Microcompression tests on multilayered thin films

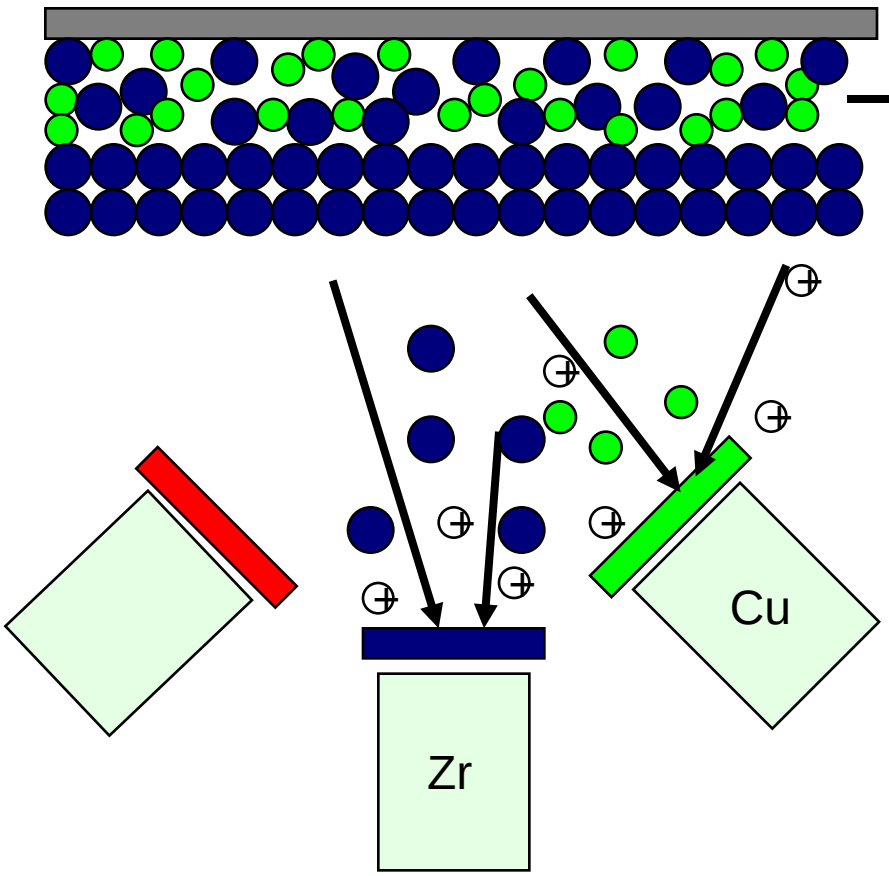
Student: Mingche Liu

Adviser: Prof. Huang

Current topic

- **Compression behavior of the micro-scale amorphous-crystalline multilayer pillars.**
- **A thin layer of nanocrystalline metal film beneath the brittle binary ZrCu thin film metallic glass (TFMG) layer.**
- **Effects of different nanocrystalline structure on multilayer pillars.**

