Phase stability and stress evolution of nano-multilayered coatings upon thermal treatment

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The functionality, reliability and service lifetime of nano-multilayered (NML) devices and components are largely affected by the stress evolution during fabrication, processing and operation. Hence a comprehensive experimental assessment of their structural integrity, including stress state evolution, during thermal loading is a crucial step to evaluate their applicability. This contribution addresses recent advances in the experimental investigation of the phase stability, microstructural integrity and stress evolution of metal/metal (Cu/W) [1] and metal/ceramic (Ag/AlN, Ag60wt.%Cu40at.%/AlN, AgGe10at% /AlN) NML coatings during heating by advanced in-situ diffraction methods in combination with XPS, SEM and TEM analysis: see Fig.1. Such NML systems, as prepared by conventional magnetron sputtering, are envisaged as novel nano-structured brazing filler materials for advanced joining applications [2]..

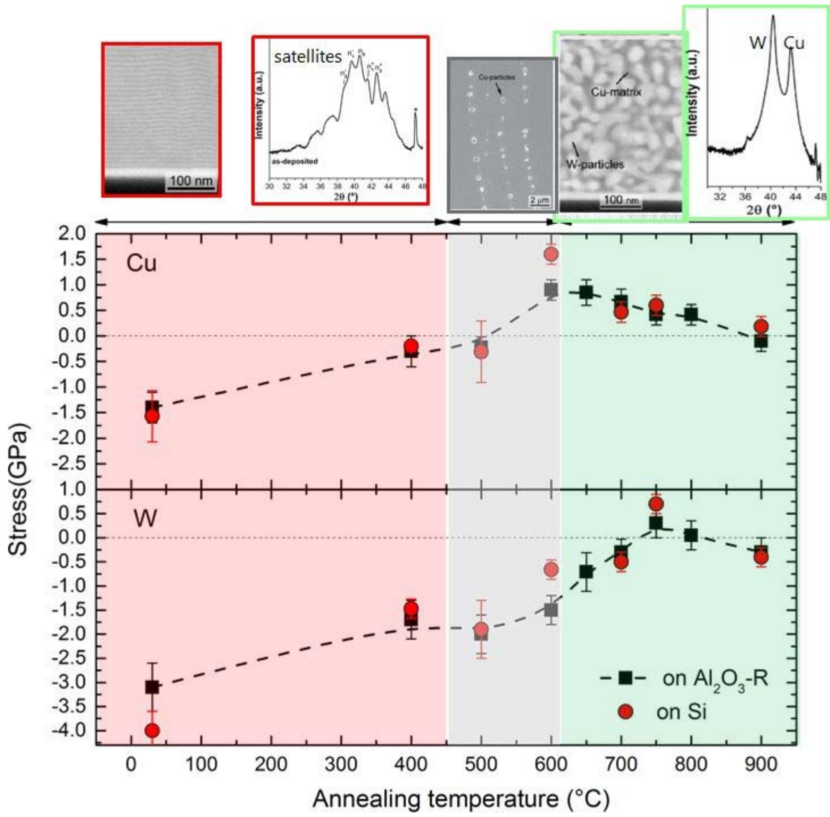

Figure 2: Stress evolution of Cu, W layers combined with SEM morphologic analysis

It is shown that the Cu/W NMLs gradually transform from a nano-laminated into a nano-composite structure upon heating at T >750°C, as accompanied by a complete relaxation of the compressive growth stresses in the confined Cu and W nanolayers. On the contrary, fast heating of the Ag/AlN NMLs in air invokes massive mass transport of Ag from the NML interior to the coating surface at temperatures as low as 200°C (i.e. much below the Ag bulk melting point), as accompanied by a fast relaxation of thermally-induced compressive stresses [3]. The crucial role of the processing atmosphere and of co-alloying elements like Cu and Ge on the phase stability and compressive/tensile stress determination of the Ag-based NMLs is rationalized.

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References

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