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How Residual Stresses Affect the Fracture Properties of Layered Thin Films

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The continued miniaturization effort has revealed exciting new material behavior at small length scales, where pronounced size effects come into play and material properties are subject to change. This has led to the development of miniaturized testing techniques to determine local plastic properties. So far, however, only few efforts regarding the determination of residual stresses and fracture properties in miniaturized systems were made.

In this presentation, we will focus on recent developments regarding the measurement of residual stresses and miniaturized fracture properties using FIB based sample preparation and *in situ* SEM experiments. The depth resolved residual film stresses are determined by an improved stepwise beam layer removal method [1]. From the same film systems, beams are FIB fabricated for miniaturized fracture testing in the SEM [2]. We will discuss the general possibilities, challenges, and benefits of these approaches by examining the internal stresses and fracture properties of single layer and multilayer thin films in the immiscible system Cu-W. Particular emphasis is placed on the effect of residual stresses on the fracture properties. Moreover, possible limitations of commonly used data analysis approaches are addressed, and related improvements using finite element modelling to determine crack-driving forces in the presence of interfaces and residual stresses are presented [3]. Notably, the required material input data in terms of flow behavior for this modeling approach was determined using spherical nanoindentation experiments on single and multilayer films. Finally, the possibility of further miniaturization of such experiments by using *in situ* TEM is demonstrated [4].

References:

[1] Schöngrundner, R., et al., 2014. Thin Solid Films 564, 321-330.
[2] Treml, R. et al., 2015. Under preparation.
[3] Kozic, D, et al., 2014. Proceedings EuroSimE 2014; Ghent; Belgium; 7 April 2014 through 9 April 2014; DOI: 10.1109/EuroSimE.2014.6813785
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