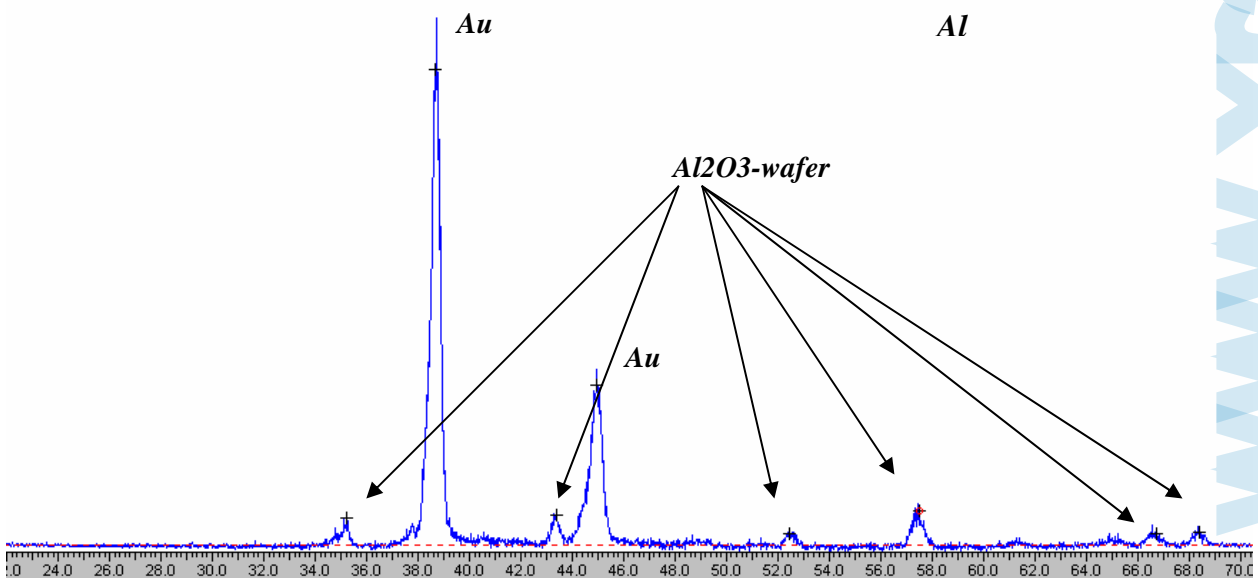
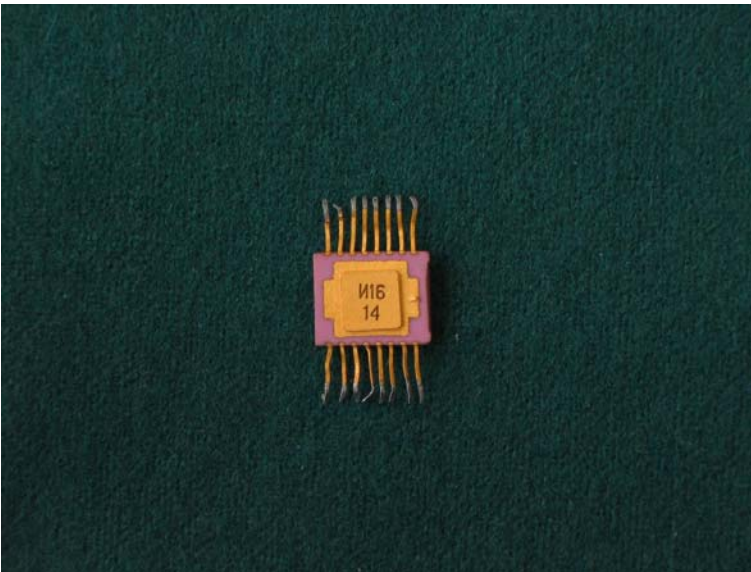