Co-sputtering

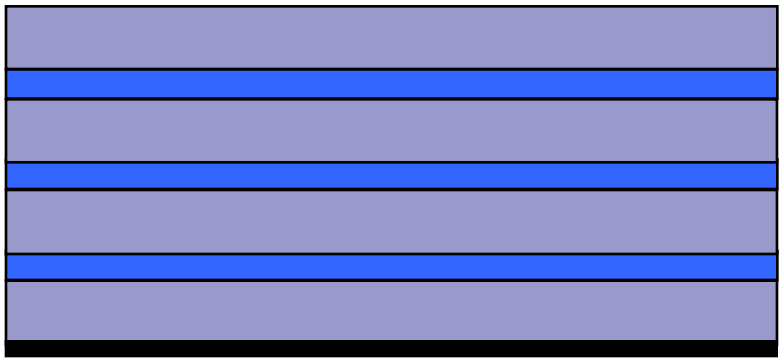


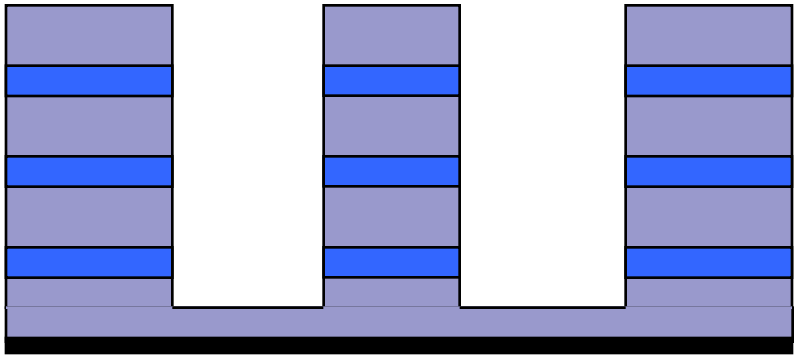
Si substrate

Zr-Cu thin film metallic glasses

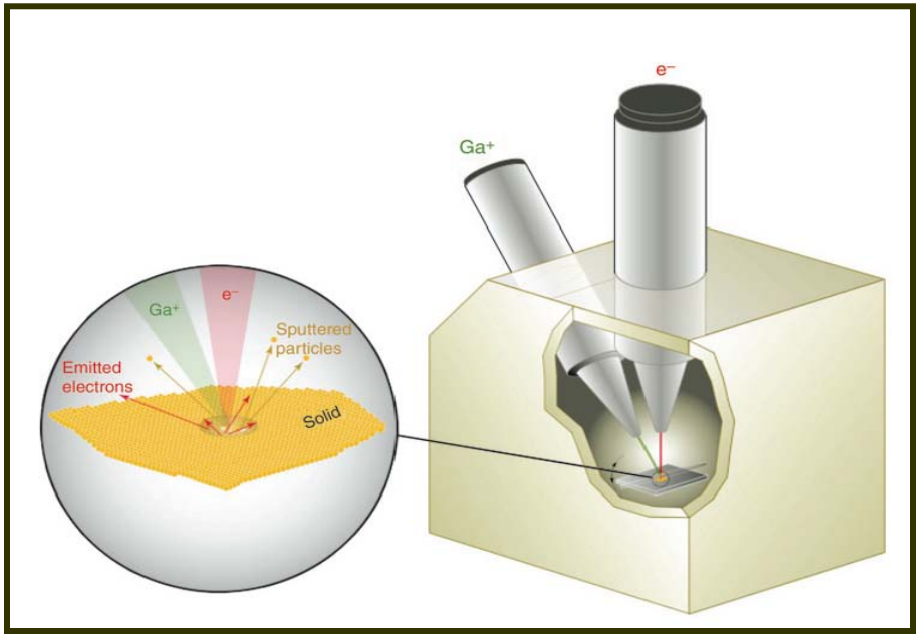
Zr crystalline thin film

Experimental procedure





Dual focus ion beam (FIB)



