Microstructure and properties control in sputter-deposited Zr-Cu thin film metallic glasses

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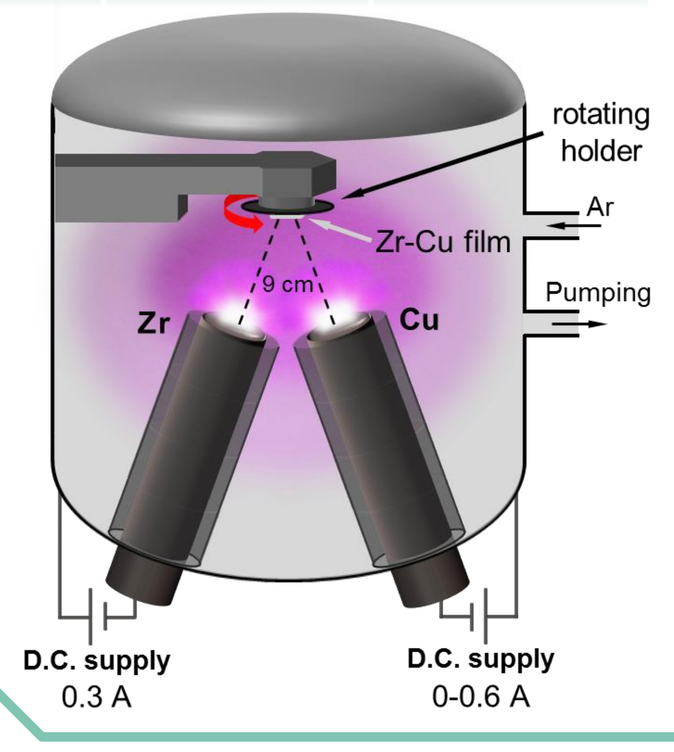
Introduction

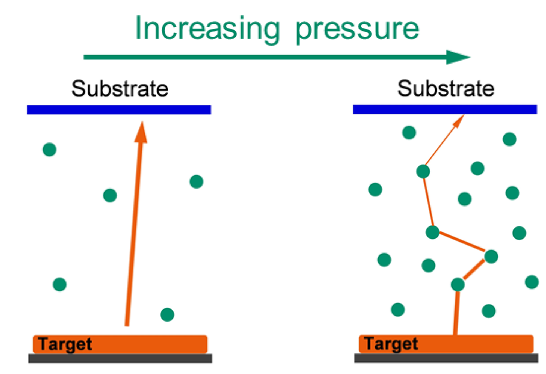
- Metallic glasses (MGs) have emerged as a new class of materials with remarkable properties compared with their crystalline counterpart.
- Using physical vapor deposition methods such as sputtering, MGs can be prepared in the form of thin film metallic glasses (TFMGs).
  - The microstructural control inherent to the sputtering process can be exploited to tailor the properties of TFMGs.
- Here, we report on the influence that the energy of the sputtered atoms arriving at the substrate (controlled here through the deposition pressure) has on the structure, microstructure and properties of the deposited films.
- Zr-Cu alloys are used as a model system and studied over a wide range of compositions.

Deposition process



Magnetron co-sputtering

- Vacuum limit in the chamber: 10^{-5} - 10^{-7} Pa
- Substrate: (100) silicon single crystal substrates
- Films deposited without external heating
- Working argon pressures
  - 0.25 Pa
  - 0.5 Pa
  - 1 Pa
  - 2 Pa

