

High-resolution depth profile analyses of Al/Cu and Ni/Cr superlattices with periodicities ≤ 100 nm by ns/fs-LA-ICPMS

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To fulfill ever-growing requirements in materials science the utilization of superlattices, *i.e.*, modulated metal/semiconductor heterojunctions and oxide thin films, has become of major interest for engineering and fabrication processes of future thermo-electrical and electro-phonic devices [1]. Worth mentioning, individual layers of such periodic composite materials are of thicknesses in the sub-100 nm range which makes them ideal test targets for researchers to (dis-)prove concepts of quantum confinement, a collective term commonly used in the framework of the discretization of an object's physical properties (*e.g.*, optical, thermal, or electrical) when shrinking its dimensions to the nanoscale. To adapt the properties of superlattices to a specific set of applications material structure (crystalline/amorphous) and thickness, and composition (major, minor, and/or traces) of layers are adjusted and hence need to be analyzed.

In this paper, the capabilities of nanosecond and femtosecond laser ablation inductively-coupled plasma mass spectrometry (ns/fs-LA-ICPMS) for the sub-100 nm depth profile analysis of (semi-)conducting materials composition were explored [2]. Two state-of-the-art ArF ns- and Ti:Sapphire fs-LA systems operated at wavelengths and pulse widths of 193 nm/25 ns and 400 nm/150 fs, respectively, both equipped with laser radiation homogenization assemblies were applied to the analysis of well-characterized Cr/Ni and Al/Cu metal superlattices (substrate material: SiO₂, periodicity: 60-100 nm, total thickness: 0.6-1 mm) and Cr/brass plain coating (thickness: 5 mm). Our data suggests fs-LA to permit the analysis of individual metal layers by ICPMS with depth resolutions ranging from approximately 10 nm for Cr/Ni to < 100 nm for Al/Cu; no such depth resolution could be achieved through ns-LA due to the strong heat diffusion, which gave rise to instantaneous melting of material [3]. By comparison, depth resolutions achievable for single Cr/brass transitions using either of the LA systems were found to be in a range of approximately 500 nm. Still, progressive changes of Cu/Zn responses acquired by ns-LA-ICPMS indicated the occurrence of heat diffusion and, thus, re-distribution of substrate material in the course of analysis.

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