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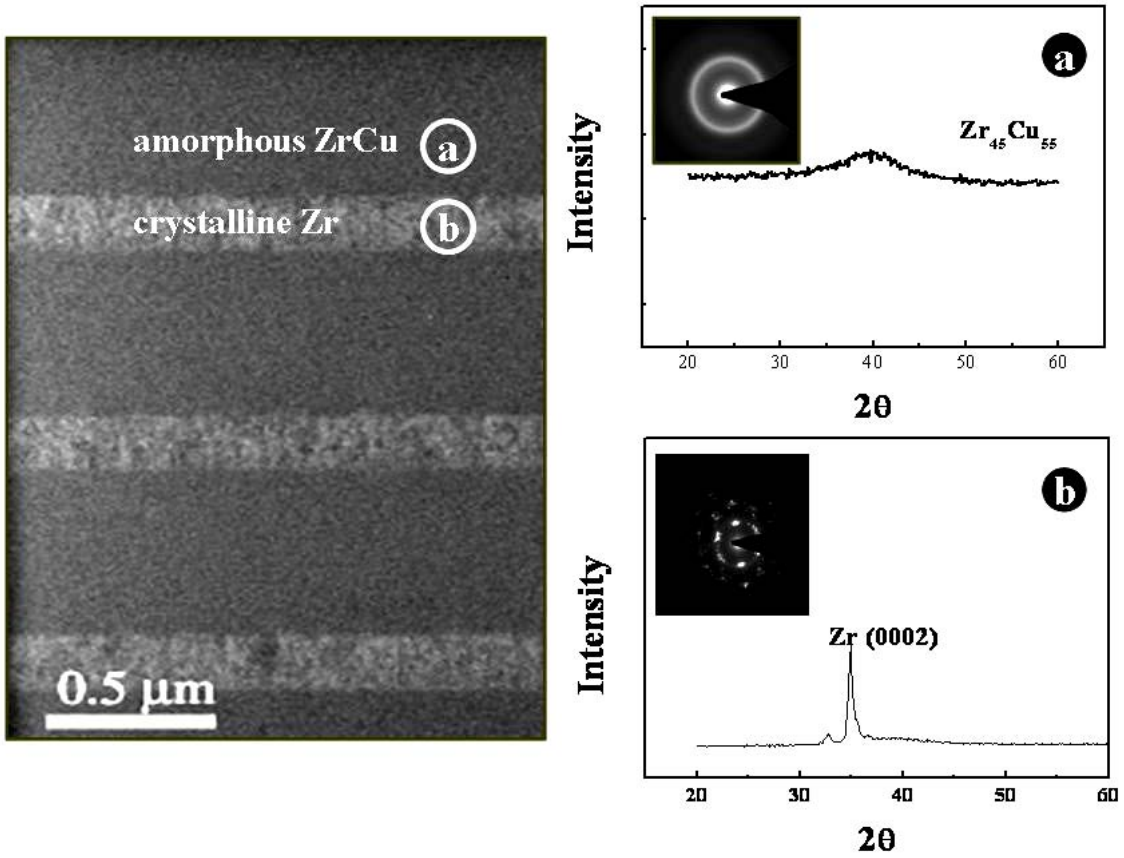
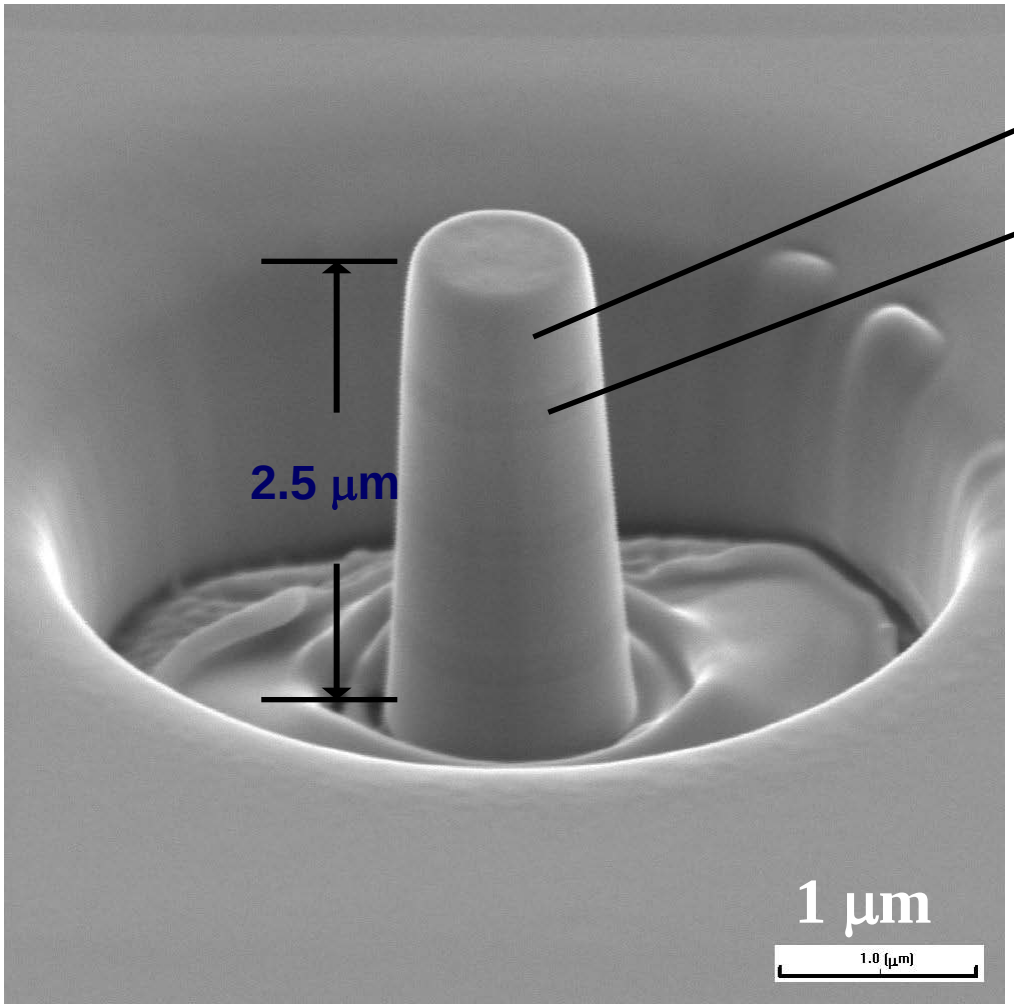
Preliminary results



TEM micrograph (left) showing the morphology of amorphous/nanocrystalline laminates. The amorphous and crystalline nature of the $Zr_{45}Cu_{55}$ and pure Zr layers can be seen from the right (a) and (b), respectively.

