CHEMICAL SPECIATION OF THIN FILMS USING PARTICLE-INDUCED X-RAY EMISSION SPECTROMETRY

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The chemical bonds of the metal atoms in thin film, like TiN_x and TiO_x, will greatly affect the properties and applicability of the film. A widely used technique to study these bonds has been x-ray photoelectron spectroscopy (XPS). In this paper, the chemical information potential of proton-induced x-ray emission (PIXE), which is based on characteristic x-rays and generally used for quantitative elemental analysis, will be discussed. In PIXE, chemical shifts of the x-ray energies [1, 2] and relative intensity changes in the x-ray fine structure [3] can reveal information about chemical bonds. This far this has been possible only by means of wavelength dispersive x-ray detectors (WDX).

Currently the measurement system at the University of Jyväskylä consists of 120 transition-edge sensor (TES) pixels integrated with 1.7 MV Pelletron accelerator. Our system has demonstrated high-energy resolution in 1–10 keV energy-range [3]. This allows us to study the fine structure of characteristic x-rays giving us information about the chemical environment of the atoms. The advantages over WDX are the much wider energy-range and faster measurements allowing thin film studies.

We have systematically studied two ALD-grown (atomic layer deposition) titanium compounds (TiO_2 and TiN) using different incident ions and energies. One example of this is shown in Figure 1, and a difference in relative intensities of different characteristic Ti peaks is observed using 11.9 MeV $^{63}Cu^{6+}$ beam. Similar chemical effects were also observed with other beams, like 6.8 MeV $^{12}C^{3+}$ beam, but not with proton beam (Figure 1). The results will be presented, and the pros and cons of TES detector in this application will be discussed.

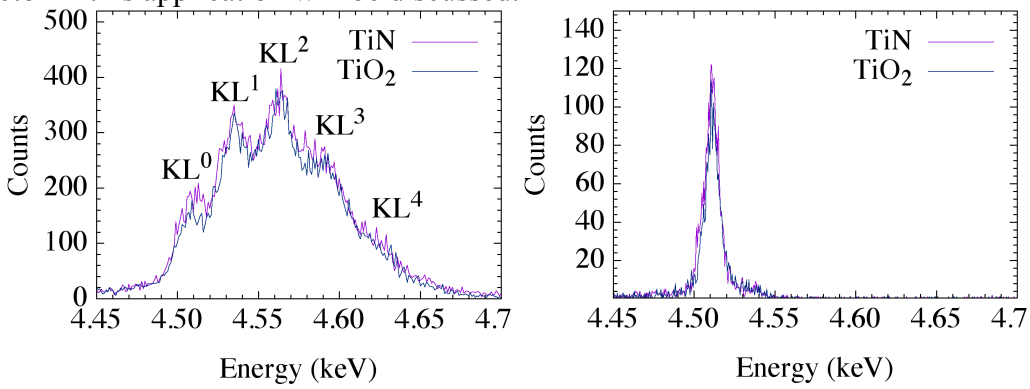

Figure 1: 50 nm thick TiN and TiO_2 thin films measured with 11.9 MeV Cu (left) and 2.0 MeV protons (right). A clear difference in the intensity of KL^0 peak was observed using Cu beam, whereas using proton beam x-ray fine structure is not visible.

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[2] M.R.J. Palosaari, M. Käyhkö, et al., *Ultra-high-resolution Particle-Induced X-ray Elemental analysis using Superconducting Microcalorimeter arrays*, paper submitted.
[3] R.L. Watson, A. K. Leeper, et al. Phys. Rev. A, 15 914, 1977.