# Thin Film Analysis

## 1. Microelectronics

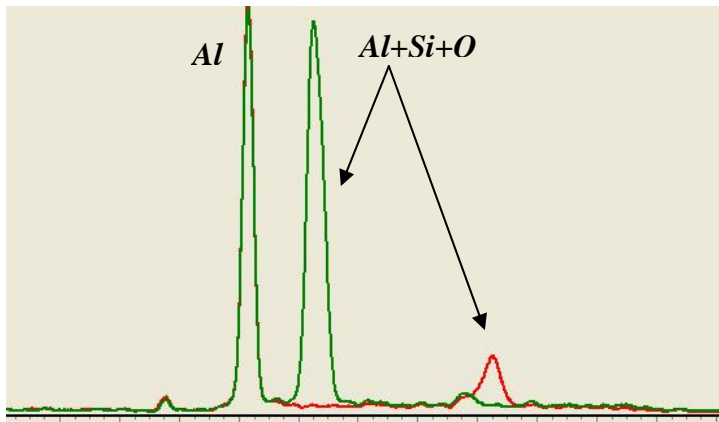
Express technique for non-destructive check of thickness of coatings.  
Gold coatings of chips on corundum-based ceramic wafer



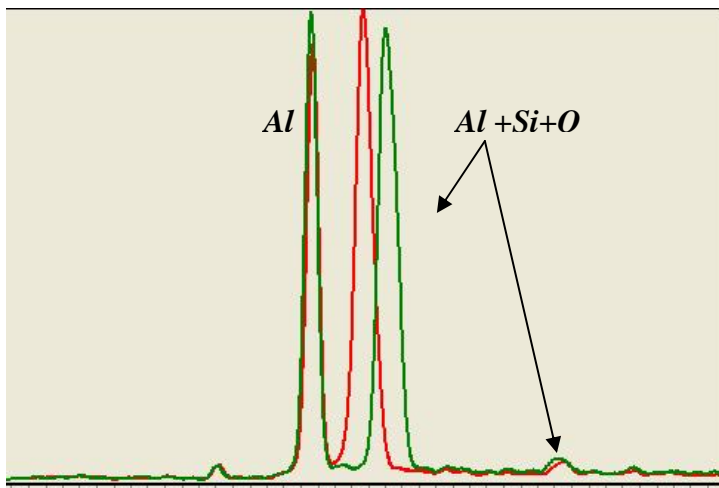
The diffractogram shows presence of both diffraction maximums typical for gold coating and maximums from ceramic wafer  $\text{Al}_2\text{O}_3$ . By assessing weakening of  $\text{Al}_2\text{O}_3$  lines intensity, one can determine thickness of sputtered coating. For this chip, gold coating thickness equals to 0.8 micron.

## 1a. Quality Control of Polycrystalline Coatings on Si Single-Crystal Wafers.

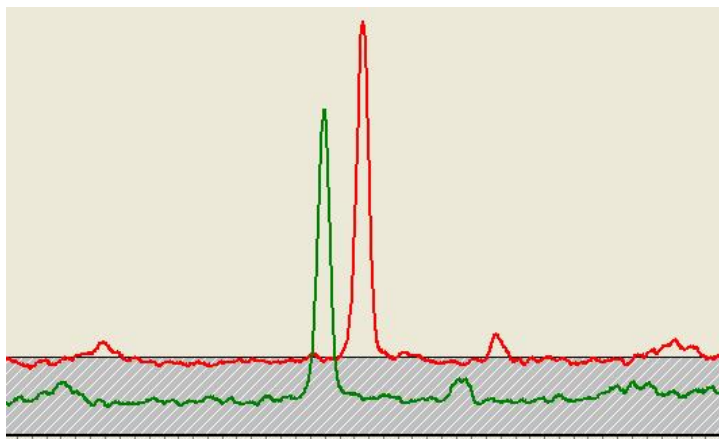
Presence of admixture phases in thin Al films sputtered on Si (001) wafers was checked. Exposure time made 500 seconds.



A fragment of diffractogram of Al film (thickness is ~1 micron), sputtered on single crystal Si, which were taken in different directions. The intermediate phase of Al-Si is evidently strongly textured and belongs to aluminosilicates.