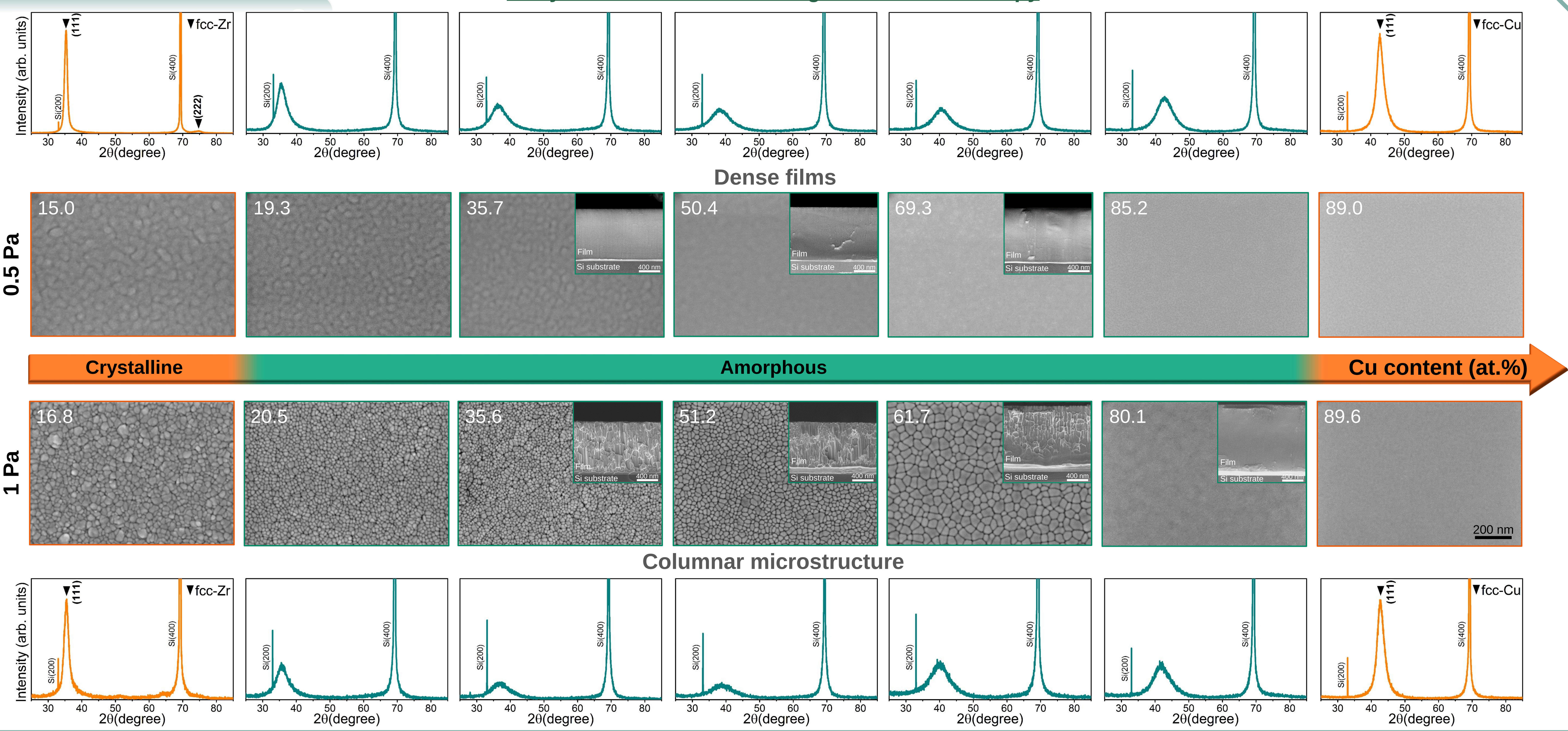


pressure ↗
mean free path ↘

$$\lambda = \frac{RT}{\sqrt{2}\pi d^2 N_A P}$$