Micro-pillar of multilayered thin films



Zr-Cu metallic glasses (A)

Zr polycrystalline (C)

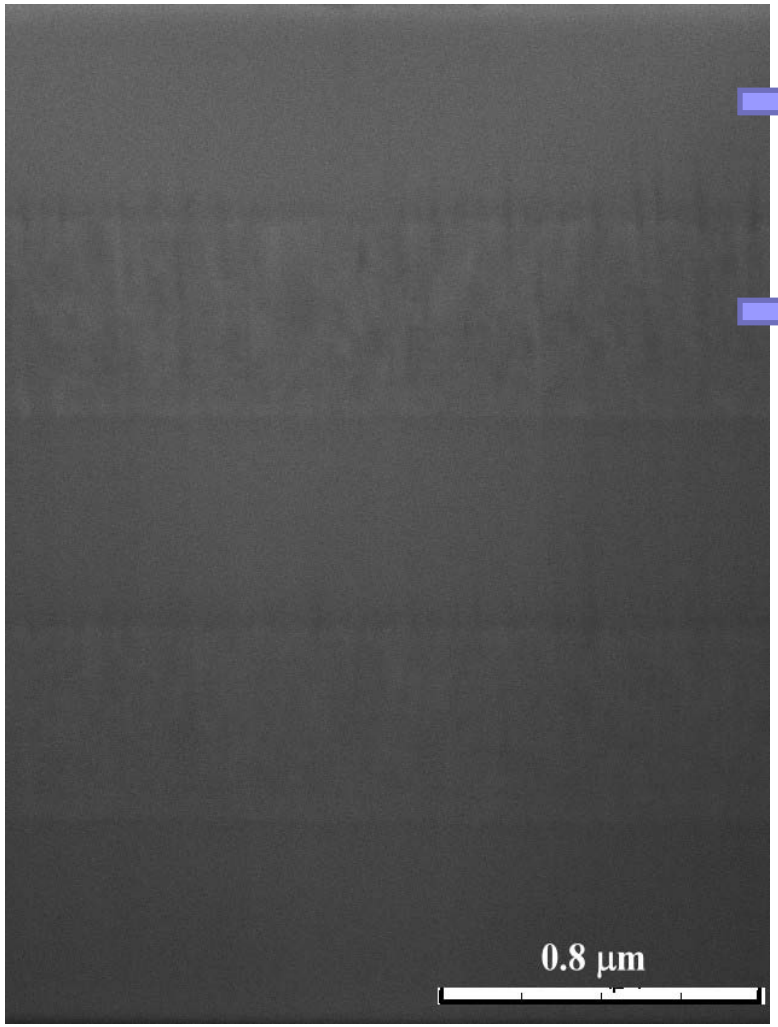
The parameters of sample:

Diameter: 1 μm

Thickness of A layer: 570 nm

Thickness of C layer: 190 nm

Total thickness: 2.5 μm



ZrCu amorphous

Mo

The parameters of sample:

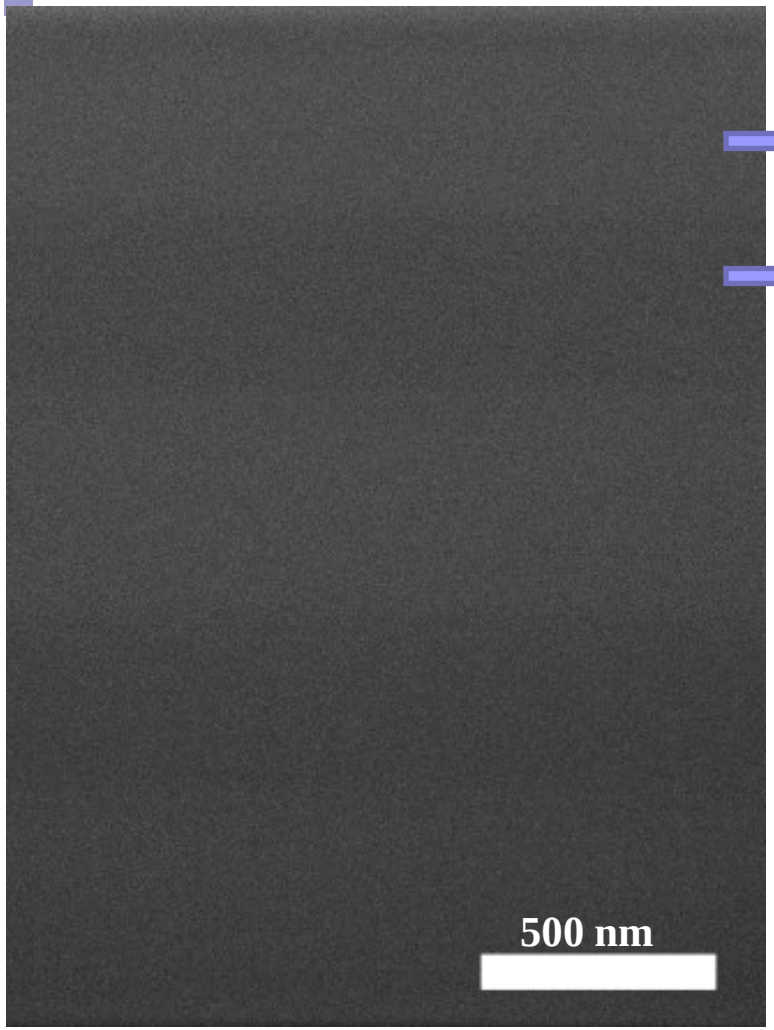
Diameter: 1 μm

Thickness of A layer: 570 ± 10 nm

Thickness of C layer: 550 ± 10 nm

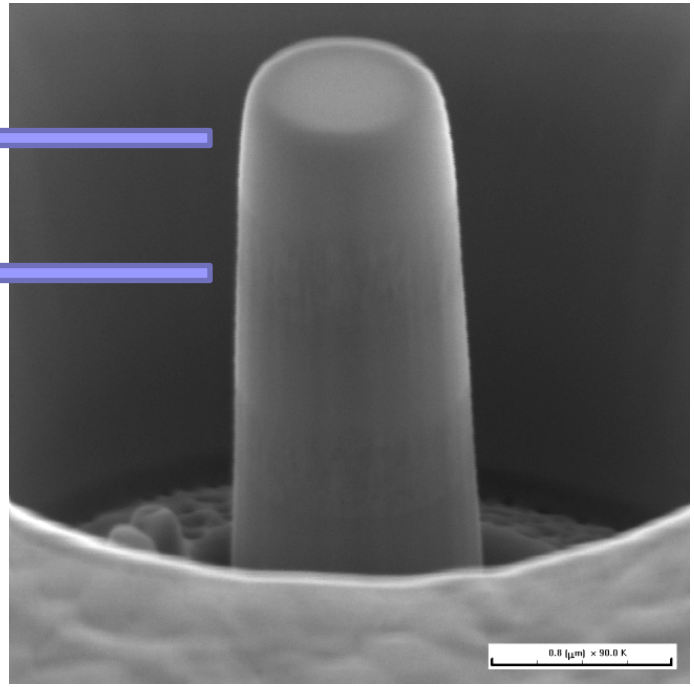
Total thickness: 2.8 μm

Cross-sectional SEM image showing the morphology of ZrCu/Mo laminates. The thicknesses of the ZrCu amorphous and Mo crystalline layers are 570 and 550 nm, respectively.



ZrCu

Cu



The parameters of sample:

Diameter: 1 μm

Thickness of A layer: 550 ± 10 nm

Thickness of Cu layer: 500 ± 10 nm

Total thickness: 2.6 μm

Mechanical properties of thin films

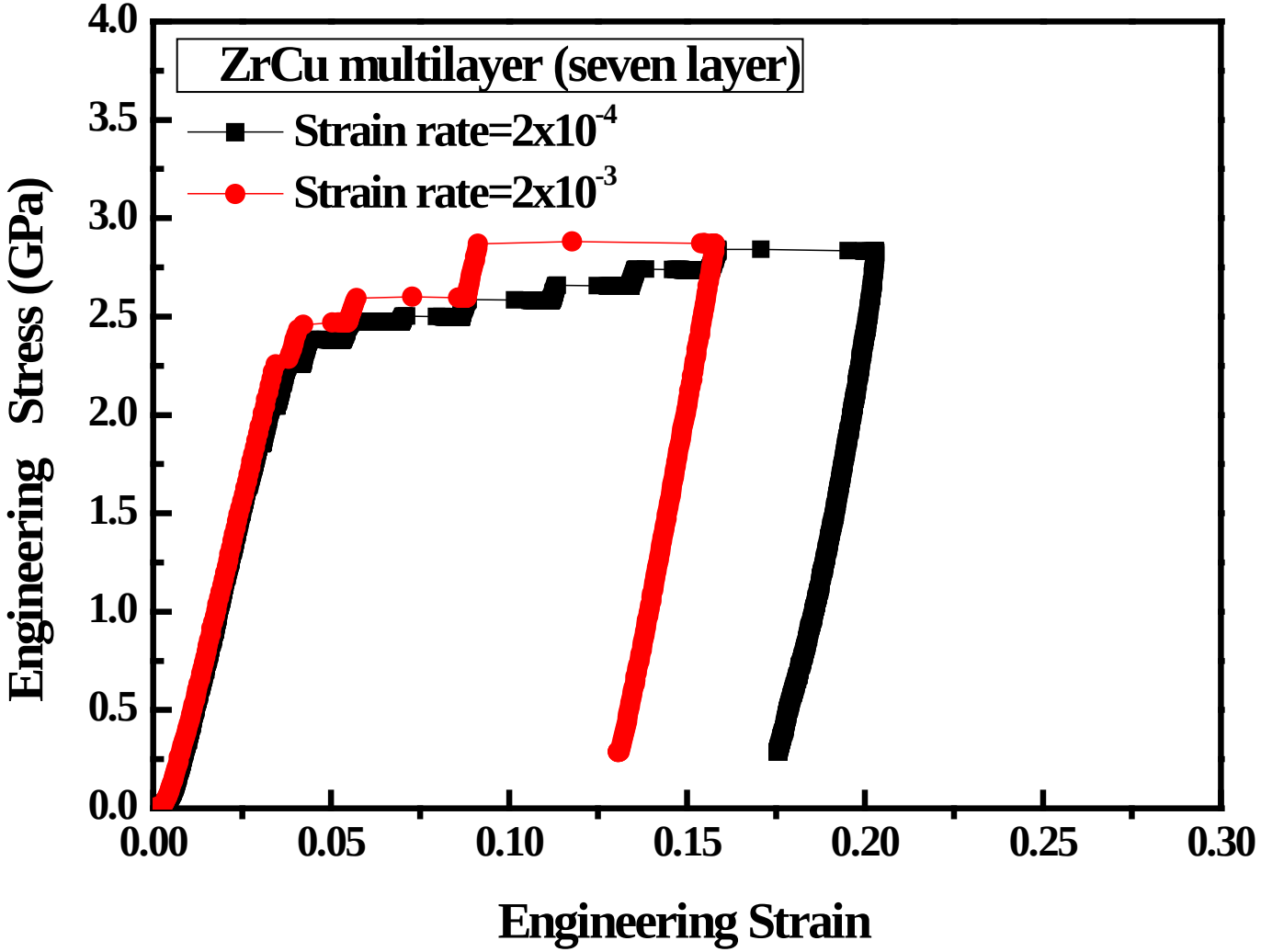
- Table 1 Summary of the modulus and hardness of the as-deposited thin films and silicon wafer, obtained from nano-indentation.

Thin film specimen	Modulus E, GPa	Hardness, GPa
Monolithic ZrCu amorphous film	**92.5**	**4.73**
Monolithic Zr crystalline film	**125.1**	**5.22**
Silicon wafer [100]	**171.9**	**11.21**

- Table 2 Summary of the results of various tested pillars, obtained from the micro-compression tests.

Thin film specimen	Strain rate, s^{-1}	Preset displacement, nm	E, GPa	YS, GPa
Monolithic ZrCu amorphous film	**$2x10^{-3}$**	**300**	**91.5**	**2.7**
Monolithic Zr crystalline film	**$2x10^{-3}$**	**300**	**128.8**	**3.2**
ZrCu/Zr seven layers: ZrCu 570 nm Zr 190 nm	**$2x10^{-3}$**	**300**	**108.1**	**2.5**
ZrCu/Zr/ZrCu Three layers: ZrCu 550 nm Zr 880 nm	**$2x10^{-3}$**	**300**	**124.3**	**2.7**

Engineering stress-strain curve



Thank you for your attention