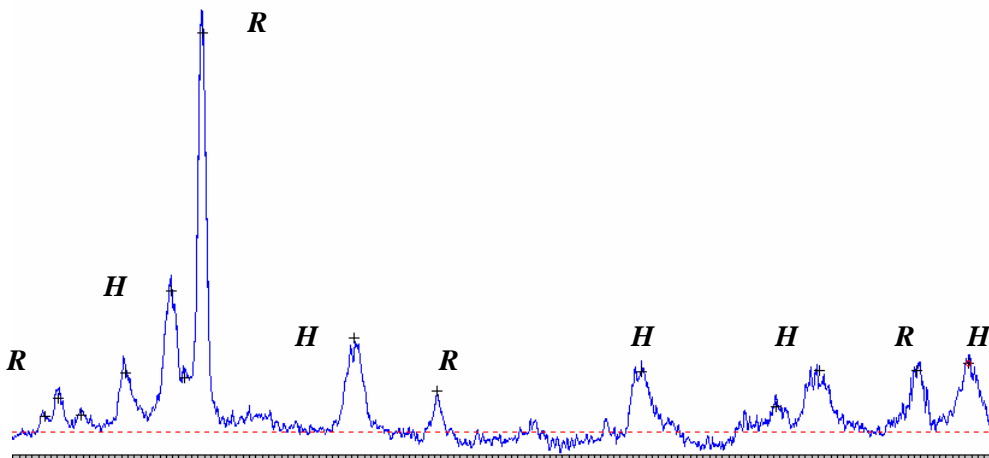
A fragment of diffractogram of Al films sputtered under different conditions. Coincidence of diffraction maximums from Al- phase and non-correspondence of diffraction maximums of Al-Si phase are evident, which proves formation of different aluminosilicate structures when the sputtering process is not observed.



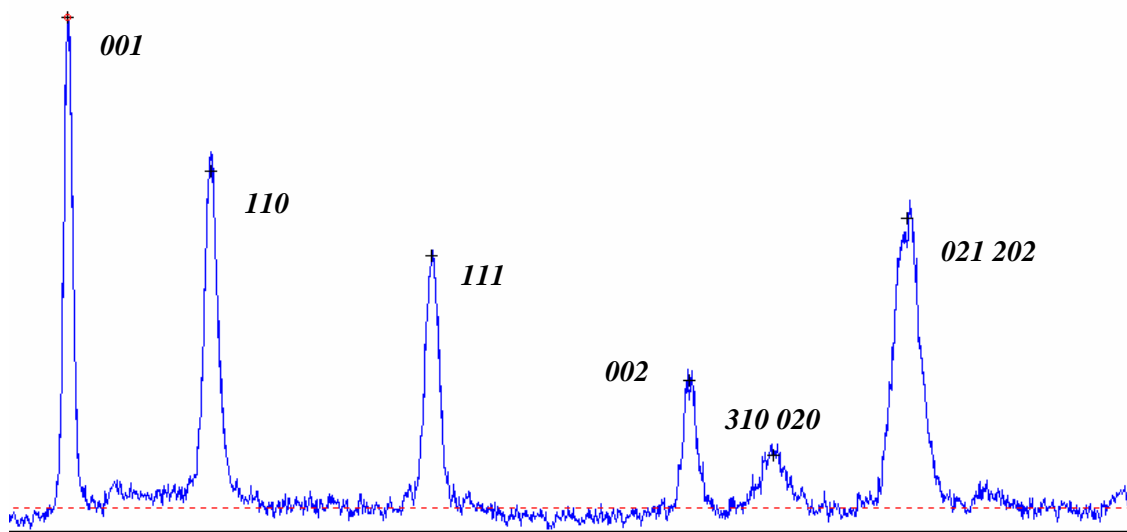
Fragments of diffractograms of various films of polycrystalline Si sputtered onto single-crystal Si wafers. Identical structures were received.

