Shear band evolution in multilayered amorphous film under nanoindentation

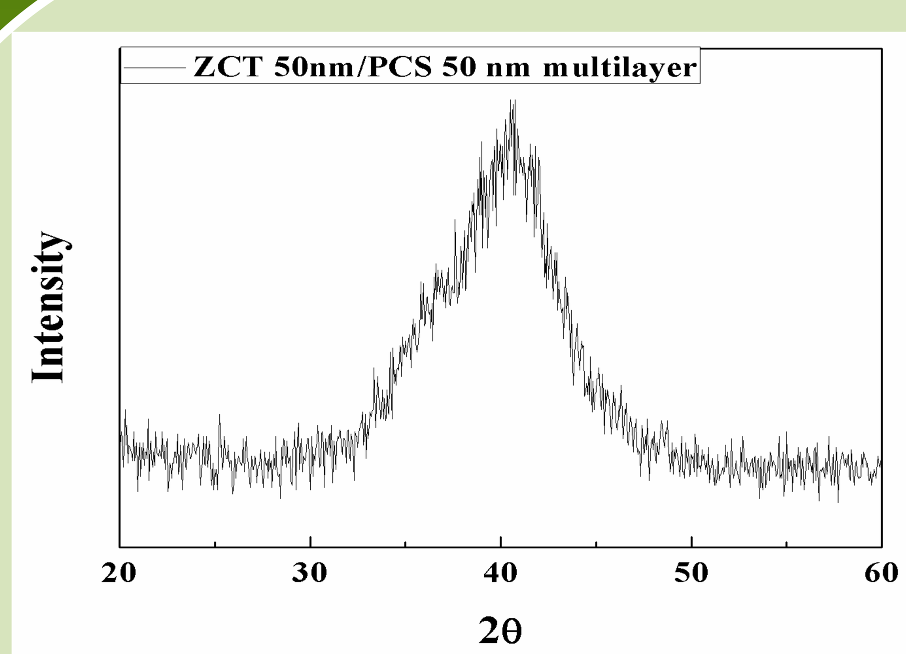
S. Y. Kuan[1], T. T. Hu[1], H. S. Chou[1] and J. C. Huang[1,*]

[1]Department of Materials and Optoelectronic Science, Center for Nanoscience and Nanotechnology,
National Sun Yat-Sen University, Kaohsiung, Taiwan 804, ROC

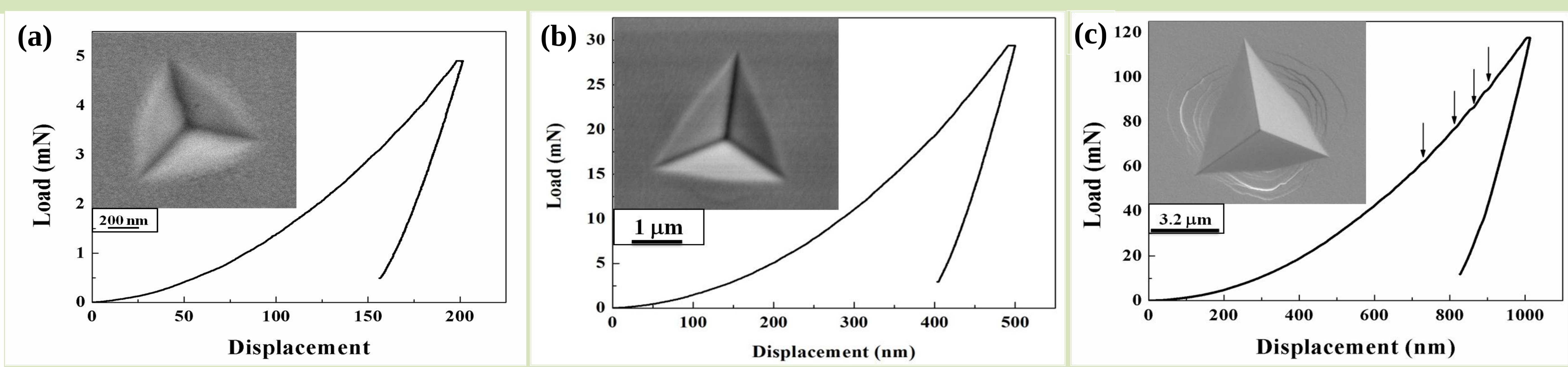
[*] Corresponding author: Tel: +886 7 5252000 ext 4063; fax: +886 7 5254099, E-mail: jacobc@mail.nsysu.edu.tw

