Texture Analysis

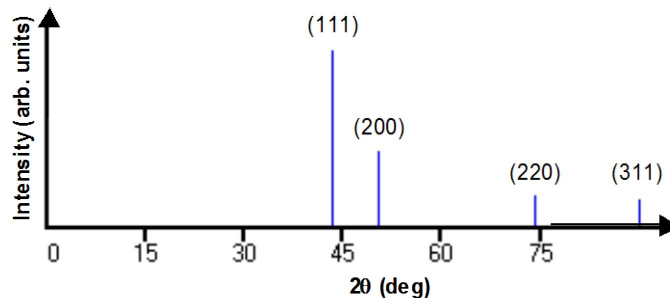
Chip manufacturing company moves from Al interconnects into Cu-based technology. Now the task is to establish proper conditions for the Cu film growth on Si. Number of samples, Cu on Si(001), were grown at different temperatures and using different Cu growth rates.
You were given one of the many samples, Cu on Si(001). Your assignment consists in: 1) determining a preferred orientation along c-axis (preferred out-of-plane orientation) of Cu film and 2) determining the in-plane orientation of the layer with respect to the Si substrate.

Preferred orientation along c-axis

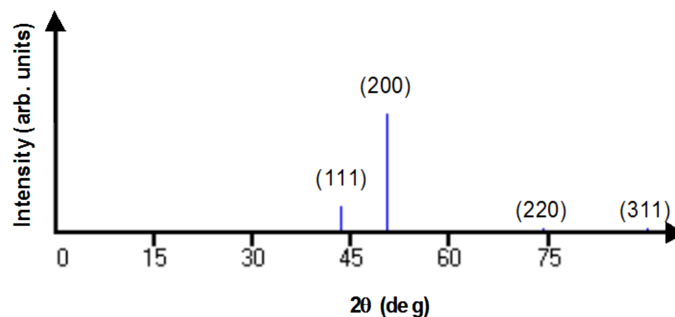
In order to determine the preferred out-of-plane orientation (PO) we can use symmetrical θ-2θ scan and look at the peaks produced by the planes parallel to the surface. The film will not have any PO if all grains in the layer are oriented randomly thus giving the relative peak intensities that agrees with powder diffraction data for Cu. We use the PDF file of Cu to compare peak intensities from the film with those published in the file from ideal powder Cu (i.e. randomly oriented). The PO can be discovered by comparing peak intensities in PDF data file and for Cu film.

Example: Cubic crystal with (100) planes parallel to the surface.

PDF Data File:



Cu Film:

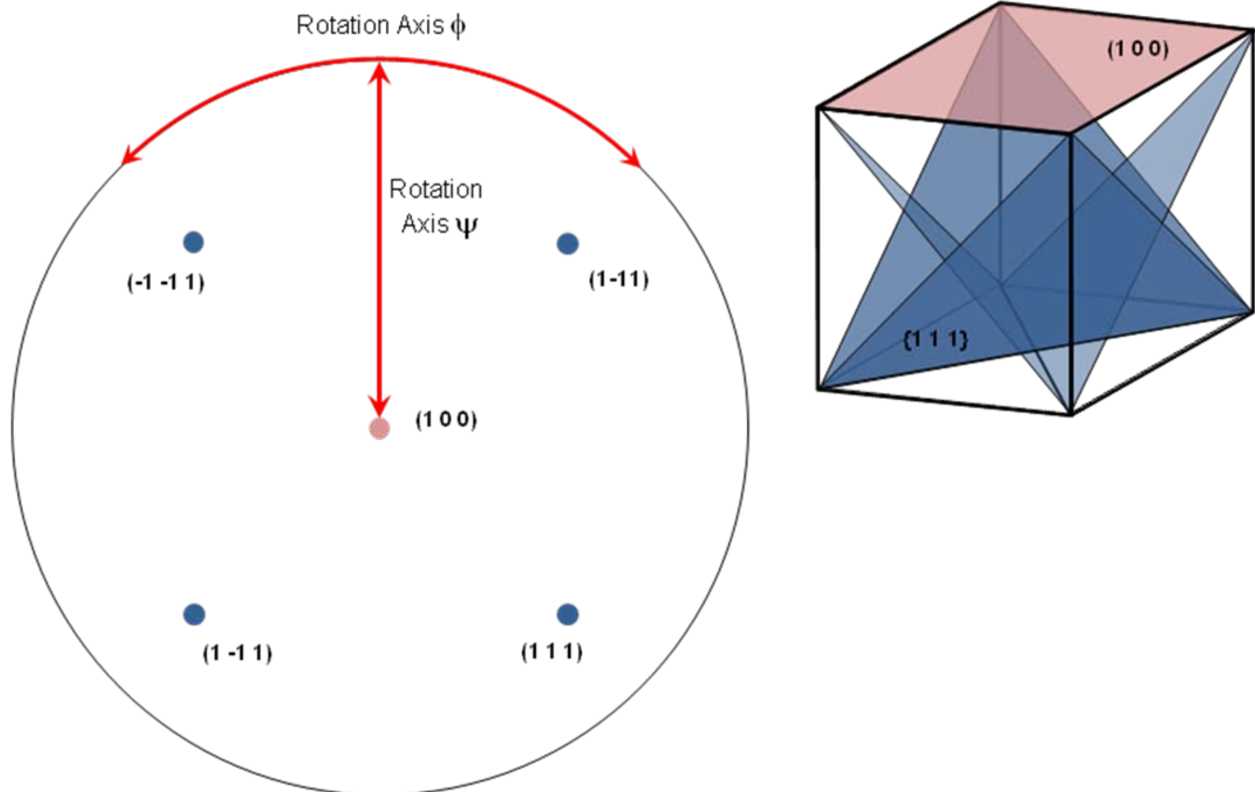


In our Cu thin film relative intensities of (111) and (200) peaks look very different from those shown in PDF data file (randomly oriented crystallites). While for

randomly oriented powder sample (111) diffraction peak is roughly two times larger than (200) peak, for Cu layer grown on Si(001) (200) peak is dominating. Such situation tells us that our Cu layer contains many more grains that are (100) oriented than (111) oriented along out-of-plane direction. In this case we say that Cu film exhibit preferential (100) out-of-plane orientation.