## 2. Oxide Coatings

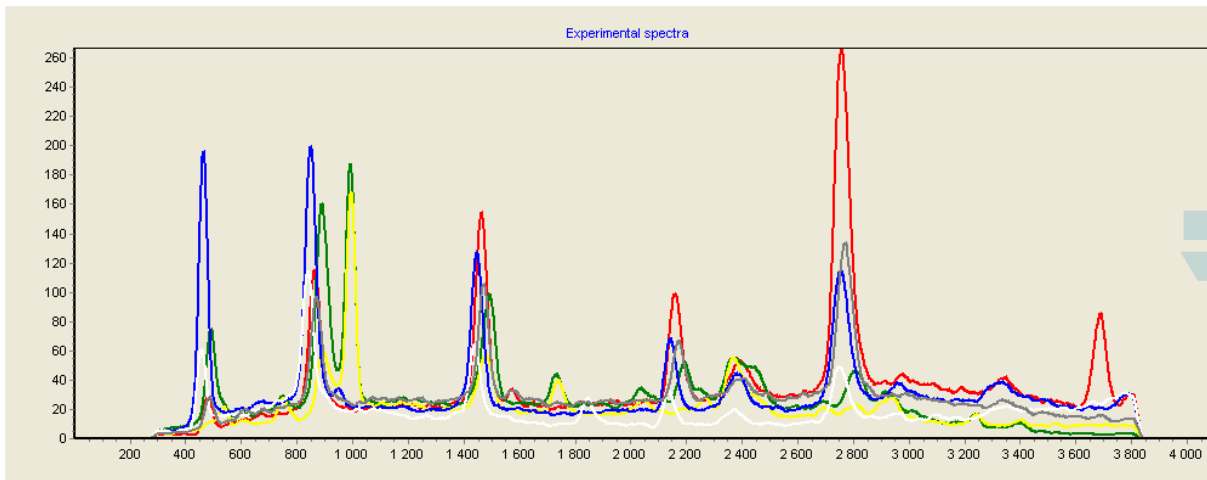
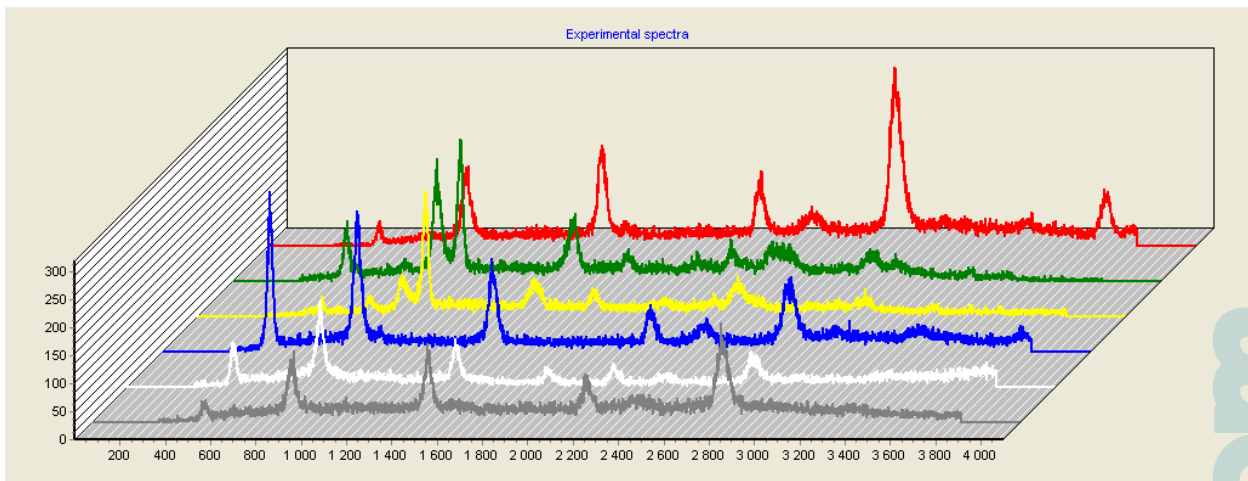
Ta oxide coatings produced in gas pulse charge at equal pulse time ( $150\mu\text{sec}$ ) at equal current density ( $2\text{A}/\text{cm}^2$ ) but with different pulse frequency.



The coating was produced at the largest pulse frequency (250 pulses/sec); both rhombic **R** modification of  $\text{Ta}_2\text{O}_5$  oxide and hexagonal **H** are observed.