Abstract

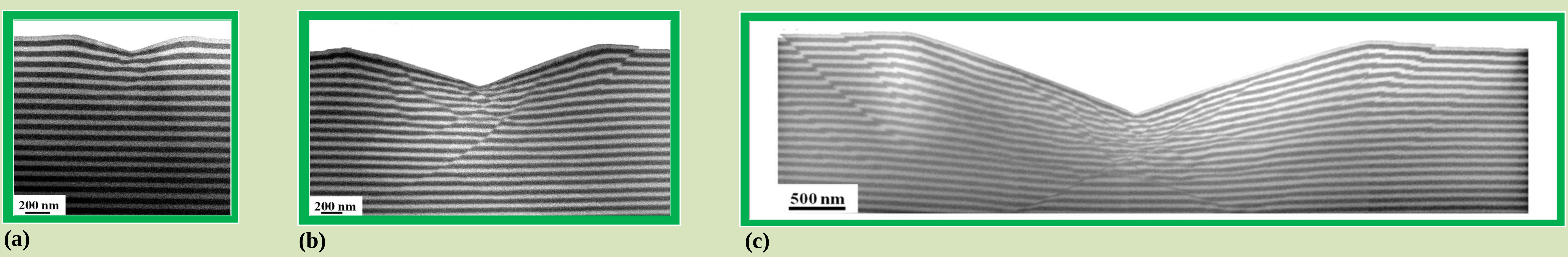
Thin film metallic glasses (TFMGs) have been applied for micro-electromechanical systems (MEMS) devices. The mechanical properties and the deformation characteristics of TFMGs are usually investigated by nanoindentation tests. The expanding cavity model is widely used to analyze the shear bands of micro-indentation. In this study, the ZrCuTi (ZCT) 50 nm / PdCuSi (PCS) 50 nm multilayered thin film metallic glasses are prepared by sputtering. Utilizing the multilayer structure, the as-formed shear bands can be easily visualized by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). In our study, two kinds of shear bands (i.e., the radius shear bands and semi-circular shear bands) can be clearly observed by cross-sectional TEM characterization. To combine the deformed microstructure and the recorded data, the transition point from the radius type to semi-circular type can be determined. The underlying mechanisms for such shear band evolution in multilayered films will be proposed and discussed.



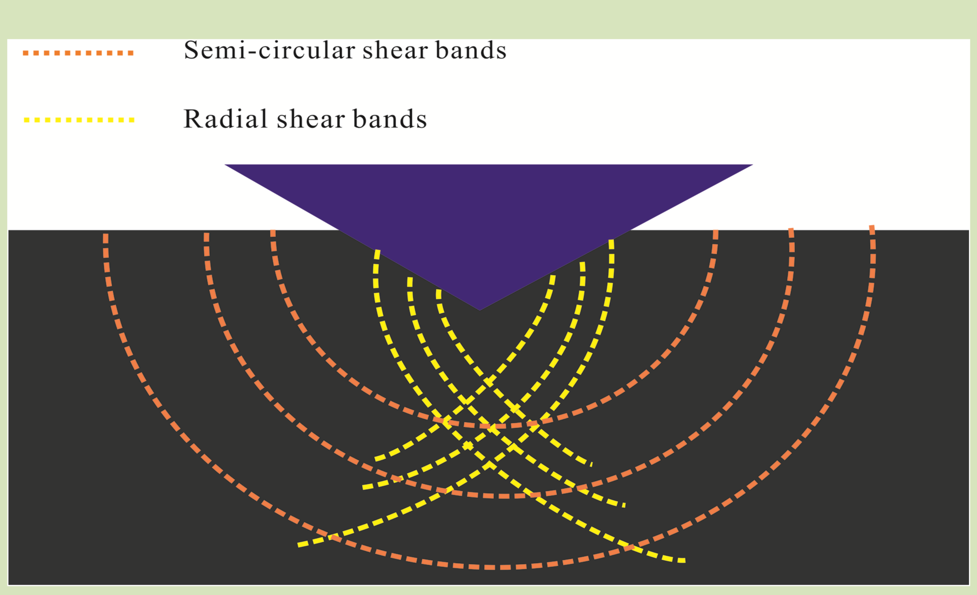
X-ray diffraction pattern of ZCT/PCS amorphous multilayer



