# Exploring fast diffusion at the nano-scale for nanojoining technologies

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With the continuing miniaturisation of micro-electronic devices the nanojoining technology is expected to become an enabling technology for the large-scale production of integrated components in the coming decades. The successful development of nanojoining processes requires fundamental understanding of diffusion, melting and phase formation at surfaces and interfaces at the nano-scale.

At Empa novel nanomultilayer (NML) joining materials are developed for fast, low-temperature nanojoining processes by exploiting short and fast diffusion paths along surfaces and interfaces [1]. Such NML fillers typically consist of alternating nanolayers (individual thickness < 10 nm) of a brazing metal/alloy filler (e.g. Ag, Cu, Ag-Cu) and a chemically-inert barrier material (e.g. carbon, nitride, oxide, refractory metal) and are deposited by magnetron sputtering techniques: see Fig. 1a.

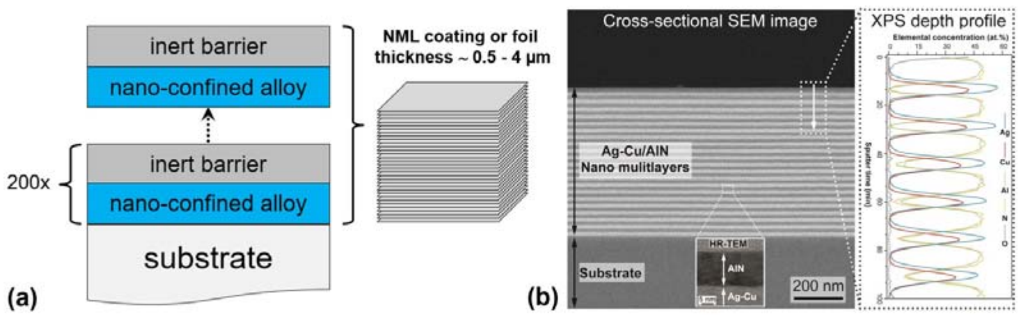


Figure 7: a) Schematic of the NML-filler, constituted of alternating nano-layers (thickness < 10 nm) of a metal or alloy (e.g. Ag, Cu, Ag-Cu) and a chemically inert barrier material (e.g. carbon, nitride, oxide, refractory metal). (b) Cross-sectional secondary electron image (light grey: Ag-Cu, dark grey: AlN) and corresponding composition-depth profile measured by XPS of an as-deposited Ag-Cu/AlN NML.

With the aim to exploit fast directional mass transport of the brazing material, the structural evolution of Ag/AlN and Ag-Cu nano-multilayers (NMLs), as deposited on α-$Al_2O_3$ substrates by magnetron sputtering, upon heating was investigated. A combinatorial analytical approach using real-time in-situ Synchrotron Transmission-X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and Auger Electron Spectroscopy (AES) was applied to study the structural and morphological changes of the NMLs during fast heating up to 550°C [2,3]. The experiments evidence fast transport of the metallic brazing filler to the NML surface at temperatures starting from 200 °C. The process is governed by the delicate interplay between spatial confinement, atmosphere [2], internal stress gradients [4] and the interfacial structure [5].

The investigations show that nano-confinement of metals and alloys in a NML configuration may be exploited to invoke fast directional mass transport at low temperatures for joining technologies.

**Acknowledgment**

The authors acknowledge the financial support of FP7-PEOPLE-2013-IRSES Project EXMONAN.

**References**

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