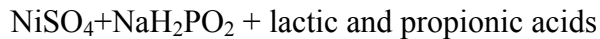
The coating is produced at the smallest pulse frequency (100 pulses/sec.); only rhombic phase of  $\text{Ta}_2\text{O}_5$  oxide is observed.



Comparison of diffractograms of Ta<sub>2</sub>O<sub>5</sub> coatings produced under different conditions.

### 3. Amorphous Coatings

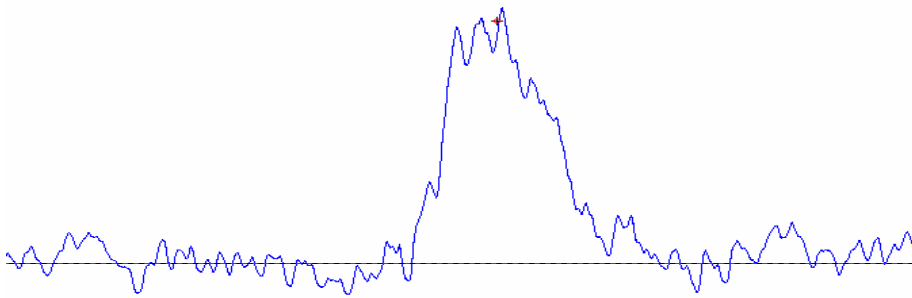
The samples under analysis are Ni-based amorphous films deposited on copper wafer. Films were produced through chemical sedimentation in solution:



Sedimentation was performed at temperature  $T=85^\circ\text{C}$  for 60 minutes.

The coating composition was: Ni-90at%, B-10at%.

Coating thickness was assessed and made 16micron.

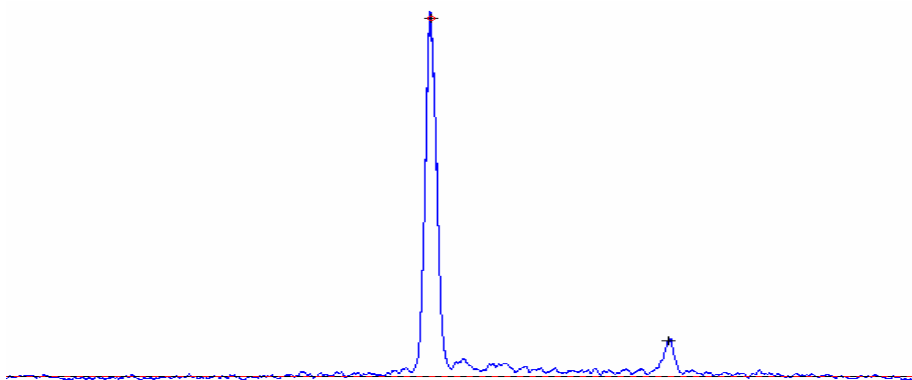


Diffractogram of amorphous NiB sample. Peak width equals to  $\sim 5^\circ$ .

To study the crystallization process, samples were subjected to step-by-step isothermal annealing.

Samples were annealed in sequence at temperatures of 150, 200, and  $300^\circ\text{C}$  for two hours at each temperature in vacuum of not less than  $10^{-4}$  mm Mercury column. After each annealing, diffractograms of samples were taken, phase analysis was performed, and the sizes of free phase clusters were assessed by the method of Selyakov –Sherer.

As a result of thermal treatment in case of first annealing ( $150^\circ\text{C}$ ), no modification in the diffuse scattering picture was observed, that is samples stayed amorphous. In case of second annealing ( $200^\circ\text{C}$ ), the process of crystallization started. In this instance, Ni and  $\text{Ni}_3\text{B}$  phases were freed. As a result of the third annealing ( $300^\circ\text{C}$ ), increase in Ni peaks intensities was observed while  $\text{Ni}_3\text{B}$  lines remained practically unchanged.



Diffractogram of the same sample after second annealing ( $200^\circ$ ). Formation of  $\text{Ni}_3\text{B}$  phase is observed.

In amorphous NiB alloys produced by chemical sedimentation, the temperature at which crystallization starts is significantly lower than that for the same alloys but produced by the method of super-fast tempering, which can be explained by presence of a large number of crystallization centers in case of chemical sedimentation.