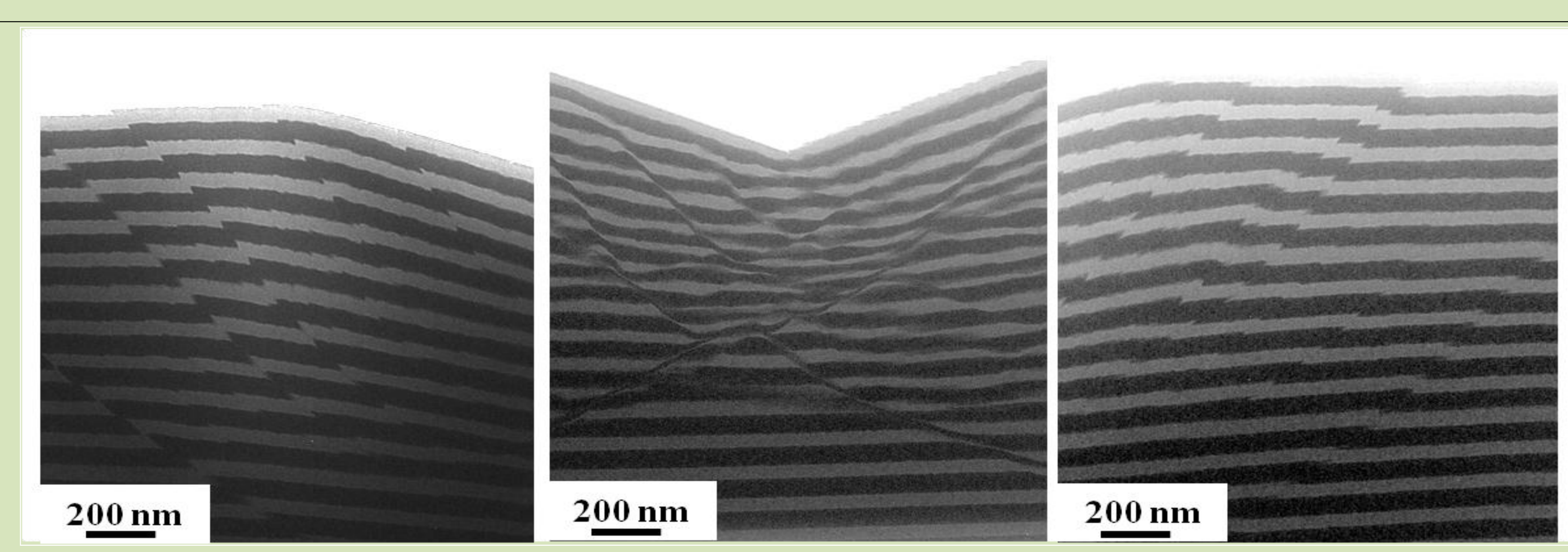
The load-displacement curves and surface morphology for the 50/50 ZCT/PCS films indented to (a) 200 nm (b) 500 nm (c) 1000 nm.



Full view of shear bands patterns beneath nanoindent indented to (a) 200nm, (b) 500 nm and (c)1000 nm.



Expanding cavity model



The enlarged views of the shear bands indented to 1000 nm.

Conclusion

1. **The shear band evolution in multilayer amorphous film under nanoindentation is combined radial shear bands with semi-circular shear bands which correspond to expanding cavity model.**
2. **TEM images of indentation mark with different displacement show radial shear bands come before semi-circular shear bands.**
3. **Multiple radial shear bands cause continue deformation. However, the discontinue load-displacement curve is due to strain burst of semi-circular shear bands when the displacement reach about 700 nm.**