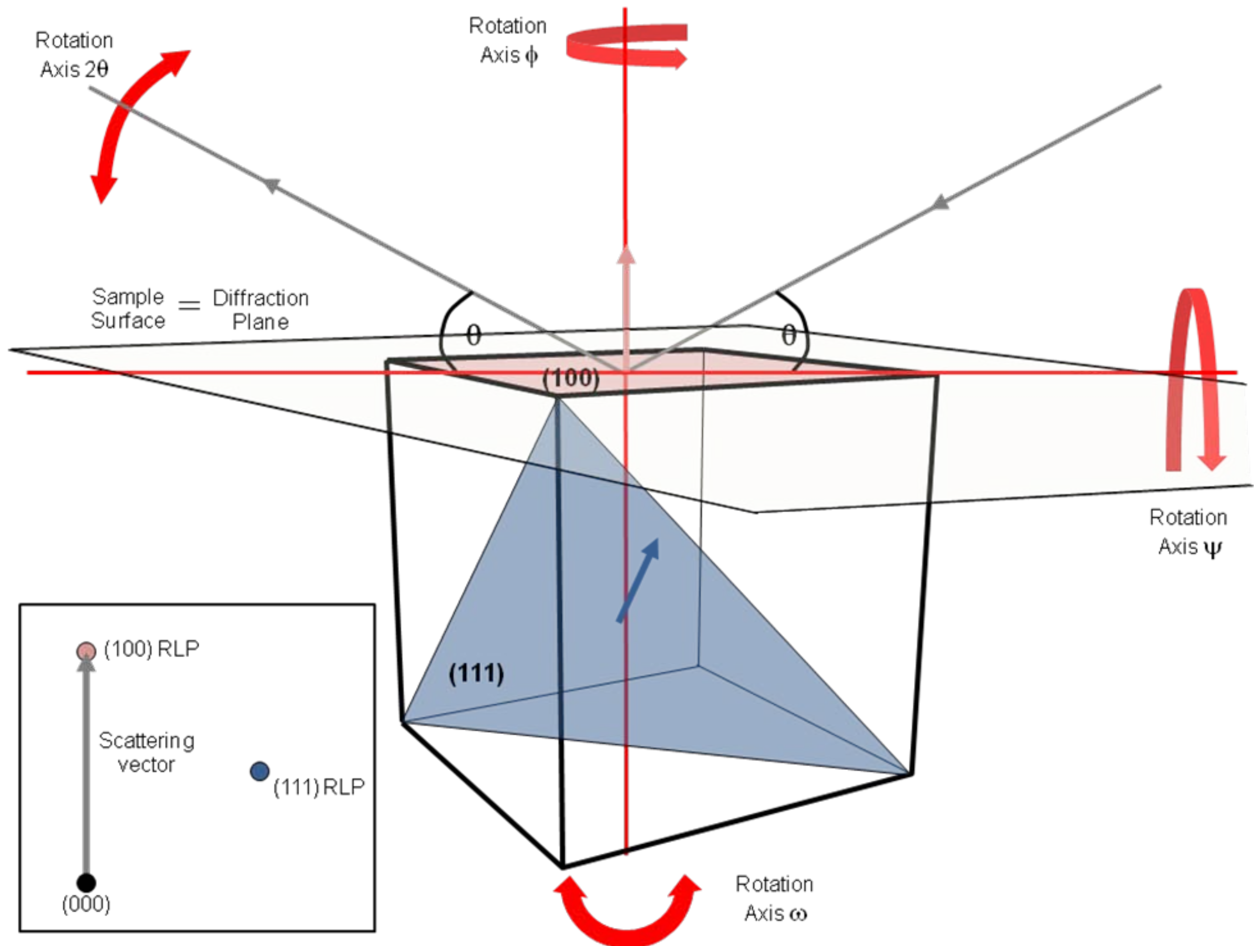
In-plane orientation with respect to the Si substrate

In-plane orientation can be established by rotation the sample around the axis perpendicular to the sample surface (ϕ axis). In this case, however, crystalline planes that are parallel to the surface will not provide the necessary information.



The combination of diffraction from planes inclined with respect to the surface and rotation around the axis perpendicular to the surface will provide us the information about the in-plane orientation.

