

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.

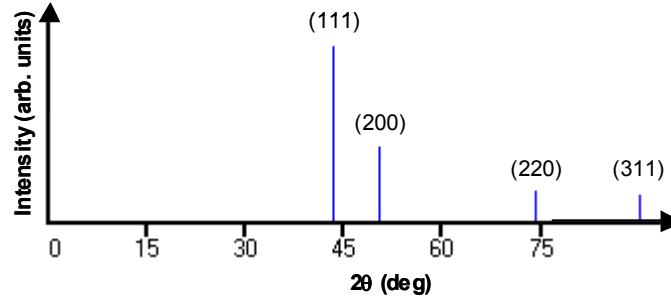
You were given one of the many samples, Cu on Si(001). Your assignment consists in: 1) determining a preferred orientation along c-axis (preferred out-of-plane orientation) of Cu film and 2) determining the in-plane orientation of the layer with respect to the Si substrate.

Preferred orientation along c-axis

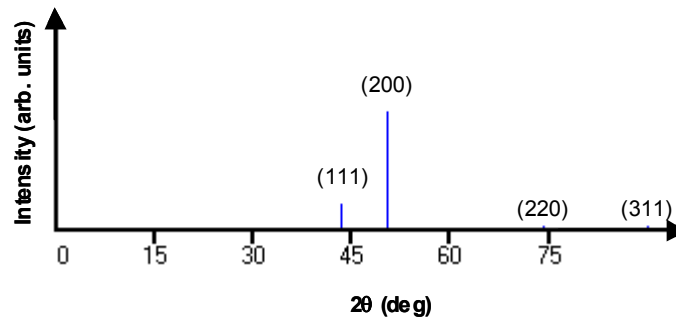
In order to determine the preferred orientation (PO) we can use symmetrical θ - 2θ scan and look at the peaks produced by the planes parallel to the surface. The film will not have any PO if all grains in the layer are oriented randomly thus giving the relative peak intensities that agrees with powder 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:

PDF Data File:



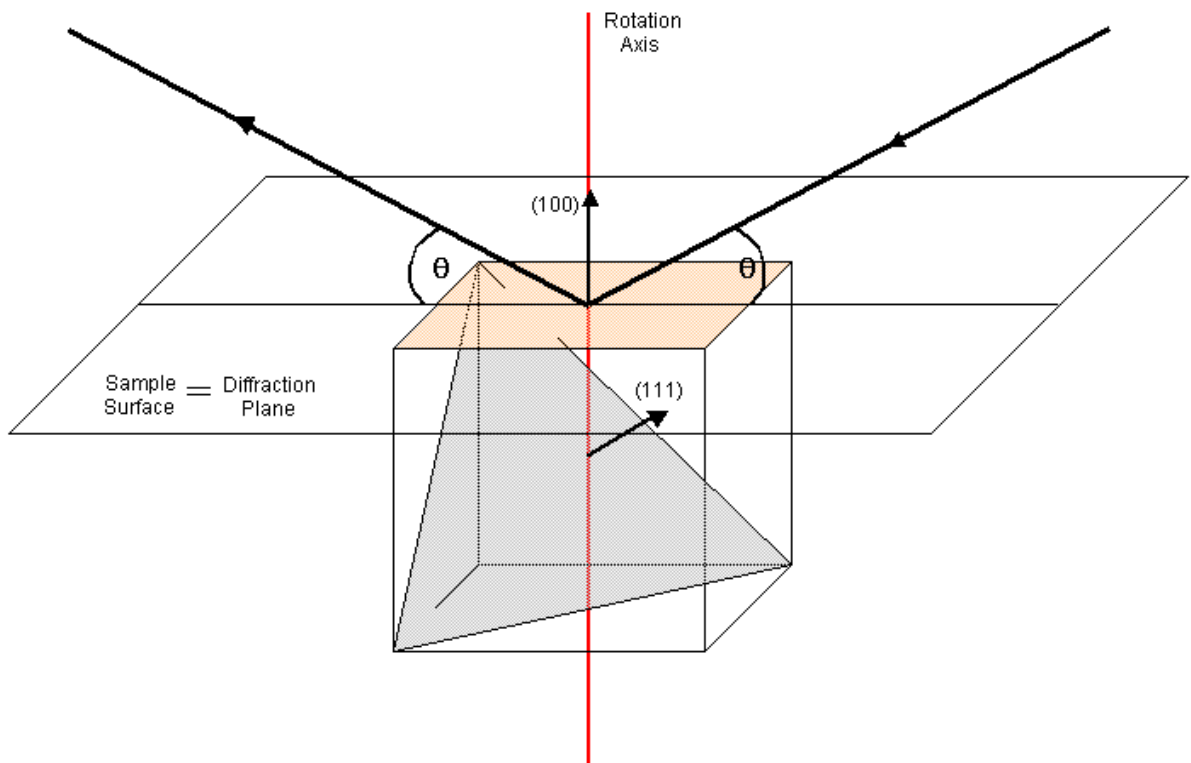
Cu Film:



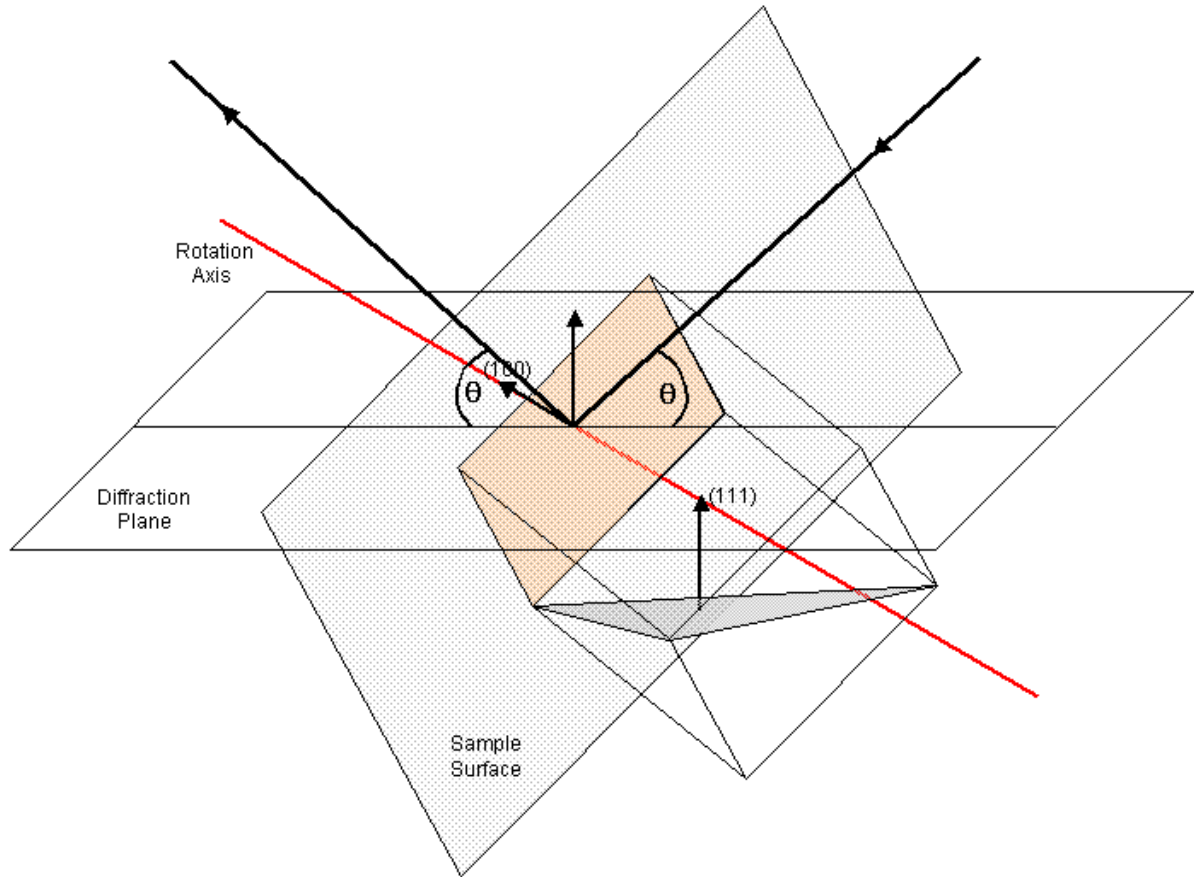
In this case Cu layer on Si(001) has much higher (200) peak than PDF Data File shows. We conclude that Cu film has 100 out-of-plane preferred orientation.

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. 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 parallel to the surface will provide us the information about the in-plane orientation.



Cubic crystal with (100) planes parallel to the surface. Combination of diffraction from (100) planes and rotation around rotation axis shown will give straight line on Intensity vs ϕ graph.



Cubic crystal with (100) planes parallel to the surface. Combination of diffraction from (111) planes and rotation around rotation axis shown will give four peaks on 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 straight line on 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° up to 360° .

Your report is an internal report you have to prepare for the manager in chip manufacturing company. The report has to describe the structural properties of the Cu film grown on Si(001) substrate.