Steacie Institute for Molecular Sciences

Neutron Program for Materials Research

Neutrons as a Surface Probe

Surface Composition
Roughness
Multilayers
Buried Interfaces
Bio-membranes

NEUTRON FACT SHEET #3

Neutron Reflectometry

Non-invasive and non-destructive, neutron reflectometry can determine area-averaged chemical composition and roughness of a surface. In addition, the technique is sensitive to variation of chemical composition with depth. If the sample consists of layers of different materials it gives chemical composition and thickness of each layer, as well as the roughness of the interfaces between the layers.

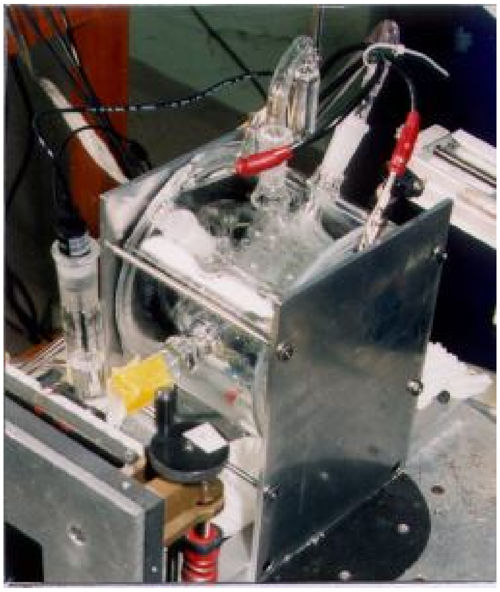

Fig 1. In-situ neutron reflectometry to study hydrogen ingress into metal films

With suitable samples, researchers can acheive excellent resolution: within the overall sensitive depth of up to 300 nm one can often see layers that are only a few atomic layers thick.

Sample Requirements

Samples for reflectometry must be very flat but do not need to be atomically flat. Samples with large surface area generally give better results but those as small as 10 × 10 mm can be studied.

Since many metals, alloys and polymers can be deposited on to a Si or sapphire substrate, the technique is applicable to a wide variety of R&D topics.

Research Topics

Neutron reflectometry is often applied to the study of metallic films, polymer films and biological membranes. Since neutrons are sensitive to magnetism, it is also used to study surface magnetism and artificial magnetic/non-magnetic multilayers. It is a powerful research tool for probing solid/liquid interfaces such as an electrode in contact with an aqueous solution.

For many problems, it is often possible to design a special sample environment for *in-situ* studies. The figure overleaf, for example, shows an electrochemical cell used to observe, in-situ, the ingress of hydrogen into metal under an applied cathodic potential.

What do We Learn?

Result from a typical reflectometry experiment is shown in the figure below. The x-axis of the figure is depth. The quantity along the y-axis is the density of the material at a particular depth, times its “neutron scattering length”. The latter is a measure of how strongly a given material scatters neutrons, a known quantity and signature of each material.

This particular result shows how the natural oxide layer on the surface of Ti thickens when the metal is anodized to 2 volt. From this result one can deduce the type of oxides present after anodization and percentages of cation and anion migration during the anodization process.

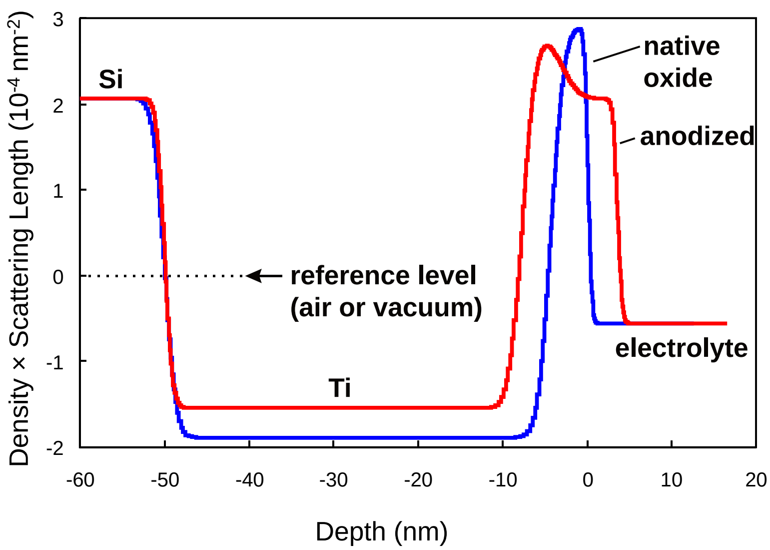

Figure 2. Chemical changes produced by anodization of a Ti film deposited on a Si substrate.

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