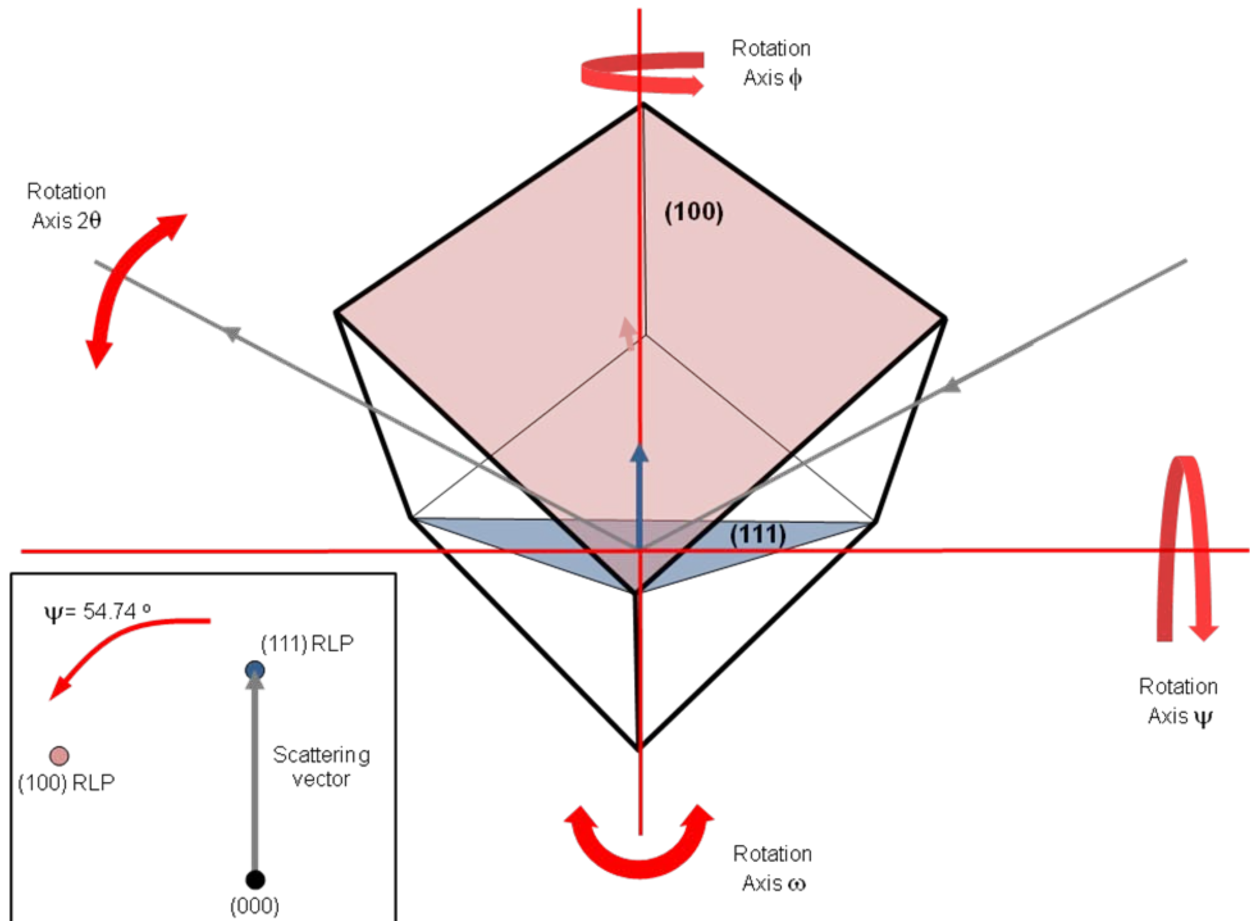
Example: Cubic crystal with (100) planes parallel to the surface.



Combination of diffraction from (100) planes and rotation around ϕ-axis will give straight line in intensity vs ϕ graph. This is because (100) planes are parallel to the sample surface and rotation axis is perpendicular to both sample surface and (100) plane.

In this example, we choose {111} family of planes which are tilted from the sample surface by 54.74 deg. The diffraction will occur if reciprocal lattice point from {111} planes will touch the scattering vector. This can be achieved through:

1. Setting the scattering vector length to be equal to (111) RLP distance.
2. Tilting ψ by 54.74 deg.
3. Rotating ϕ until diffraction occurs.



Combination of diffraction from (111) planes and rotation around rotation axis shown will give four peaks in intensity vs ϕ graph. The peaks will be 90° apart from each other.

If the (100) out-of-plane oriented sample does not have in-plane preferred orientation, diffraction from (111) planes for such sample will not produce four peaks. The phi scan will rather show more less constant intensity line in intensity vs ϕ graph.

Rule for samples that are randomly oriented in-plane:
ϕ-scan from the planes inclined with respect to the surface will not produce any peaks. The scan will rather show a constant intensity line for ϕ from 0^0 up to 360^0.

The report has to describe the structural properties of the Cu film grown on Si(001) substrate.