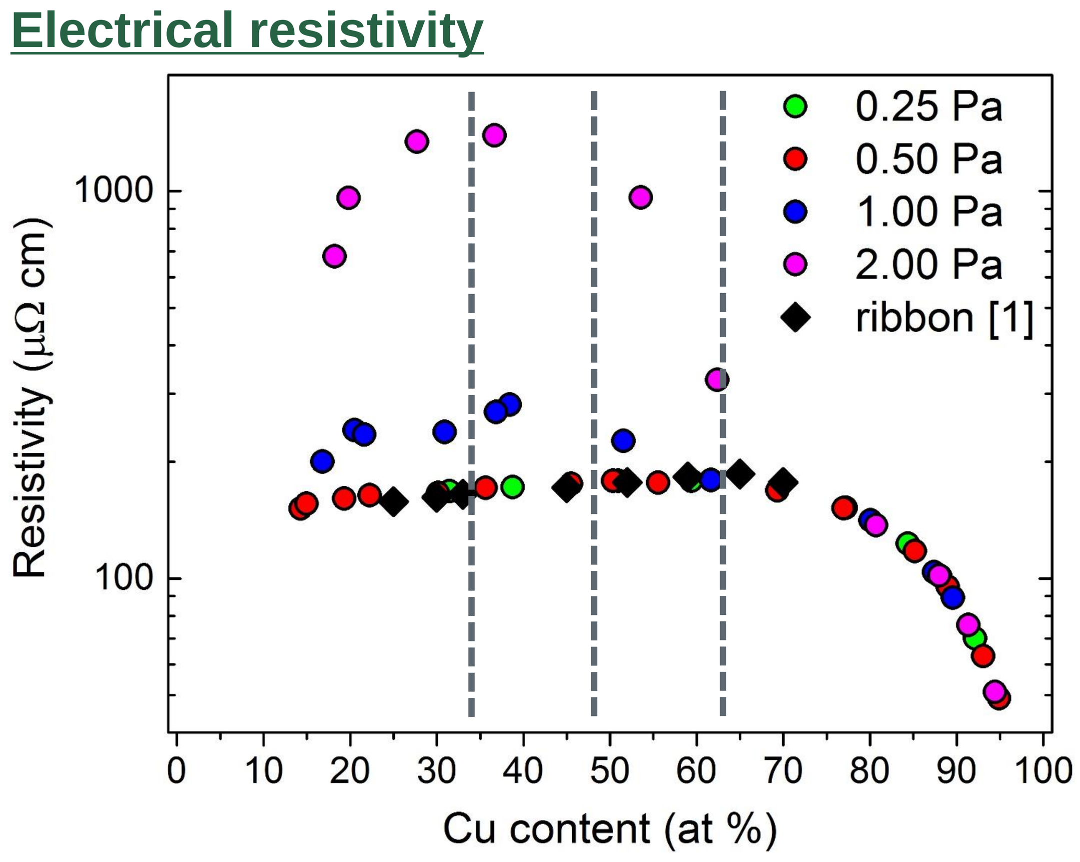
Microstructural tuning

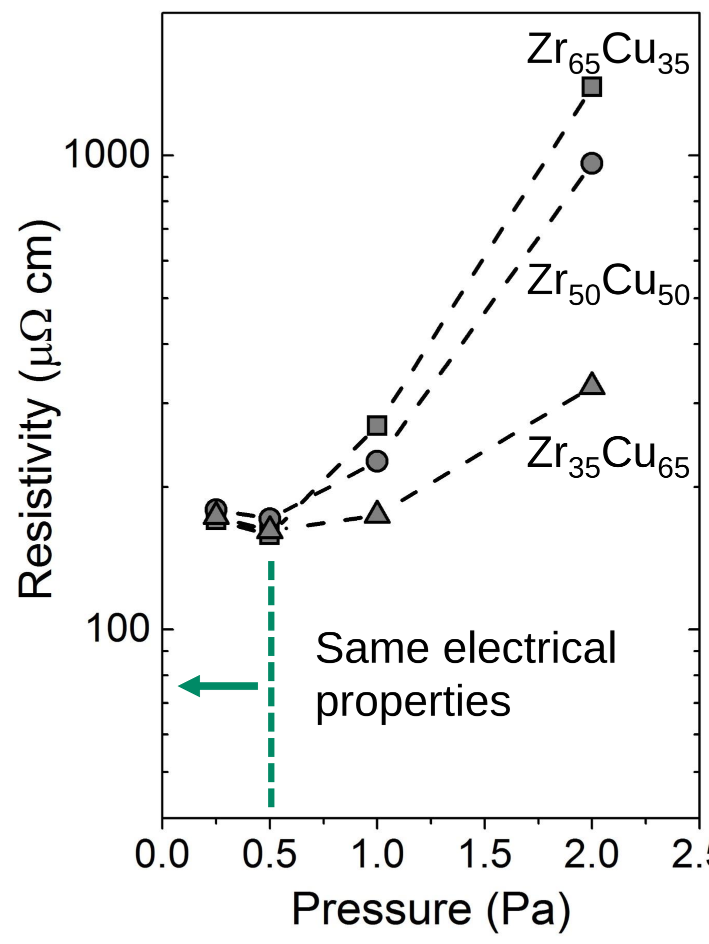
X-ray diffraction and scanning electron microscopy



