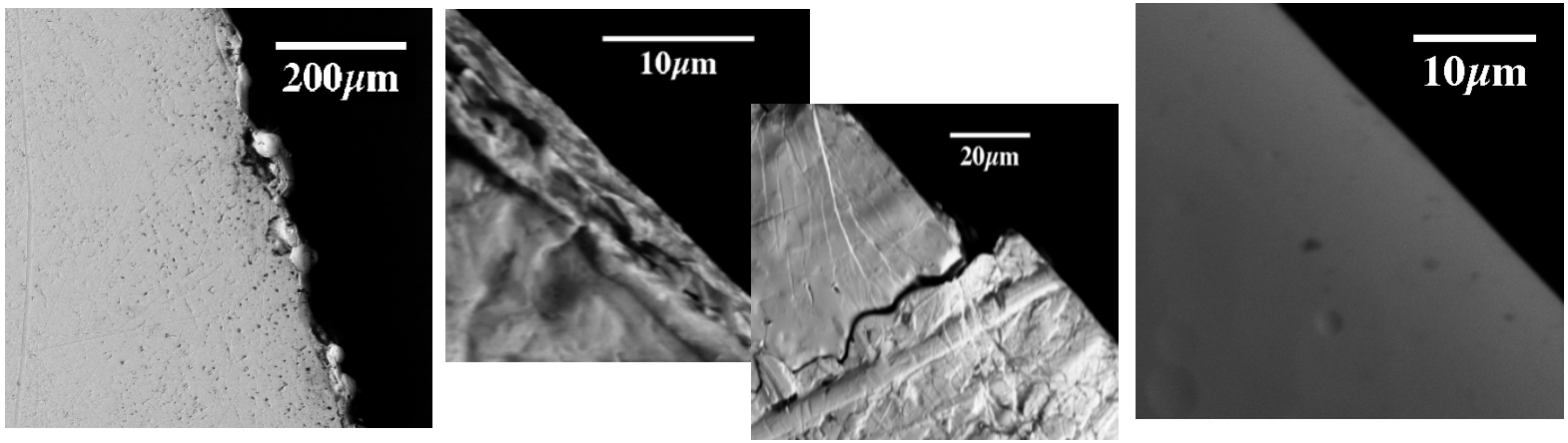
Non-uniformity of stress: effective cross-section is LOWER than the measured one.
Solution: self-aligning swivel holders (already in production):



LIGO

Why low values for yield point?

Nucleation of cracks. To take good measurements we need regular borders without weak point for crack nucleation:



EDM Cut
Local melting
Possible formation
Of crystals on edges

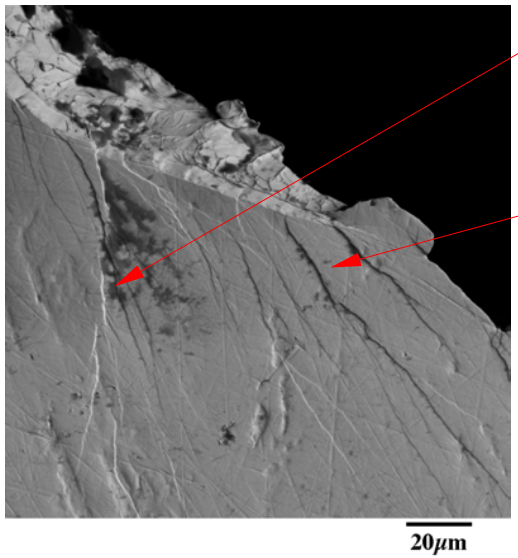
Scissor cut:
Very irregular and unreliable!

Electropolished cut:
The best!

Nucleation of cracks causes premature failure of the material!

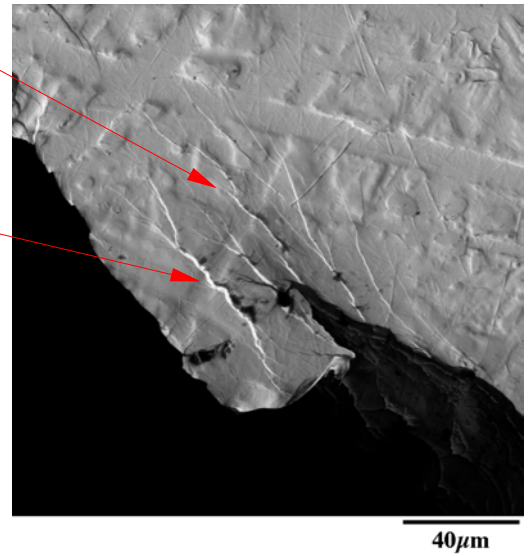
LIGO

Structural effects of stress: shear bands



Shear bands

Details of a MoRuB broken sample



Who knows about shear bands? I don't, but they're nice.

LIGO

What needs to be done:

- **Testing on electropolished samples to obtain a value close to the one calculated by Vicker hardness test (5.2GPa).**
- **Study of crack propagation.**
- **Poisson's modulus.**
- **Observation of shear bands during formations: load frame is designed to fit into an SEM casing.**

LIGO

Thanks to

Riccardo DeSalvo - Mentor

Prof. Francesco Fidecaro - University of Pisa

ChenYang Wang - Graduate Student, LabMate
Hareem Tariq - Graduate Student

Prof. William Johnson

Robert Rogan - Materials Science
Michael Hall
Brian Emmerson
Eric Kort
Maddalena Mantovani
Barbara Simoni