Scattering as a Means to Isolate Sample Components: GIPDF and Resonant Scattering

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As we consider materials not simply in isolation, but as part of a larger whole, we must begin to consider how to study the individual components as well as their interactions. Many of our X-ray based characterization approaches are volume averaging, meaning often we necessarily probe the complex system as a whole. This becomes critically important as materials are incorporated into technological devices or new phenomena are discovered at material interfaces [1]. Scattering methods present a means to isolate regions of a sample for different measurements. By being able to accurately model the X-ray matter interaction we can leverage X-ray scattering to control the component of a sample which we are characterizing. For example, depth resolution can be obtained for layered systems through control over the incidence angle. This allows for extremely surface sensitive probes such as total scattering by working near to the critical angle. Such an approach can fully isolate the scattering from a thin film from that of the substrate [2].

Resonant scattering approaches allow us to separate the spectroscopic signals from individual components in a multi-component system. Reflectivity can be used to do this in a depth resolved manner, extracting X-ray absorption spectra (XAS) for each layer independent of the whole [3]. Buried layers or interfacial regions can be investigated in this way. This is extensible to other scattering approaches such as diffraction. Diffraction provides a simple way to separate the scattering signal from different crystalline phases. Combining this with resonant X-ray energies allows determination of the XAS signal from each phase in a mixture. This can be extended further to determine the XAS signal from a common element in different crystallographic sites in a site-specific manner. Our understanding of the X-ray matter interaction for many scattering processes is key to such approaches. Because we can often write down the physical formula describing the scattering process, we can understand the contribution of each component to the scattered intensity. I will present examples of where inverting this has allowed the determination of the signal from individual components in a complex system and discuss the further potential of this approach.

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