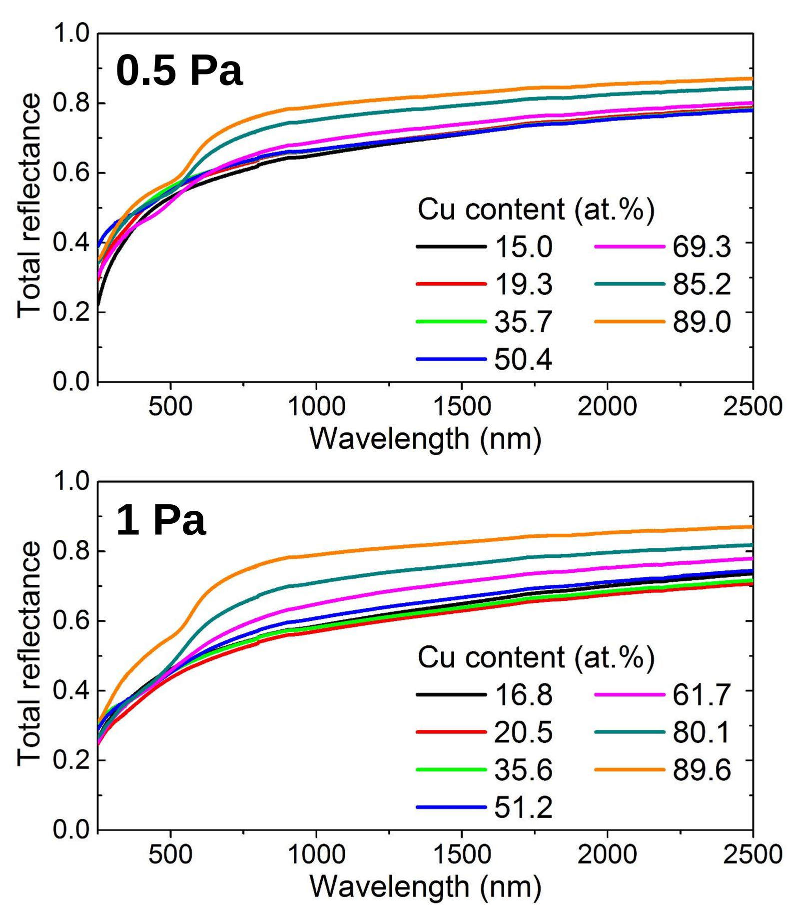
Electrical and optical properties

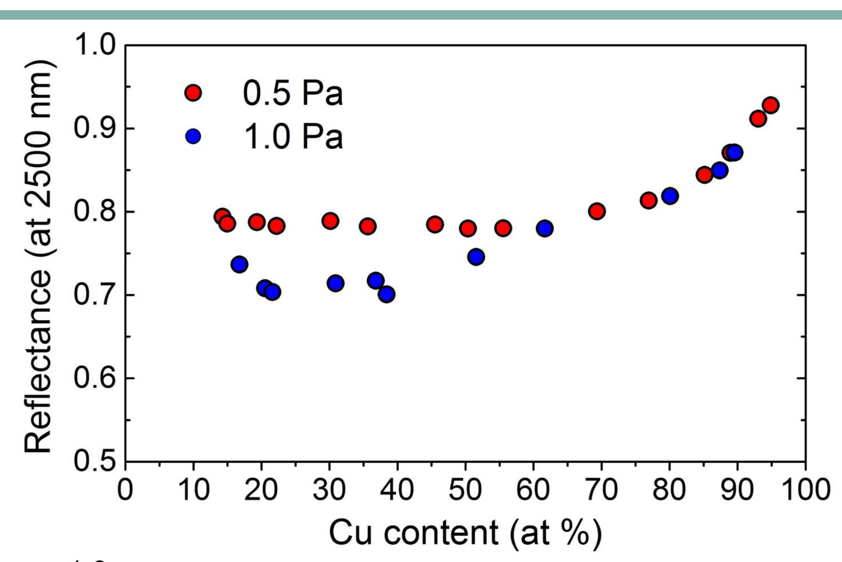
Electrical resistivity

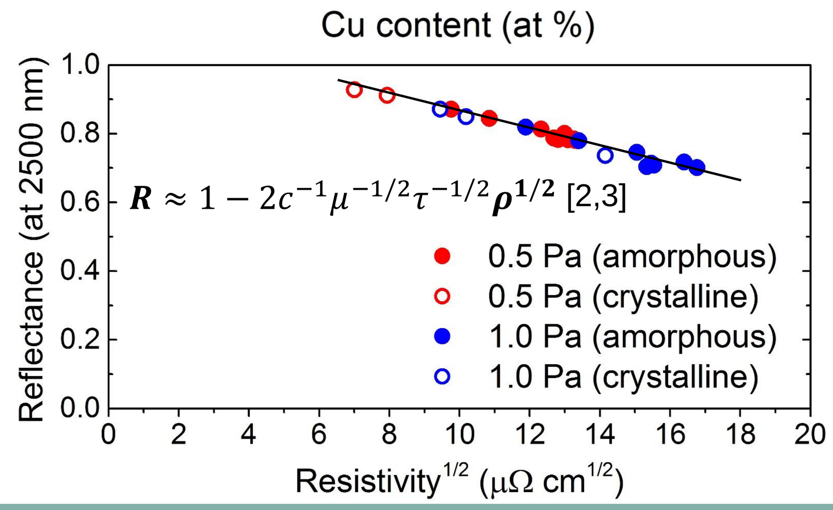




UV-visible-IR spectroscopy







Conclusion

- ✓ Increasing the deposition pressure, a composition-dependent transition from a denser to a columnar microstructure occurs.
- ✓ This microstructural transition directly affects the electrical and optical properties of the deposited TFMGs.
- ✓ There is a threshold in the deposition pressure below which the resistivity of the films remains constant.
- ✓ The optical reflectance scales linearly with the square root of the electrical resistivity, according to the classical reflection theory.

References

[1] Z. Altounian *et al.*, *Journal of Applied Physics* **53**, 4755 (1982)
[2] T. T. Hu *et al.*, *Appl. Phys. Lett.* **101**, 011902 (2012)
[3] S. Canulescu *et al.*, *Appl. Phys. Lett.* **108**, 141909 (2016)

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